BIAZA Research Committee Conference

July 2021

Book of Abstracts

BIAZA
WORKING TOGETHER FOR WILDLIFE

BIAZA
Research Committee

Second annual virtual conference
Tuesday 13th & Wednesday 14th July 2021

Strategies for Zoo Research in a post-COVID world

Organisers
Dr Paul Rose
Dr Lisa Riley
Ricardo Lemos de Figueiredo
Frankie Lawrence-Thompson
With help from the BIAZA Research Committee

Welcome

Kirsten Pullen
BIAZA Research Committee Chair

Welcome to the 2021 Annual Research Conference! The last 18 months have been so difficult for zoos and zoo researchers. We have had to change what data we collect and how we collected it. However the last year has demonstrated that our zoos are just as relevant as ever, and that means that zoo research is needed more than ever. Over the last year zoo researchers have had to show resilience and adaptability to the lockdowns and the lack of access to places we would usually go. But we have also seen opportunities arise for using technology and looking at other data sources to answer the questions we have. Going forward zoo research will be stronger for having to exploit these opportunities.
We have put together a fantastic agenda for the conference this year. We have a range of speakers and guest speakers highlighting the need for continued zoo research and inspiring us to keep moving forward. While it is disappointing we can't be together, we look forward to seeing you all online!

Jo Judge
BIAZA CEO

As CEO of BIAZA it is fantastic to see that zoo research continues to be fresh, relevant and cutting edge. Congratulations for maintaining and showcasing an impressive output of research despite the prolonged impacts of the pandemic. It is brilliant to see the Research Committee's conference reaching an international audience and that keepers and other zoo staff are involved at the forefront of zoo research development.

Schedule

Pre-event and Day 1

Date	Time	Event	Platform	Information
12/07	14:00	Meeting of the Research Committee	Zoom	Closed event
13/07	10:00	Welcome *Hosted by Dr Kirsten Pullen*	Zoom	Ticketed event
	10:30	Invited speaker 1 *Dan Kane from ZSL* Research at ZSL London Zoo during a global pandemic	Zoom	Ticketed event
	11:00	Discussion with speaker *Hosted by Dr Chris Michaels*	Zoom	Ticketed event
	Session ends 11:20			
	11:30	Invited speaker 2 *Dr Andrew Moss from Chester Zoo* The role of zoos in a post-Covid world: Has everything changed?	Zoom	Ticketed event
	12:00	Discussion with invited speaker *Hosted by Dr Leah Williams*	Zoom	Ticketed event
	Session ends 12:20			
	14:00	Welcome (speed talks and posters) *Hosted by Dr Paul Rose*	Facebook	Free event
	14:15	Speed talk session 1	Facebook	Free event. See timetable below for details
	15:00	Online chat with speed talk 1 presenters *Hosted by Dr Paul Rose & Ricardo Lemos de Figueiredo*	Facebook	Free event
	15:30	Virtual poster session 1	Facebook	Free event. See timetable below for details
	16:30	Online chat with poster presenters 1 *Hosted by Dr Paul Rose & Ricardo Lemos de Figueiredo*	Facebook	Free event
	17:00	Close *Hosted by Dr Paul Rose*	Facebook	Free event
	Day 1 ends 17:10			
	19:00	Virtual pub quiz *Optional social activity for those that wish to be tested on their zoo geekery knowledge!*	Facebook	Free event
	Social ends 20:30			

Day 2

Date	Time	Event	Platform	Information
14/07	10:00	Welcome *Hosted by Dr Kirsten Pullen*	Zoom	Ticketed event
	10:15	Invited speaker 3 *Prof. Dalia Conde & Prof. Fernando Colchero from Species360* The Species360 Conservation Science Alliance: Research and future directions.	Zoom	Ticketed event
	10:45	Discussion with invited speaker *Hosted by Lewis Rowden*	Zoom	Ticketed event
	Session ends 11:05			
	11:15	Welcome (speed talks and posters) *Hosted by Ricardo Lemos de Figueiredo*	Facebook	Free event
	11:30	Speed talks session 2	Facebook	Free event. See timetable below for details
	12:15	Online chat with speed talk 2 presenters *Hosted by Ricardo Lemos de Figueiredo & Dr Paul Rose*	Facebook	Free event
	14:00	Virtual poster session 2	Facebook	Free event
	14:40	Online chat with poster presenters 2 *Hosted by Ricardo Lemos de Figueiredo & Dr Paul Rose*	Facebook	Free event. See timetable below for details
	Session ends 15:00			
	15:10	Invited speaker 4 *Prof. Thomas Hildebrandt from Leibniz Institute for Zoo & Wild Animal Research* "BioRescue": The Northern White Rhino Rescue Project. The obstacles overcome during the COVID-19 pandemic and its potential as blueprint for other critically endangered species.	Zoom	Ticketed event
	15:40	Discussion with invited speaker *Hosted by Dr Leah Williams*	Zoom	Ticketed event
	16:00	Panel discussion "Moving on from Covid- what research are zoos looking for? In need of?" *Hosted by Louise Bell*	Zoom	Ticketed event
	17:00	Closing address BIAZA & Dr Kirsten Pullen	Zoom	Ticketed Event
	Conference closes 17:15			

Timetable for posters and speed talks: Day 1

Date	Session	Lead author	Title	Topic
13/07	Speed talks 1	Sandri	Genetic analysis of captive mountain bongo	Management, reproduction & genetics
		Colin	What's left in the tank? Identification of non-ascribed aquarium's coral collections with DNA barcodes as part of an integrated diagnostic approach	
		Mooney	Flamingo management: from data to decisions	
		Major	Home range and microhabitat preferences of Aesculapian snakes in North Wales.	Technology in applied science
		Showell	Measuring the unwatchable, using accelerometers to predict slow loris behaviour	
		Schneiderova	Bioacoustics as a tool to monitor the oestrus cycle in a female slow loris	
		Slaney	Saving cheetahs one footprint at a time – How footprint analysis can help cheetah conservation	
	Virtual posters 1	Kistner	The Footprint Identification Technology (FIT) - Conservation from the ground up	
		Phillips	Research trends and influences: A gap analysis of *Canidae* and *Hyaenidae*	Management, reproduction & genetics
		Bartlett	A comparative multi zoo survey investigating the housing and husbandry of Goeldi's monkeys	
		Wareing	Breeding success of red titi monkeys: a preliminary study	
		McKinney	Effect of zoo closure due to COVID-19 on the behaviour and enclosure use of Asian elephants	Visitor effects
		Bond	Effect of zoo closure due to Covid-19 on the behaviour and enclosure use of Asiatic lions	
		Jenkins	Zoo-housed mammals do not avoid giving birth on weekends	
		Walsh	An analysis of the nutritional components of Linnaeus's two-toed sloth diets in Captivity	Nutrition
		Norman	Potential applications of personality assessments to the management of non-human primates: A review of 10 Years of study	Behaviour, physiology & welfare

Date	Session	Lead author	Title	Topic
		Holcombe	Caretaker perceptions of auditory enrichment and species-specific music for captive animals	
		Depauw	Enrichment of gorillas with ensiled willow: tastes for more	
		Van den Oudenhoven	Survey on animal welfare and lockdown measures in Flemish zoo's	
		Hope	Validating faecal thyroid hormones in the black rhinoceros	
		Torfs	Investigating the effects of sex and rearing-history on social network position in zoo-housed bonobos	
		Ford	The effect of long-term visitor deprivation on patterns of behaviour in captive Chilean flamingo and greater flamingo	
		Bartle	Body condition scoring and activity levels of southern white rhinoceros	
		Maher	Developing a composite welfare assessment tool for bears in zoos	
		Willis	Investigating the time-budget study of an Arctic fox housed within a zoological collection	

Timetable for posters and speed talks: Day 2

Date	Session	Lead author	Title	Topic
14/07	Speed talks 2	Kidd	Influences of rearing environment on behaviour and welfare of captive Chilean flamingos.	Behaviour, physiology & welfare
		Machado	Factors affected performance of self-directed behaviours in Hamadryas baboons.	
		Clegg	Keeper-generated data and zoo animal welfare	
		Taberer	Exploring the impact of contraception on the social behaviour and welfare of captive guinea baboons.	
		Logan	Monitoring faecal glucocorticoids in pregnant and non-pregnant equids	
		Laméris	Lateralised production of self-directed behaviours in bonobos during a touchscreen task	
		Doodson	Exploring public perceptions of animal experiences in BIAZA zoos	Education, human-

Date	Session	Lead author	Title	Topic
	Virtual posters 2	Coales	Engaging audiences with your science via online events	animal interactions, sociology
		Shaw	Quantifying predictors for online engagement when society 'stays at home': how did zoos connect with people during the UK COVID-19 lockdown?	
		Freeman	Increasing the effectiveness of community science in zoo research	
		Settle	Virtual learning literature review: Zoo-based education in a post Covid-19 world	
		Doyle	An investigation into zoo professionals' opinions of population management euthanasia in BIAZA member zoos	
		Higgs	Role and purpose of direct human-animal interactions in the crested porcupine and guinea pig in educational establishments in the United Kingdom	
		Elwell	Using scent-marks to create a novel enrichment for ruffed lemurs	Behaviour, physiology & welfare
		Bwye	Social play in pygmy slow loris: a comparison between adult-adult play and juvenile-adult play	
		Vaesen	24/7 behaviour and welfare of giraffes	
		Stevens	Monitoring the welfare of giraffes in two Belgian zoos	
		Verbruggen	Social behaviour in a group of Colombian spider monkeys	

Abstracts

Day 1 Invited Speakers

Daniel Kane[1]
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Research at ZSL London Zoo during a global pandemic

In this presentation I will discuss how the COVID-19 pandemic impacted research and other work done by the herpetology team at ZSL London Zoo. Across BIAZA collections in 2020 new research programmes declined by over 40% compared to a prior baseline however at ZSL London Zoo daily work was adapted to maintain research as a core principle of the zoo keeping role. Living on-site at the zoo gives me the opportunity to provide an insight into the day-to-day work for a zoo keeper throughout national lockdowns, isolation & zoo closures. Following this, I will discuss the varying research opportunities COVID-19 has provided, with particular focus on work to inform the captive management of reptiles and amphibians using theoretical best-practice for creating an environment conducive to more natural behaviours and a higher state of welfare. Other research from the herpetology section, including visitor density effects on animal behaviour and a BIAZA first breeding, will also be highlighted.

Andy Moss
Chester Zoo, Caughall Road, Chester CH2 1LH. a.moss@chesterzoo.org

The role of zoos in a post-covid world: Has everything changed?

Over the past year, we have seen dramatic changes to the society we live in. For us, in zoos, we have been greatly affected, and mainly for the worse. Forced closures, staff losses, a total cessation of most of our incomes and, for some, a sense of disaffection as to where we now stand in society have been bitter pills to swallow. However, I will argue that this now presents an opportunity for us to re-evaluate what the role of zoos are, as well as what they could and should be. The four-pillar model of conservation, education, research and recreation is now over 50 years old and in need of a rethink. Focusing specifically on the human value of zoos, such as conservation education and nature connectedness, I will propose one such possible future for zoos.

Day 1 Speed Talks

Tommy Sandri[1,2], Nick Davis[1], Bradley Cain[2], Martin Jones[2], Richard Preziosi[2], W. Ed Harris[3]
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[2] Manchester Metropolitan University, Manchester, Greater Manchester, UK. M15 5RN
[3] Harper Adams University, Newport, Shropshire, TF10 8NB
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The Influence of founder relatedness in the captive population of a critically endangered antelope

The main goal of captive breeding management is to limit the loss of genetic variation while minimizing accumulation of inbreeding, as both can hamper the efficacy of a conservation breeding program. The characteristics of the founder population are known to be paramount in influencing the level of inbreeding and genetic variation preservation. The size of founder populations is considered of major influence in predicting the level of inbreeding in the living populations, as breeding programmes started with larger population show lower levels of inbreeding. However, another aspect of the founder population is also relevant: founder relatedness. Therefore, we assess the influence of founder population relatedness and size on inbreeding in conservation breeding programmes via simulations of microsatellite-like genotypes along pedigrees of simulated populations. We then compare empirical measures of inbreeding in 28 individuals in the critically endangered Mountain bongo *(Tragelaphus eurycerus isaaci)* studbook with simulated genotypes derived from different levels of relatedness of founders to assess the origin of current genetic situation in the bongo captive population. Our results show that although size is usually considered of major influence in driving inbreeding in captive populations, size is in fact less relevant than founder relatedness in shaping the genetic situation of living population in captive breeding programs. Moreover, the current genetic situation of the bongo captive population (measured via 19 microsatellites

in 28 individuals representative of 31/38 founders) is most similar to that resulting from inbred founders. Thus, we provide evidence that size of founder population does not guarantee lower inbreeding accumulation in conservation breeding, reinstating the relevance of knowing the genetic situation of founders to have a better understanding of the situiation of current managed populations. Also, analysis of the bongo studbook shows that the current genetic situation is likley due to an already depleted founder stock rather than a shortcoming of the conservation breeding program.

Luigi Colin[1]; Daniel Abed-Navandi[2]; Dalia A. Conde[3,4]; Jamie Craggs[5]; Rita da Silva[3]; Max Janse[6]; Björn Källström[7]; Alexander Pearce-Kelly[8]; Chris Yesson[1]

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2Haus des Meeres - Aqua Terra Zoo, Fritz Gruenbaum Platz 1, 1060 Vienna, Austria.

3Interdisciplinary Centre on Population Dynamics (CPop), University of Southern Denmark, Biology Department, Syddansk Universitet, Campusvej 55, DD-5230 Odense M, Denmark.

4Conservation Science Alliance, Species360, 7900 International Drive, Suite 1040 Bloomington, MN, 55425 USA.

5Horniman Museum & Gardens, 100 London Road, Forest Hill, London SE23 3PQ, UK.

6Royal Burgers' Zoo, Antoon van Hooffplein 1, 6816 SH Arnhem, the Netherlands.

7Maritime Museum & Aquarium, Karl Johansgatan 1-3, SE-41459, Göteborg, Sweden.

8Zoological Society of London, Regent's Park, London NW1 4RY, UK.

What's left in the tank? Identification of non-ascribed aquarium's coral collections with DNA barcodes as part of an integrated diagnostic approach

The unprecedented threats to coral reef ecosystems from global climate change (GCC) require an urgent response from the aquarium community, which is becoming an increasingly vital coral conservation resource (24% of assessed corals in aquarium collections are classified as highly vulnerable to climate change). Unfortunately, many hermatypic corals in aquaria are not identified to species level (c. 42.9% identified to genus or higher taxonomic level), which hinders assessment of their conservation significance. Traditional methods of species identification using morphology can be challenging, especially to non-taxonomists. DNA barcoding is an option for species identification of Scleractinian corals, especially when used in concert with morphology-based assessment. This study uses DNA barcodes to try to identify aquarium specimens of the diverse reef-forming family Acroporidae from hundreds of samples across seven institutions, while highlighting the shortcomings of the state of the art. We identified to species name 44% of the analysed samples and provided provisional identification for 80% of them (in the form of a list of species names with associate confidence values). We highlighted a sampling bias in public nucleotide sequences repertories (e.g.: GenBank) towards more charismatic and more studied species, even inside a well-studied genus like Acropora. In addition, we showed a potential "single observer" effect with over a quarter of the reference sequences used for these identifications coming from the same study. We propose the use of barcoding and query matching as an additional tool for taxonomic experts and general aquarists to increase their chances of making high confidence species-level identifications. We produce a standardised and repeatable methodology to increase the capacity of aquariums and other facilities to assess non-ascribed species. Our DNA based identifications have been integrated into the "idheper.net" database, a ZSL-led initiative to house information about coral collections in aquaria.

Andrew Mooney[1,2], Andrew Teare[2], Johanna Staerk[2,3], Simeon Q. Smeele[2,3], Paul Rose[4], Catherine King[5], Laurie Conrad[6,7], Harrison Edell[8], Dalia A. Conde[2,3], Yvonne M. Buckley [1,9]

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[5] Zoo de Lagos, Barão de São João, Portugal,

[6] IUCN SSC Flamingo Specialist Group Steering Committee.

[7] Former AZA Lesser Flamingo SSP Program Manager / TAG Steering Committee

[8] Dallas Zoo, 650 S R L Thornton Fwy, Dallas, Texas 75203, USA.

[9] School of Biological Sciences, University of Queensland, St Lucia, Queensland, Australia

Flamingo management: from data to decisions

The majority of managed *ex situ* populations are not meeting sustainability criteria and are therefore not viable in the long-term, as demonstrated by the low rates of reproductive success seen in *ex situ* flamingo (Phoenicopteridae) populations. Both flock size and environmental suitability have been shown to be important determinants of *ex situ* reproductive success; however previous work is limited by the number of species, institutions and geographic areas assessed and has failed to consider species-specific differences in reproductive behaviour. The identification of species-specific requirements and associated management recommendations is necessary to improve *ex situ* flamingo population sustainability. Here we combined current and historic globally shared zoological records (ZIMS) for four of the six extant species of flamingo (*Phoeniconaias minor, Phoenicopterus chilensis, P. roseus*, and *P. ruber*) to analyse how flock size, structure and climatic variables have influenced reproductive success in *ex situ* flamingo populations at 540 zoological institutions between 1990 and 2019. We show that flock size has a strong non-linear relationship with reproductive success for all species, with flock sizes of 41 – 100 birds necessary to achieve a 50% probability of reproduction. In addition, we show that an even sex ratio and the introduction of new individuals to a flock both increase reproductive success, while climatic variables play a limited role in determining ex situ flamingo reproductive success. We provide species-specific management recommendations to increase the reproductive success of global *ex situ* flamingo populations and encourage greater collaboration between individual institutions and regional associations. Our analyses demonstrate the conservation potential and management information available from globally shared zoological data and we strongly encourage the continued sharing of standardised zoological records.

Tom Major[1,2] & Wolfgang Wüster[1] & John Mulley[1]
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Radio tracking an introduced snake in North Wales

The research investigates the spatial ecology of a non-native species of snake, the Aesculapian snake (*Zamenis longissimus*) in North Wales. The snakes were accidentally introduced to Colwn Bay in the 1960s, and have been breeding successfully in the wild since then. There are two other populations, one in London, and one in Bridgend. The project represents an opportunity to study the habitat use and home range of an introduced species, to understand how it persists in a novel environment. We have been tracking snakes since June 2021, and will be presenting preliminary findings.

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Measuring the unwatchable, using accelerometers to predict slow loris behaviour

Advancements in accelerometer technology now provide a method to capture long term data on species behaviour and can be incredibly beneficial for the study of cryptic species. The study used accelerometer measurements and camera footage of a captive Bengal slow loris, *Nycticebus bengalensis*, to calibrate the different behavioural patterns from the accelerometer readings. This allows us to be able to predict behavioural locomotion patterns of the slow loris and in the long term provide a base understanding of the accelerometer reading that could in turn be used in wild free-roaming slow lorises. The use of accelerometers is highly recommended in collecting and predicting behaviour as it not only reduces the time spent conducting observation but also allows researchers to collect behavioural data in a non-intrusive manner.

Irena Schneiderová[1,2] & Roman Vodička[3]
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Bioacoustics as a tool to monitor the estrus cycle in a female slow loris (*Nycticebus* sp.)

Evidence-based husbandry leading to increased reproductive success and strengthening of ex situ populations of slow lorises (*Nycticebus* sp.) living in zoos is highly important. Better fulfillment of their social needs is one of

the main priorities in achieving these objectives. We performed twenty-one-month-long acoustic monitoring of a zoo-kept female slow loris (*Nycticebus* sp.) housed either singly or with one of two males to examine whether her estrus cycle potentially could be detected based on her vocal activity. We found a regular cycle of remarkably increased whistle production that lasted approximately 31.2 days in a nocturnal exhibit and approximately 39 days in an off-show room. The regular cycle of increased vocal activity corresponded to a previously described estrus cycle of slow lorises and was observable in the presence of both males as well as when the female was housed singly. Additionally, vaginal smears collected from the female close to the peak period of her vocal activity showed signs of proestrus and estrus. The acoustic properties of the whistles, specifically that they did not overlap with or were loud enough to exceed background noise commonly occurring in zoos, made them perfect candidates for analyses involving automatic processing of a large number of recordings. We conclude that bioacoustics represents a promising, completely noninvasive and relatively easily applicable tool that allows detection and anticipation of the estrus cycle in some females, thus improving the social management of slow lorises living in zoos.

Larissa Slaney
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Saving cheetahs one footprint at a time – How footprint analysis can help cheetah conservation

There are fewer than 7,000 cheetahs *(Acinonyx jubatus)* left in the wild. One problem the species faces is low genetic variation, which results in health problems and higher mortality. It is therefore important, that cheetah conservation efforts address this problem. Zoos are already contributing in the form of breeding programmes, but it is important to highlight the role zoos can play beyond this. This research project investigates whether the innovative and non-invasive Footprint Identification Technology (FIT) by WildTrack can identify relatedness, subspecies and sex of individual cheetahs. The aim is to develop this non-invasive monitoring technology further for in-situ conservation projects with the support of zoos. For this, a standardised protocol is followed for footprint collection and morphometrics in footprint images are measured using data visualisation software. Measurements are analysed with a cross-validated pairwise discriminant analysis in JMP statistical software. FIT has previously been shown to classify individual cheetahs with high accuracy. Data on the relatedness of individuals gives important insights into populations and may influence conservation efforts to avoid inbreeding depression. Although footprints are unique to each individual, the morphology is genetically influenced and may be more similar between related individuals. The hypothesis is that if footprint morphometrics can be measured, FIT is able to detect whether two cheetahs are related. For this study, over 3,000 digital cheetah footprint images have been collected from captive populations at ex-situ organisations in the UK, Namibia, UAE and USA. Preliminary results show a 99% accuracy in the classification of individual cheetahs. Related cheetahs are grouped together in cluster dendrograms and Wards distances between related cheetahs are shown to be smaller than between unrelated individuals. Sex classification is currently at 74% accuracy. More data is needed for subspecies classification and data is still being analysed. If FIT is able to identify relatedness, subspecies and sex in cheetah, it would be a cost- and time-effective, non-invasive way to monitor populations in-situ. It could be combined with other monitoring techniques and developed for further endangered species. Without footprint data collected at *ex situ* organisations, this research would not have been possible. Captive populations can help their free-ranging cousins' survival by donating their footprints.

Day 1 Posters

Frederick Kistner[1&2], Zoe Jewell[2] &Sky Alibhai[2],
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The Footprint Identification Technology (FIT) - Conservation from the ground up

Good conservation strategies and management of Human Wildlife coexistence depend on reliable data such as population numbers and distribution of animals of conservation concern DNA-based estimates are often the method of choice to generate this data, however they might not always be feasible as they can be expensive and rely on fresh samples which can be potential limiting factors for a wider use. *Ex situ* organisations can however have an important role in developing alternative methods such as the Footprints Identification Technology (FIT). The non-invasive Footprints Identification Technology (FIT) developed and employed by the WildTrack Group follows a different, "From the ground up", approach using digital images of footprints as data resource. FIT has

been successfully developed and employed and several articles for a wide range of species ranging from Amur tigers *(Panthera tigris altaica)* to white rhinos *(Ceratotherium simum)*, giant pandas *(Ailuropoda melanoleuca)* and lowland tapirs *(Tapirus terrestris)* have been published in peer-reviewed scientific journals. FIT combines traditional animal tracking, with modern machine learning algorithms. FIT currently follows two approaches. The first is based on biometric features within a footprint that are manually selected by an expert operator. This approach achieves validated classification accuracies for sex, species and individuals above 90%. The downside of this approach is that it requires a highly skilled operator to set the landmark points, a step that is also very time consuming. To overcome this limitation current research focuses on an automation of this process using artificial intelligence. The second part of the presentation will therefore highlight ongoing research by the WildTrack AI project to facilitate data processing using state of the art Deep Learning Models. WildTrack AI aims to develop automized species monitoring tools for a wide range of animals. This AI approach achieves species classification rates of 90%, but lower accuracies for individual identification. While AI currently gives lower accuracy than the 'gold-standard' morphometric approach, we anticipate that with bigger data sets it will become much more accurate. We see AI at least being an ideal data sorting and pre-processing tool to augment FIT, and possibly much more. The speaker will explicitly highlight how Ex-situ organizations play an important role to a crowd source data collection process to help developing good and reliable non-invasive monitoring methods based on animal tracks. A guideline of how to collect good quality footprint images will be presented. This can be seen as direct contribution of research conducted on zoo animals to their free ranging counterparts.

Zoe Phillips[1], Kerry Hunt[1,2] and Marianne Freeman[1]
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Research trends and influences: A gap analysis of *Canidae* and *Hyaenidae*

Scientific research has provided advancements within conservation however, it has been highlighted that this research does not always match conservation priorities leaving large gaps in knowledge necessary for effectively managing a range of species. A systematic search on 10 species for the European Association of Zoos and Aquaria (EAZA) *Canid* and *Hyaenid* TAG across three search engines (Google scholar, Scopus and Web of Science) was conducted utilising publications from 2010-2020. Comparisons of the number of publications per topic showed no significant difference ($p=0.423$) however, trends from the descriptive statistics suggest more empirical focused research such as veterinary ($N=244$) rather than zoo education ($N=3$). There was however, a significant difference ($p<0.01$) when comparing the years of publications between the topics potentially influenced by funding, and the species kept in captivity each year. The quantity of publications between in-situ and ex-situ research also highlighted a significant difference ($p=0.008$) with in-situ papers being more commonly seen. There was a significant association ($r=0.806$, $p=0.005$) between the number of each species kept in captivity and the quantity of publications whilst there was no significant difference ($p=0.943$) between the IUCN endangerment category of a species and the quantity of papers on them. Commonly kept *Canidae* and *Hyaenidae* species in *ex-situ* settings receive prominently more research than those less commonly kept with this research focused on veterinary treatment and reproduction. However, it has been highlighted that there is no bias between endangerment and quantity of literature, leaving those more endangered species with prominent research gaps in managing them within captivity as well as refuting conservation priorities for research focus. The only exception for this being, African painted dog (*Lycaon pictus*) which although endangered, collated the most research identified in this study, potentially due to being a priority species. Species less commonly kept in captivity such as bat-eared fox (*Otocyon megalotis*) received less overall research, than those more commonly kept such as grey wolves (*Canis lupus*) and spotted hyena (*Crocuta crocuta*). This indicated gaps which suggests replication of research and under prioritisation of various areas for species otherwise thought to be highly researched such as grey wolves due to there being more individuals kept in captivity. This research is being used to help develop the EAZA *Canid* and *Hyaenid* Taxon Advisory Group research priority list as an effective and valuable tool for research strategies to be developed within the industry.

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A comparative multi zoo survey investigating the housing and husbandry of callimico (*Callimico goeldii)*

The callimico (*Callimico goeldii)* is a callitrichid and a species of conservation concern managed within the European Association of Zoos and Aquaria (EAZA) *ex situ* programme. They benefit from extensive 'Best Practice'

guidelines developed by the Callitrichid Taxon Advisory Group (TAG) but there are gaps in species specific knowledge and captive management research. A survey was created to understand and evaluate current housing and husbandry within EAZA collections holding callimico. The questionnaire allowed collation of details including enclosure size along with prevalence of mixed species exhibits, use of UV-B lighting, enclosure complexity and enrichment routines. Responding collections represented 44% of current callimico holders with the results allowing comparative analysis of current practice against the guidelines and in light of previous research. Significant differences were discovered between minimum recommended enclosure dimensions including that for total volume, 32m³ (P<0.001, median =100) and for height, 2.5m (P<0.001, median =3). While variation was noted, there was no significant difference in the complexity of 'on' and 'off' exhibit housing (X^2 = 2.667, *d.f.,* 12, P = 0.997). Complexity of enclosures revealed overall good practice although some disparity was noted. A variety of UV-B lighting systems was used by 59% of responding collections, with 53% of collections reporting that enrichment formed part of their daily husbandry routine. Encouragingly 97% of respondents use planting in their enclosures, and 40% of exhibits house mixed species, 57% of which included other callitrichid species. Observational research focusing on spatial use, preference and behaviour is recommended to complement husbandry guidelines. Reference of the survey findings to welfare indicators could determine the effect of current housing and husbandry on *callimico* welfare.

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Breeding success of red titi monkeys (*Callicebus cupreus*): a preliminary study

Captive breeding programmes must be managed as metapopulations, in which the collections involved must work cooperatively, scientifically and professionally, to not only control numbers, but to ensure that there is as much genetic diversity in the captive population as possible. As one of the strictly managed EEP's, the red titi monkey (*Callicebus cupreus*) is part of a thriving breeding programme, despite concerns over the lack of pedigree information known and number of infant mortalities. The main aim of this study was to determine the breeding success of red titi monkeys, focusing on the male biased sex ratio, whilst also considering reproductive factors that may influence offspring survival, by analysing the European Regional Studbook. It was hypothesised that the effects of inbreeding, the number of pairings and the dam's interbirth intervals would negatively affect offspring survival rate. Despite a weak correlation, high significance (P <0.01) was found for inbreeding coefficient and offspring days alive specifically for males, yet no significant relationship was found (P>0.05) for number of pairings, nor dam interbirth intervals (P >0.05). Despite no significance, interbirth intervals <1 year negatively affected offspring survival, thus require further investigation. Concerns over infant mortality could potentially be minimised by increasing genetic diversity via polyandry, due to the minimal effects of total number of pairings on offspring survival. As males were significantly affected by inbreeding, further exploration into interactions between the environment and genetics is suggested.

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Effect of zoo closure due to COVID-19 on the behaviour and enclosure use of Asian elephants (*Elephas maximus*)

The closure of UK zoos for extended periods due to the COVID-19 pandemic has presented a unique opportunity to investigate the impact of visitors on animals. Visitors act as a constant stimulus, with many captive born individuals never having experienced life without them. In some studies, visitors have been found to be enriching, whilst in others they have been found to have a negative impact on animal behaviour and welfare. Anecdotal reports from zoo staff during recent closures included varying responses of animals to human presence from indifference to hypervigilance, to fleeing and hiding. Recent studies using data collected during zoo closures show variable results in behaviour and enclosure use across species, with some showing significant differences and others not. This study aims to investigate the effect of visitor presence and their extended absence on a herd of Asian elephants (*Elephas maximus*) at Chester Zoo. Five elephants were observed for this study, one bull, two cows and three calves. The herd's enclosure is located by the zoo's main entrance, this central position results in the herd experiencing nearly constant visitor foot flow and presence around their enclosure. Data were collected between October and December 2020 for nine 'open' and nine 'closed' days using the ZooObserver App (developed by the Zoo Biology Research Group, Goethe University, Frankfurt). The app enables the recording of

an individual's behaviour alongside their spatial location within the exhibit. Preliminary results indicate little difference between the herd's activity budgets with visitor presence and absence, and any slight differences in behaviour is likely due to changes in husbandry routine during zoo closure. It has been proposed that larger animals may experience a lesser visitor effect than smaller species, though many other factors may impact this such as visitor densities and enclosure design. Research into the effect of visitor presence and sudden absence during the current pandemic have found that the behaviour and enclosure use of large mammal species remains relatively unchanged. In another study focusing on visitor noise, Asian elephants were found to exhibit little change in behaviour on days with visitor presence and absence. Our current research supports these previous studies in that visitor presence has relatively little impact on Asian elephant behaviour.

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Effect of zoo closure due to Covid-19 on the behaviour and enclosure use of Asiatic lions (*Panthera leo persica*)

The closure of UK zoos due to the COVID-19 pandemic has provided a unique opportunity to assess behavioural changes across different species. The absence of the visiting public is the removal of a daily stimulus that many captive-bred individuals have never lived without. Previous research has found increases in vigilance and stereotypic behaviours with increasing visitor presence in a number of species. However, research into the effects of visitors on felids have found that individuals reduce active complex behaviours during visiting hours, including a reduction in abnormal stereotypies in Asiatic lions (*Panthera leo persica*). In this project, we compare data collected during zoo closure to that collected during a normal open period, to assess whether the behaviour and enclosure use of Asiatic lions is affected by visitor presence. Three lions (one male, two females) at Chester Zoo were observed for this study. Data were collected during the zoo closure in November 2020 and after the zoo reopened December 2020. Behaviour and enclosure use were recorded using live instantaneous group scan sampling. Preliminary results suggest some behavioural changes between open and closed days across all three lions. Both females were seen to spend more time inside when the zoo was open and less time in areas close to the public. All individuals spent more time sleeping when open, in line with previous studies. Previous research has proposed that felid species are affected differently by visitor presence with Asiatic lions displaying more inactivity during zoo open days, along with reduced stereotypies. Our preliminary results reveal some changes in behaviour, which appear to be in line with previous research in terms of feline space use and how it is affected by visitor presence.

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Zoo-housed mammals do not avoid giving birth on weekends

There is evidence that zoo visitor presence can influence the behaviour and, in some cases, adrenal response of zoo animals, and can sometimes compromise animal welfare. In some laboratory studies, significantly more primate births have been reported on weekends, when fewer people are working there, compared with weekdays when staffing levels are at their highest. Here, we investigate whether there is evidence of a "weekend effect" on births in zoo animals as a result of visitor numbers. Unlike laboratories, zoos are typically busier with visitors on weekends than on weekdays, although staffing levels remain fairly consistent across days of the week. If zoo animal parturition is sensitive to human presence, then fewer births would be expected on weekends compared with weekdays. We tested this using birth data and visitor numbers on the entrance gate from zoo records across 16 species representing artiodactyls, perissodactyls, carnivores and primates at four British zoos, to see whether there is an association between mean daily birth rates and average visitor numbers. We predict that, if there is a visitor effect, daily births should be lower on weekends than weekdays and should correlate with mean daily visitor numbers. Results showed that births for all 16 species were randomly distributed through the week, and there was no significant decline in births on weekends. We conclude that the "weekend effect", if such a thing exists, does not appear to be a feature of zoo births, suggesting that elevated weekend visitor numbers are not sufficiently stressful to trigger delayed parturition.

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An analysis of the nutritional components of Linnaeus's two-toed sloth (*Choloepus didactylus*) diets in captivity

Sloths are a poorly studied folivore and there is currently a lack of species-specific research for *C. didactylus* with no studies having directly analysed their diet in the wild. Some studies have been published on the captive diet for this species, however direct comparison between collections is not common in literature. A nutritional assessment was performed on the captive diets of *C. didactylus* in eight zoological collections across the United Kingdom and Ireland. A total of nine diets were obtained and compared against one another to see if there were significant differences in the nutritional content between collections. Analysis focused on average dietary provision per sloth for the following nutrients: crude protein (CP), crude fibre (CF), ether extract (EE), nitrogen-free extract (NFE) and gross energy (GE). Zootrition™ was used to determine the nutritional content of each diet. In addition, five diets that provided browse were compared under three different criteria: (i) exclusion of browse, (ii) using 500g browse and (iii) using 800g browse, to determine what effect browse had on the nutritional content of a diet. There were variations in the amount of food provided in each diet. Statistical analyses revealed that there were significant differences between collections (CP $p < 0.001$; CF $p < 0.001$; EE $p < 0.001$; NFE $p < 0.001$; GE $p < 0.001$) and significant differences in the nutritional content of a diet when browse was added (CF $p < 0.001$; GE $p < 0.001$; NFE $p < 0.01$). Common disorders associated with sloths in captivity include malnutrition, digestive diseases, bloating and urolithiasis, with inadequate nutrition playing a potential role in the cause of these. Browse is recommended in literature for this species. However, only 55.6% of diets have provided it. It is recommended that collections incorporate browse into the diets for this species. Conclusions drawn from this research highlight the importance of nutritional research in order to improve the health and welfare of *C. didactylus* in captivity.

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Potential Applications of Personality Assessments to the Management of Nonhuman Primates: A Review of 10 Years of Study

Studies of primate personality have become increasingly common over the past three decades. Recently, studies have begun to focus on the health, welfare and conservation implications of personality, and the potential applications of incorporating quantitative personality assessments into animal management programmes. However, this literature is disparate and dispersed across a multitude of settings and scientific disciplines. We conducted a review of nonhuman primate personality studies relevant to these issues published since 2010. The databases ScienceDirect, PubMed and Web of Science were used to identify relevant articles. After eliminating irrelevant or duplicate papers, 68 studies were selected. Our review reveals that, while primate personality research is carried out on a range of species, there is strong taxonomic bias. While 28 species appeared within the reviewed literature, 51% of studies were carried out on just five species. Further, the most common research focus (43%) was validating new assessment methods or describing personality in different species, rather than exploring the links between personality and animal welfare using existing validated methods. However, among the remaining studies that did explore the role of animal personality in husbandry, health, and welfare, we identified increased progression towards integrating personality data into various aspects of animal management. Evidence suggests the assessment of personality may benefit social group management, enrichment practices, training protocols, health and welfare monitoring, and conservation planning for endangered species. We argue that further research which develops our understanding of primate personality and its influence in these areas will provide a valuable tool to inform existing animal management practices.

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Caretaker perceptions of auditory enrichment and species-specific music for captive animals

A captive animal's acoustic environment is often overlooked. Auditory enrichment (AE) improves the welfare of captive animals through sensory and cognitive stimulation, promotion of natural behaviours and reduction stereotypies yet is underused in captive environments. Caretakers' perceptions and efficacy of AE (human music and naturalistic sounds) for captive animals needs thorough reevaluation as it is often misused, which can be detrimental to welfare. Species Specific Music (SSM) is a relatively unknown type of AE that is composed based on the specie's bioacoustics and positive-valenced vocalisations, aimed to elicit certain affective states. SSM has

shown promising results yet requires further empirical evidence for a range of taxa. This study presents the findings of a survey of 118 caretakers' perceptions and experiences towards AE and SSM, covering a range of caretaker roles, establishment types and taxa from nine countries. Survey questions explored prior knowledge and experience with AE, effects, benefits and limitations to welfare, usage, frequency and taxa. SSM audio examples and questions surrounding prior knowledge, opinions and intentions to use SSM within captive collections were also presented. Caretakers with AE experience were significantly more likely to believe AE ($p=0.023$) and SSM ($p<0.001$) benefits captive animal welfare, and implement SSM into their collections ($p=0.007$). They were also significantly more likely to implement SSM if they perceive SSM benefits captive animal welfare ($p<0.017$). Further research could explore limitations on AE use whilst educating current/potential users on the importance of species-appropriate AE. Caretakers' perceptions and experience with AE are generally positive; experience, perception and knowledge of species-appropriate AE can influence caretakers' perception and incite behavioural change. Caretakers are the key holders to animal welfare so it is vital caretakers consider the species' bioacoustics to ensure AE and SSM is species-appropriate.

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Enrichment of gorillas with ensiled willow: tastes for more

It is recognized that good husbandry practice in captive gorillas includes the daily provision of leaves and twigs of bushes and trees (browse) throughout the year. Plants consumed by gorillas in the wild are particularly fibrous which implies an adaptation of their digestive system to high fibre diets. Previous studies proved that increasing the amount of dietary fibre has a positive effect on health, satiety and natural behaviour. Wintertime is however a major challenge in European zoos housing gorillas. This study examined the palatability of willow twigs (*Salix burjatica x Salix. Viminalis)* ensiled with two types of commonly used additives (1. molasse (4% of willow (DM)) + homofermentative silage inoculant (10^8 CFU/kg fresh browse); 2. nitrogen (flushing drum with 2 bar, 1.5 min). Three types of enrichment barrels (empty, 250 gram willow additive 1, 250 gram willow additive 2) were each 8 times ad randomly offered during the morning or afternoon to four gorillas housed at Zoo Antwerp. The behaviour of the gorillas was individually observed for 2.5 hours after offering the browse by means of "all occurrence sampling". Ensiled willow silage was accepted by all gorillas and they were motivated to work for this food. The time spent eating willow was equal among used additives. Also, results show that foraging time for vegetables decreased when ensiled willow was offered, which might suggest a preference for ensiled willow over their standard meal. However, the provision of this limited amount of ensiled browse was insufficient to reduce abnormal behaviour (regurgitation/reingestion, coprophagy) and stress related behaviour such as yawning and scratching. Moreover, despite the provision of one barrel per individual, it was clear that gorillas lower in rang spent less time eating the ensiled browse. More challenging ways of browse enrichment or increasing the amount of barrels or browse might be more successful in decreasing abnormal behaviour or stress. The provision of ensiled willow did significantly increase positive social behaviour among the gorillas. Yet, on days that the animals received primate pellets on top of their regular diet, this positive effect disappeared. This emphasizes the negative impact of competition for food on social behaviour. This research also revealed that, in contrast to the wild, the gorillas were more active in the afternoon compared to the mornings. The animals showed more foraging behaviour but also significantly more abnormal and stress related behaviour. A possible explanation is the provision of a broader range of vegetables in the afternoon which might have led to more competition within the group. Increasing efforts to provide browse during winter as well as investing in feeding strategies that reduce competition for food is therefore important to enhance welfare in captive gorillas.

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Survey on animal welfare and lockdown measures in Flemish zoo's

The COVID-19 lockdown measures may have affected the daily lives of zoo animals and consequently their welfare. In several Flemish zoos, employees working with or on animals, were asked how they perceived the impact of the lock-down measures on their work and their animals. 32 people of 8 different zoos responded, half of them were caretakers, half were curators, vets, researchers, or veterinary assistants. Several respondents that work with animals said they had less time to take care of the animals (n=12) compared to the period before the lockdown-measures, a minority had more time (n=2) and for most (n=13) the time to take care of the animals

remained the same. The caretaking routine had changed according to roughly half of the respondents on this question (11/24) and remained the same for the other half (13/24). Animal trainings had diminished for most respondents (n=15), had increased for a few (n=2) or had remained the same (n=6). 43% of the respondents (n=10) said there were no changes in the amount of enrichment available to the animals, 48% (n=11) said there was less enrichment because they had less time, the enriching visitors were absent or less material was available. Only one person said there was more enrichment due to the extra time gained from lower maintenance of visitor spaces. The tasks listed by the respondents at which less time was allotted due to impact of Covid-measures were cleaning, training, observation, enrichment, maintenance, and animal treatments. Of 28 respondents 54% felt more stressed at work, 46% was not more stressed than usual. The observed changes in animal behaviour in the lockdown-period were more play (3/25), less play (2/25), more sexual behaviour (3/19), more sleep (2/16), more time spent inside (1/23). We conclude that the factor with the highest risk for decreased welfare was the decreased time that could be allotted to the animal care, training and enrichment due to the restriction of personnel number. No conclusive results regarding the actual welfare could be drawn from the few reported changes in behaviour.

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Validating faecal thyroid hormones in the black rhinoceros (*Diceros bicornis*)

Management of the black rhinoceros (*Diceros bicornis*) is important both *in-* and *ex-situ* due to the species' critically endangered status. It is fundamental that individuals acquire adequate energy in their diet to fuel growth, reproduction and overall survival. Analysis of thyroid hormones can be used to assess an animal's energetic condition due to their crucial roles in energy homeostasis and distribution. We used enzyme-immunoassays to non-invasively monitor the thyroid hormones triiodothyronine (T3) and thyroxine (T4) using faecal samples (n=490) from 58 captive black rhinoceroses (22 male and 36 female) across British and European zoos to infer their energetic condition and investigate potential differences over time and between physiological states. Using these tools, we are investigating whether levels of T3 and/or T4 significantly differ between i) seasons, ii) sex, iii) age category, iv) with body condition scores, and v) throughout pregnancy. This study will contribute to the current literature regarding the endocrinology of the black rhinoceros and in the future could aid *in-situ* conservation by providing a basis for future monitoring the health and ecophysiology of wild populations in relation to their different habitats.

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Investigating the effects of sex and rearing-history on social network position in zoo-housed bonobos

Social network analysis can be a valuable tool for the management of zoo-housed animals and captive breeding programs, since an individual's social network position is typically associated with its reproductive success, longevity, and overall welfare. This is especially true for primates, due to their rich and complex social lives. While many studies have investigated individual network position in primates, most studies typically sample only one group. Therefore, the question remains as to whether such results can be generalized across different groups of the same species. Moreover, many social network studies tend to focus on model species like macaques and chimpanzees, while other species, like bonobos, remain understudied. To fill these gaps in our knowledge, we constructed social grooming networks for 14 different groups of zoo-housed bonobos, and investigated the effects of sex and rearing-history (mother reared versus atypically reared, e.g. being wild-caught or hand-reared) on individual variation in social network position. Results showed that males and females did not differ in the amount of grooming given or grooming received, nor in network centrality. However, males were more restricted in their grooming relationships than females. In addition, an effect of rearing-history was found on the centrality of an individual, with mother-reared individuals being more central, and therefore more popular, in the grooming network than atypically-reared individuals. Rearing-history also affected the amount of grooming received, but in a sex-specific matter: mother-reared males received more grooming than atypically-reared males, while this effect was absent in female bonobos. While past studies on grooming behaviour in bonobos focused strongly on sex-differences, our results show that males and females do not differ in grooming rates, and both sexes can occupy

central positions in the grooming network. However, males employ a different grooming strategy than females, since they tend to focus their grooming on a subset of group members, while females distribute their grooming more equally among group members. Our results also stress the importance of mother-rearing for the proper development of social skills. Especially in atypically-reared males, popularity in the grooming network appears to be impacted, which can be explained by the importance of maternal support and mother-son bonds in bonobos. Our study is one of the first to investigate individual variation in social network position in bonobos, and also one of the first social network studies to compile multiple groups into one large dataset, making the results more representative and reliable for bonobos as a species.

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The effect of long-term visitor deprivation on patterns of behaviour in captive Chilean flamingos *(Phoenicopterus chilensis)* and greater flamingos *(Phoenicopterus roseus)*

The influence of visitor presence within zoological enclosures is widely documented, with effects varying between species, individuals, and enclosures. Typically during visitor studies, behavioural responses to increasing levels of visitor numbers are measured. During these studies visitors are consistently present during observation. Alternatively, blocking studies observe species behaviour when visitors are present and compare these results to when visitors are prevented from entering the species enclosure (or entire zoo). However, current blocking studies have been limited to short intermittent periods of blocking where subjects are provided opportunities to re-habituate with humans between observations. COVID-19 lockdown restrictions on UK zoological institutions presented a unique opportunity to observe captive flamingo behaviour without the presence of visitors over a long and consistent period of time, followed by the reintroduction of visitors to the enclosure and wider zoo when restrictions were lifted. Photographic data were collected from Banham Zoo, Norfolk and African Alive, Suffolk from 24.06.20 to 30.06.20 during zoo closure, and from 01.07.20 to 08.07.20 during zoo reopening (excluding the date of 05.07.20). Data was collected at three time points, consistent across each day of observation. Generalized linear mixed models will be used to assess differences in activity and enclosure usage between observations during closure and reopening whilst accounting for climatic factors. We hypothesise that captive flamingos, previously habituated to humans, will exhibit behavioural alterations in response to visitors after long-term zoo closures (negative or positive effect); or that the flamingos habituation to visitors persists over the blocking period and mitigates behavioural alterations (neutral effect). Our results have important implications for ex-situ conservation programmes, such as captive-breeding for release, due to the extensive habituation to humans in these settings. Our findings also have the potential to inform flamingo husbandry guidelines during zoo closures.

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Body Condition Scoring and activity levels of Southern white rhinoceros (*Ceratotherium simum simum*)

Southern white rhinoceros (*Ceratotherium simum* ssp. *simum*) can be prone to carrying excessive weight in captivity with obesity often leading to foot and joint damage or decreased reproductive success. As a threatened species, captive breeding programmes are crucial to conservation success, and so efforts should be made wherever possible to improve reproductive health. The reason for high body condition scores within the species remain undetermined, although evidence suggests links to diet or activity level. In order to assess potential causes of weight gain in rhinos, a study held at Knowsley Safari Park assessed body condition, behaviour, social preference and enclosure use of seven white rhino. Data were collected from September to December 2020, with 2 hour biweekly observations split between the two groups for AM and PM observation sessions. Continuous observations were conducted simultaneously, in addition to instantaneous sampling of enclosure location, and frequency of social interactions. While no significant relationship ($P > 0.05$) was found between activity level and body condition, findings suggested social preferences between individuals, with relevant behaviours. Enclosure use varied most significantly with sex and age ($P < 0.05$) with behavioural analysis showing similar results. The eldest females displayed the least active behaviours and used the smallest amount of enclosure space, while males and juvenile females were significantly more active and social ($P < 0.05$). Further research using a larger study sample and over a longer timescale is planned to be able to more accurately determine relationships between behaviour and body condition, as these study subjects were found to have relatively similar condition scores.

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Developing a composite welfare assessment tool for bears (*Ursidae*) in zoos

Bears are commonly housed in zoos, are long-lived, wide-ranging carnivores, and the eight bear species each have their own species-specific and individual needs. A number of behavioural and physiological welfare indicators have been described in bears, but as yet no validated composite bear welfare assessment tool exists. This study describes the development of a composite welfare assessment for use across all eight bear species in zoos. Using indicators derived from the literature, an assessment tool was developed as well as a training guide detailing how to use the welfare assessment tool. The main aim of this study was to validate this welfare assessment tool for captive bears. A total of 30 bear keepers, to date, from zoos around the world were recruited to trial the tool with their own bears, comprising 38 individuals and seven species of bear (brown bear, American black bear, polar bear, sloth bear, Andean bear, sun bear and Giant panda). The participating keepers were asked to assess their bears three times across the space of nine days. Intraclass correlation coefficients analysis was used to assess inter- and intra-rater reliability. The inter- and intra-rater reliability showed good to excellent levels of agreement (>0.75, $p<0.05$). Item reliability has also been assessed and shows good to excellent levels of agreement (>0.75, $p<0.05$) as well. This welfare assessment tool has shown to be reliable and valid on seven of the eight bear species in zoos. Despite certain reservations within the scientific community, keeper assessments have shown high reliability in multiple zoo species and allow for the integration of data over a longer period of time. This was also the case in this study. As this was a multi-institutional study and with the impact of Covid-19, it was necessary to recruit bear keepers to assess their own bears at their own institutions. This required the use of a remote training tool which the keepers used for the assessment (a training technique which, I believe, has not been implemented before). It is hoped that, with further research, a composite welfare assessment tool can be designed which can be utilised by keepers to monitor the welfare of all eight species of bear in the long-term.

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Investigating the time-budget study of an Arctic fox (*Vulpes lagopus*) housed within a zoological collection

As an understudied zoological *Canidae* species, it is important to understand the behavioural repertoire and species-specific responses of the Arctic fox (*Vulpes lagopus*) and how these may change under different environmental factors when habituating to a new enclosure. This study therefore aimed to create an activity budget and to determine enclosure usage for a single 10-month-old Arctic fox housed at Wild Discovery, Preston, UK. Using trail cameras to prevent observer disturbance, daily enclosure use, behaviour and environmental factors including; weather, wind speed, humidity and moon phase, were recorded over a one-week period for 7 individual 14 hour observation sessions. Instantaneous scan sampling with five-minute intervals were used to observe behaviour for each study period covering diurnal (11:00-17:00) and nocturnal (23:00-06:00) periods. Observed behaviour differed between diurnal and nocturnal periods despite 'locomotion' being performed most frequently across both periods. Higher frequencies of 'out of sight' (P 0.001) and 'sleeping' (P 0.026) were recorded during nocturnal periods and of 'alert' (P 0.025), 'foraging' (P >0.05), 'self-groom' (P 0.001) during diurnal periods. Despite enclosure habituation, study day did not affect behaviour (P >0.05). No environmental factor significantly affected behaviour (P >0.05). Enclosure location differed per study day despite behaviours observed in all areas with a significant preference (P 0.001) to the centre of the enclosure close to the out of sight housing unit. Differences observed in behaviour and location suggest that species-specific behaviours can be observed for captive Arctic fox proposing a suitable time-budget for individual comparisons, important for managing small understudied *Canidae*.

Day 2 Invited Speaker 1

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The Species360 Conservation Science Alliance: Research and future directions

For over two centuries, zoos and aquaria around the world have managed populations of a large number of animal species under human care. This long history of management has culminated an unprecedented amount of knowledge on the demography, behavior and physiology of a vast number of species. This wealth of information comes into stark contrast with the glaring gaps of knowledge for populations in their natural habitat. Thus, this untapped source of knowledge from zoo and aquaria provides a unique opportunity not only to improve the management of individuals under human care, but to contribute to the conservation of species in their natural habitat. At the Species360 Conservation Science Alliance we have launched an exciting research and support program, where we explore the possibilities of using zoo and aquaria data from the Species360 Zoological Information Management System (ZIMS) both, to support in-situ conservation, and to provide tools and analytics to our member institutions. Here we will show results from different studies that combine data from ZIMS with data from wild populations, as well as studies that explore improvements in welfare of animals under human care. Furthermore, we will show novel analytics tools that will be available as web-based reports for all our member institutions.

Day 2 Speed Talks

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Influences of rearing environment on behaviour and welfare of captive Chilean flamingos: A case study on foster-reared and parent-reared birds

Behaviour signals the internal states that relate to an individual's welfare and its development is influenced by the early social environment that an animal experiences. Husbandry practices can alter this early social environment, for example different rearing conditions (e.g., foster rearing by a surrogate parent of another species). Widespread implementation of altered rearing can lack empirical support and non-parent-reared animals may experience poorer welfare resulting from maternal deprivation. An opportunity presented itself to measure the effect of foster-rearing on Chilean flamingo behaviour and social preferences at WWT Slimbridge Wetland Centre and compare findings to parent-reared conspecifics in the same time period. Data were collected from April to July 2019 at three timepoints during each observation day. Binomial generalized linear mixed models were used to assess the relationship between focal chicks' rearing background with behaviour, zone usage, and flock position whilst accounting for climatic factors and visitor numbers. The development of social preferences was assessed using social network analysis. Our results showed limited impacts on flamingo behavioural development due to foster rearing. Foster-reared chicks spent less time feeding, were more likely to occupy the nesting area of the enclosure and had fewer significant preferred associations than parent-reared chicks, but preferred social bonds were as equally strong and durable for both foster-reared and parent-reared chicks. Our results have important welfare implications for the use of foster-rearing in captive environments; altered early social rearing environments through cross-fostering in Chilean flamingos is associated with limited differences in behavioural and social development.

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Longitudinal correlates of self-directed behaviours in a zoo-housed troop of hamadryas baboons (*Papio hamadryas*)

Self-directed behaviours (SBDs) are known welfare indicators in primates, linked to social anxiety. The aim of our study was to describe the impact of extrinsic and intrinsic variables on the performance of SBDs in a zoo-housed

troop of Hamadryas baboons (*Papio hamadryas)*, by analysing data from a decade-long behavioural monitoring project. We found significant inter-individual variance in SDB rates and that males performed higher rates of SDBs than females, perhaps due to differing social stressors. Both sexes performed higher rates of SDBs in autumn compared to summer and winter months, reflecting a slight autumnal peak in breeding. Positive correlations were found between SDB rates and adult population size as well as male-to-female ratio, which may be explained by higher levels of social anxiety due to reproductive competition. Negative correlations were found between SDB rates and age, as well as time spent feeding, locomoting, and grooming. In addition, lactating females performed lower SDB rates compared to females in other reproductive states. These findings may be due to time conflicts in performing SDBs, with animals more engaged in maintenance behaviours. Our results highlight the ability of longitudinal paradigms to identify psychosocial stressors in the zoo environment and to inform management decisions.

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Keeper-generated data and zoo animal welfare

There has been much progress in zoo animal welfare assessment, but one of the major remaining barriers is the feasibility of collecting valid welfare data on a regular basis. External scientists generally devise their own measures which may not be sustainable after the project ends. However, recent efforts have involved zoo keepers collecting scientific welfare data using feasible methods that fit into their daily routine. Here, several such projects are reviewed, including those that employed: 1) Likert-scale animal-based data, 2) multi-disciplinary husbandry data, and 3) behavioural observations. These keeper-led approaches lead to better monitoring of animal health, training session motivation, and enrichment engagement, and as a result evidence-based welfare improvements were able to be made.

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The impact of female contraception for population management on behaviour and social interactions in a captive troop of Guinea Bbboons *Papio papio*

Modern husbandry of captive animals often leads to populations outgrowing their enclosure space, resulting in welfare issues. To manage its Guinea baboon *(Papio papio*) population, Yorkshire Wildlife Park decided to use Suprelorin contraceptive implants in the adult females. Although Suprelorin has a high efficacy (>99%), data on the impacts on behaviour in baboons are lacking; furthermore, little is known about the reproductive behaviours of Guinea baboons. Research on other contraceptive implants in related Hamadryas baboons *(Papio hamadryas)* showed no detecetable increase in self-directed behaviours (SD), of which high levels are associated with stress so are indicative of weldare. Additionally, frequency of social behaviours, including affiliative (AF) and agonistic (AG) interactions, are impacted by oestrus, and would thus be expected to be change in frequency. This provided a unique opportunity to study the impact of Suprelorin on social behaviour and welfare in adult Guinea baboons using focal and whole-group scanning sampling before (Sep 2019) and after (Sep 2020) implantation to determine behavioural impacts of this contraceptive. Data were analysed using Generalised Linear Mixed Models in R, with sex and year as fixed factors and individual as a random factor, and controlled for multiple testing with Q-values. There was a significant reduction of SD behavioural bouts in both sexes after the contraception, with males having significantly higher rates compared to females in both treatments. Additionally, the rate of behavioural state change per hour and duration of sentry behaviour were significantly lower post-contraception, further suggesting improvements in welfare due to signs of reduced restlessness. Although there were also no significant decreases in the duration of positive social interactions, such as allogrooming and play, overall AF bouts decreased in the year post-contraception. Furthermore, the bouts of AG behaviours also decreased, suggesting that social interactions were less-common in the troop after the females were implanted. Finally, the ability of the public to view the social behaviours of the troop had no effect on the frequency of AF and AG behaviours in either year. This is the first study to look at the impact of contraceptive on social behaviour and welfare of Guinea baboons. Suprelorin had no detrimental impact on the behaviour of adults in the troop, and no negative impact on welfare. The research confirmes the importance of female fertility in influencing social behaviour, supportive of previous studies in other social primates. Results indicate that Yorkshire Wildlife Park have improved the welfare of their Guinea baboons due to reduced SD behaviours and restlessness, with no influence of public presence on social interactions. This research could be used to support Suprelorin as an effective, reversible population management technique for species living in similar social systems.

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Monitoring faecal glucocorticoids in pregnant and non-pregnant equids

Measuring glucocorticoid concentrations in the blood is one of the most widely used methods of measuring adrenal physiology, however it can be limiting when working with endangered species both *in-situ* and *ex-situ*. Developing methods that can be used non-invasively allow for increased knowledge of health, reproduction and wellbeing for a variety of species, which leads to informed decision making for optimal management. Before these techniques can be applied, it is important to understand how concentrations differ between normal physiological states. The aim of this study was to measure faecal glucocorticoid metabolites (fGCM) in three endangered equid species: Persian onager *(Equus hemionus onager)*, Przewalski's horse *(Equus ferus przewalskii)* and Grevy's zebra *(Equus grevyi)*, along with the more thoroughly studied domestic horse *(Equus ferus caballus)* for comparison. fGCM were quantified during pregnancy and non-pregnancy using an enzyme immunoassay, to investigate any differences between physiological states (pregnant v non-pregnant, trimester 1, 2 and 3 of pregnancy and follicular vs. luteal phase of the oestrous cycle). We hypothesised that fGCM would differ between stages of the oestrus cycle and an overall increase in fGCM would be observed in pregnant compared to non-pregnant samples, particularly during the third trimester. Faecal samples (N=1624) from a total of 26 individuals (Persian onager, N=6; Przewalski's horse, N=3; Grevy's zebra, N=3; and domestic horse, N=14) across a total of 22 pregnancies and corresponding non-pregnant periods are currently being analysed. Although glucocorticoids are typically considered from a welfare perspective in relation to potential stressors, these data will increase our understanding of glucocorticoid concentrations during normal reproductive events. Together this information will inform management within captive breeding programmes and can provide important background on normal physiology for future *in situ* studies on these species.

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Lateralised production of self-directed behaviours in bonobos (*Pan paniscus*) during a touchscreen task

While cognitive research using touchscreen technology is rising in zoos and can be mentally enriching for the participating individuals, assessments remain important to understand possible effects on the animal's welfare. Self-directed behaviours (SDBs) are often used as indicators of emotional arousal in primates. Previous studies report that the production of SDBs can be lateralised; suggesting a reflection in the laterality of the hemispheric brain and emotional processing. We assessed individual handedness in four bonobos via a standardised tube task and while working on a touchscreen task. We then recorded the asymmetric production of SDBs and analysed when and how SDBs were performed when presented social and object images with different valent-loadings. Two bonobos showed a right-hand bias while working on the touchscreen, while the other two bonobos showed a left-hand bias. These findings did not match with handedness measures of the same individuals during the tube task. Right- and left-handed individuals did not differ in their performance on the touchscreen, nor did they differ in their production of SDBs. However, the individuals differed in terms of how likely they were to perform a SDB. Most SDBs were directed towards the face (91.7%) and to a lesser degree to the body (8.3%). SDBs were more produced with the left hand and the bonobos were more likely to perform SDBs in trials where they made incorrect responses. Furthermore, rates of SDBs did not differ between negative, neutral or positive objects, but did so between social images. Namely, rates were higher in trials with neutral and negative social images compared to positive ones and control trials. Even though the bonobos in this study participated voluntarily in touchscreen sessions, it remains important to examine how such sessions impact the welfare of the animals. While rates of SDBs were generally low, we found individual differences in their production. This is important to take into account to optimise training and testing sessions for each individual participant. We also saw that SDBs increased when the bonobos made incorrect responses, and that they were more likely performed with the left hand, suggesting that they experienced some form of emotional arousal. We furthermore found that stimulus content during trials affected the bonobos' production of SDBs, which increased in trials with negative and neutral social stimuli. Examining the lateralised production of SDBs in response to emotional stimuli may therefore help us to better

understand emotional recognition and processing. This can inform the design and implementation of cognitive research with bonobos.

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Exploring public perceptions of animal experiences in BIAZA zoos

This talk will present a brief overview of my PhD research; looking at how BIAZA zoo 'Meet & Greet' (M&G) animal experiences are advertised to potential participants, and to explore people's perceptions of the experience, the animal and the zoo.

BIAZA zoos must ensure that the experiences they offer are supporting their conservation education mission and not undermining it, but we currently do not know how these opportunities are interpreted by the people exposed to them. M&Gs have the potential to encourage support for conservation or to reinforce an image that zoos are exploiting animals for profit. To be successful, M&Gs must be entertaining without encouraging the idea that zoos prioritise entertainment over animal welfare, that the animals are photo props or make good pets, and M&Gs must not decrease concern for conservation. The aim of my PhD is to provide BIAZA zoos with information that can be used to develop M&G experiences and ensure these are advertised in a responsible way that does not send the wrong message to the general public.

Day 2 Posters

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Engaging audiences with your science via online events

Online engagement can seem daunting and there are challenges, but there are also benefits. It allows you to reach audiences that would be unable to attend in-person events, it gives you access to speakers and contributors from across the world, and it gives you material to easily create an online legacy, producing a valuable resource for future audiences. Over the past 9 months, ZSL has trialled using a range of online tools to engage with public audiences and communicate our scientific work. This poster will describe the methods used and what we have achieved, in terms of reach, staff and audience engagement, and the creation of an online legacy.

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Quantifying predictors for online engagement when society 'stays at home': how did zoos connect with people during the UK COVID-19 lockdown?

The COVID-19 pandemic and the associated lockdowns in the UK have tested the nation and the economy. British zoos have struggled during this period and many collections responded by increasing their online presence on social media with features such as keeper Q&A's, virtual zoo tours or home-schooling education resources. In this study, I aim to assess the relative success of different forms of social media engagement techniques employed during the phases of the pandemic-associated lockdowns and identify the predictors of highest levels of engagement. I will evaluate the Facebook content from a geographically-representative sample of 30 of the most mammal-rich UK zoological collections through the COVID-19 pandemic and provide insight into whether/how gzoos altered their Facebook output in response to lockdown restrictions. Specifically, the study will focus upon species bias (largely within mammals), post media type (text only/still image/video) & post content type (marketing/education/zoo action) as predictors of community engagement. This study will provide focused insight and reflections for the zoological community in relation to their social media engagement strategies and will join the wider social media literature to act as industry guidance for conservation organisations to maximise online engagement in a post-pandemic society.

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Increasing the effectiveness of community science in zoo research

Community or citizen science is an expanding area of research, generating large data sets, through a collaborative approach to data collection between scientists and members of the general public. This growing field of science can engage with the public on several levels from sensing the environment, and analysing data to collaborative creation of scientific tools. Community science projects could also be a way for zoos to meet specific educational standards. This study aims to identify the current extent of community science and to consider how zoos and aquaria can more effectively engage and encourage collaborative science participation. Initial research through online search engines (Google) and scientific search engines (Web of Science and Google Scholar) using the terms "citizen science" AND "zoo" OR "aquaria*"in July 2020 found 19 offsite and eight onsite zoo or aquarium partnered citizen science projects. There are 13 sensory projects, ten analysis projects and four self-reporting projects. Few collections use community science for behavioural recording within the zoo and despite some collections having the functionality to do so via webcams, no collections, as far as we could see, have recorded this data via community science. No projects that involve the general public in collaborative creation were found. Community science projects have the potential to reach a large audience with, for example, the Royal Society for the Protection of Birds (RSPB)'s garden birdwatch regularly having over half a million members of the public taking part. Virtual and digitalized community science projects offer an opportunity to engage wider participation and generate greater data with, often, reduced individual participant involvement, thereby potentially engaging a greater number of people.

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Virtual learning literature review: Zoo-based education in a post Covid-19 world

The aim of this study was to produce a literature review exploring and evaluating the methods and effectiveness of virtual learning, with a particular focus on how these methods can be utilised to deliver conservation education in a post Covid-19 World. The review compares and contrast various methods to decipher best practice when it comes to virtual learning. These methods are also evaluated against current conservation education teaching techniques with an emphasis on zoo-based education, therefore the most suitable recommendations for virtual learning in a zoo setting could be made. A systematic review protocol was established with 4 designated search engines used: NTU Library OneSearch/ Google Scholar/ Web of Science/ IZE JOURNAL, furthermore, key phrases were used to select the papers such as 'Virtual Learning' 'E-Learning' 'Virtual Learning Environments' 'Conservation Education'. These phrases allowed to search for relevant literature, however, to narrow the search a criterion was created, to indicate the specific aims of the papers to determine their relevance in regard to virtual learning and possible implications in conservation education. Once this process had been completed 35 relevant pieces of literature were evaluated and analysed. A common theme found across the literature was synchronous learning. This is where educator and learner are both present in real time, for example, virtual classrooms, video conference, live chats and live webcasting. The second method commonly found was asynchronous learning. This educational technique is 'time-independent' meaning activities are there to be utilised at any time. These include, computer-based training (CBT), web-based training (WBT), mobile training, social learning, game-based learning and simulation. These two methods (synchronous and asynchronous) were often compared and contrasted, highlighting the costs and benefits of the techniques and how they improve on the overall learning experience. One of the key areas of disparity was that of learner age. Younger, school age, students found most benefit from synchronous approaches, whereas older, university age students preferred an asynchronous approach. Whereas comparisons from this literature can be made to zoo-based conservation education, there is currently a dearth of studies that look specifically at virtual learning in zoos. A first-order priority, then, is for studies that directly measure the impacts of these virtual approaches, as applied to zoo conservation education. The likelihood is that virtual learning approaches will continue in the short to medium term. This makes this a priority area for zoo research.

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An investigation into zoo professionals' opinions of population management euthanasia in BIAZA member zoos

Population management euthanasia, the humane euthanasia of healthy animals for population management purposes, is one method which has been proposed to support zoo animal population management. In this study, BIAZA zoo professionals were surveyed to investigate their opinions and attitudes to population management euthanasia, in comparison with other population management techniques. The surveyed population included keepers, researchers, curators, and directors. This is an ongoing research project; thus far results have indicated opinions vary along a spectrum within professionals however some factors were seen to impact the acceptability of population management euthanasia including taxonomic group. The findings from this research aid to inform future discussions within the subject of population management of zoo animals.

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Role and purpose of direct human-animal interactions in the crested porcupine (*Hystrix africaeaustralis*) and guinea pig (*Cavia porcellus*) in educational establishments in the United Kingdom

Engagement with non-human animals is becoming a fast-growing field within animal studies, allowing for research collaboration between the animal science and comparative psychology and social science sectors. Human-animal interactions are increasing in accessibility in a range of educational, zoological and social care environments. Many ethical issues have arisen worldwide with animal interactions, with poor welfare considerations being a key focal point. One of the key focuses in this study was ensuring the welfare of the animal was maintained throughout its entirety, with emphasis on ensuring high welfare and husbandry standards being maintained and abided by before, during and after all interactions. The studies aim was to identify the benefit and role of non-human animal interactions for the animal, human and educational establishment. Both quantitative and qualitative participant questionnaires were utilised; with behavioural data collected during each 15-minute interaction using a bespoke ethogram. Data were analysed through perceptions listed and documented following completion of the questionnaires, and any change in perception following the interaction. Number of selfies and photos taken was recorded and analysed, alongside questions and perceived knowledge on the animal's conservation status gained from the interaction. The results highlighted that there was a significant difference (p=.000337) between the number of photos taken during the interaction with the African crested porcupine (N=523) and number of photos taken with the guinea pig (N=101). However, there was no significant difference (p=.346594) highlighted in the number of selfies taken during the interactions. The results also showed significant difference (p=.23423) highlighted in the number of alert behaviours exhibited by the porcupine (N=130) and guinea pig (N=64). In total 37 participants took part over a period of 10 days. Many of the participants felt 'scared' around the porcupine due to the quills present on the animal, and therefore behaviours exhibited during the study such as 'standing back' as opposed to the original questionnaire completion in which many participants. This was highlighted within the questionnaires as the top answer from participants of 'What are you looking to gain from this interaction?' was that many participants felt they wanted experiences and 'to be close' to 'exotic' animals, as opposed to the domestic animal. Whilst participants were most excited from conversation prior and during the interactions to partake in direct touching of the porcupine, when the participants were faced with the porcupine, many were anxious and this reduction in confidence was shown in the behaviours exhibited by both the human and non-human animal participants. However, although anxiety behaviours were demonstrated interactions with the animals lasted similar times with an average of 9.28 minutes with the porcupine and 9.89 minutes with the guinea pig.

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Using scent-marks to create a novel enrichment for ruffed lemurs

Many of the world's primate species are declining and face ongoing threats in the wild. However, captive populations, potentially serving as buffers against extinction, are experiencing problems that keep them from being viable for reintroduction into the wild. Particularly, managing zoo populations can be challenging because of the mismatch between natural and captive environments. Primates evolved distinct behavioural patterns, and difficulty in engaging in these behaviours can cause frustration or boredom, which, in turn, can lead to stress and development of abnormal behaviours that undermine their individual welfare as well as their breeding success. Modern zoos employ a variety of enrichment techniques to improve both psychological and physiological wellbeing of captive animals by providing a stimulating environment. There are currently a number of studies on using enrichment as a tool to increase welfare in captive primates, but these usually focus on feeding and cognitive puzzles, with less emphasis placed on sensory stimulation, as well as a bias towards charismatic species. Olfactory enrichment programmes are still understudied in primates. Furthermore, the effects of enrichment and welfare on breeding programmes have received little attention. This project aims to investigate the effects of a novel scent enrichment programme on the critically endangered red-ruffed lemur (*Varecia rubra*). Preliminary observations of a breeding pair have been conducted to understand the species' olfactory behaviours. The male were shown to scent-mark significantly more than the female, and a preference for location for each sex was observed. Scent-marks were collected from the female in both breeding and non-breeding season and analysed via gas-chromatography-mass-spectrometry. The scents have been compared and a difference shown in the chemical profiles between the seasons. Compounds that are determined to be key in advertising fertility will be used as the basis for a novel enrichment. The enrichment will be presented to ruffed lemur species to assess its potential effects on both welfare and breeding behaviours.

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Social play in pygmy slow loris: a comparison between adult-adult play and juvenile-adult play

Sociality of slow loris are not well understood and the ability to study them is limited by their nocturnal lifestyle in the wild, and their relatively small representation in zoos. When housed ex situ, they are often in diurnal exhibits or housed individually, making social behaviour studies difficult. Behavioural data was collected at Bristol Zoo Gardens' nocturnal house over two years between 2019-2020 to investigate social play in two groups of pygmy slow loris to: describe social play behaviours and play signals; calculate the duration and frequency of social play; and to compare social play between adults and adult/juveniles. The effect of female oestrus and environmental conditions including temperature, humidity, lux, and time of year on social play are also analysed and the role of ex situ facilities and social housing management are discussed to better facilitate affiliative behaviours of pygmy slow loris including social play.

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24/7 behaviour and welfare of giraffes

Giraffes are known for their remarkable sleeping patterns. While this has received ample scientific attention, and interesting differences in nocturnal behaviour between giraffe subspecies have been recently recorded, results of these studies are not always related to animal welfare. Especially now that 24/7 welfare concepts are being applied to zoos, a better understanding of sleep and nocturnal behaviour in zoo-housed giraffes can be of special interest to assess welfare in giraffes. Here we monitored the behaviour of a herd of five Kordofan giraffes *(Giraffa camelopardalis antiquorum)* at Zoo Planckendael (Belgium) during 10 days, collecting on each day four hours of observation between 0800h and 1600h (daytime), and 8 hours of observation between 1600h and 0800h (night-time). The first author used a detailed ethogram in ZooMonitor to score daytime behaviour based on live observations, while night time behaviour was scored from video recordings that were made in the stables of the giraffes. We found that the Kordofan giraffes spent on average 1.3% of the night time observations in paradoxical sleep (also known as REM sleep). They also spent 15% of the night lying down without other activity, but distinguishing between recumbent sleep and resting was difficult based on the video footage. A further 20% was

spent lying down and ruminating. During the daytime, ruminating while lying down was barely observed (0.6%), but giraffes spent more time standing in rumination during the day (19%) compared to the night (5%). While overall time spent ruminating was similar between night and day, in this herd, rumination while lying down was almost exclusively shown at night, when the animals had access to their indoor stable. Interestingly the only time they ruminated during daytime while lying down, was when the giraffes were being kept indoors because of bad weather. The giraffes spent slightly less time feeding during the night (23%) compared to the daytime (29%). Oral stereotypies (licking, tongue-rolling) and locomotor stereotypies (pacing, neck-swaying) were all reduced at night-time compared to day time. Compared to previous published studies on Rothschild and reticulated giraffes, the Kordofan giraffes have very similar percentages for time spent feeding and paradoxical sleep. Rumination was not reported in previous studies, but our results suggest potentially important qualitative differences in rumination between night-time and daytime. In other ruminants, it has been suggested that rumination while lying down is a good indicator for positive welfare. Therefore we suggest this behaviour deserves more attention in future studies of giraffe welfare in zoos.

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Monitoring the welfare of giraffes in two Belgian zoos

Giraffes *(Giraffa camelopardalis)* are a popular species held in many zoos. Welfare concerns have been expressed, and often are focussed on measuring indicators of (potential) negative welfare such as locomotory and oral stereotypies. Here we present additional data on potential positive welfare indicators, as have been suggested for ruminants, focusing on feeding time, rumination, affiliative behaviour and self-grooming. We also monitored oral stereotypies (tongue rolling and licking), locomotor stereotypies (neck swaying and pacing) and interspecific aggression. The first author observed giraffes in two Belgian zoos. Zoo A housed three giraffes of mixed subspecies and four Hartmann's mountain zebras *(Equus zebra hartmannae)* together. Zoo B housed five Kordofan giraffes *(G. c. antiquorum)* together with four addax *(Addax nasomaculatus)*, four Mohr gazelle *(Nanger dama mhorr)* and 49 guinea fowl *(Numida meleagris)*. Each individual was observed during 10 days for a total of 40 hours, using ZooMonitor. Behavioural data showed that in both zoos, feeding made up about 35% of the activity budget during daytime, but in Zoo the A giraffes spent less time interacting with feeding enrichment, and more time in "feeding with mouth". The giraffes in Zoo A spent 10% less time on rumination (7% of observation time) compared to those in Zoo B (17%). Affiliative behaviour and self-grooming occurred more in Zoo B compared to Zoo A. Time spent in stereotypical behaviour accounted for 8% of the time in Zoo A, and 5% of the time Zoo B, but differed in kind. Tongue rolling was more prevalent in Zoo A, whilst neck swaying occurred more in Zoo B. Interspecific aggression occurred in both zoos but was more common by the mountain zebras in Zoo A. Preliminary analyses of these data suggest that free access to the indoor enclosure in Zoo A may have reduced locomotory stereotypical behaviour, while in B a different feeding strategy likely resulted in less oral stereotypic behaviour and improved gastrointestinal health, as indicated by higher rates of rumination. Compared with Zoo A, Zoo B focussed more on multiple forms of feeding enrichment, used only slow feeders to provide roughage, and provided substantially more browse during winter. These results will be used in a follow up study where we will optimise dietary management in both zoos, and evaluate its impact on the positive and negative welfare indicators collected in this pilot study.

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Social behaviour in a group of Colombian spider monkeys

In the wild, Colombian spider monkeys *(Ateles fusciceps robustus)* live in large, male philopatric groups with complex fission-fusion dynamics. In zoos, management of the species can be difficult and especially male-male aggression has been identified as problematic, leading zoos to exchange males rather than females between groups. Here we present data from a small group of Colombian spider monkeys housed at Antwerp Zoo, Belgium, consisting of one adult male, two unrelated adult females, and their four male, and two female offspring (1 to 6 years old). Keepers had reported tensions between the males and had asked for a behavioural study. We used Zoomonitor to score behaviour by focal animal sampling, collecting around 810 mins of focal animal sampling per individual, totalling 122 observation hours across 25 observation days. We determine activity budgets and use sociograms to further describe social interactions between group members. Our results show that, the group

spends 42% of its time resting, 25% foraging and 19% in locomotion activities. The remaining 13% was used for social behaviour, including grooming, play, embracing and aggression; self-directed behaviour (scratching) and interactions with the environment. Males in this group played more than females, while females spent more time grooming and embracing. Grooming occurred mainly between the oldest female and the adult male, as well as her infant son. Grooming among the other adults was rare. Aggression mainly involved the 4 and 5 year old sons, as well as the 6 year old daughter, and the adult male. Embraces, which are more important than grooming for regulating social relationships in spider monkeys, occurred most frequently between the oldest adult male offspring and his father and mother, as well as between the mother and father. Overall, aggression was low and "embraces" were probably used to reduce tension between the adult male and his oldest son. While the effects of the number of enclosures and enrichment items could not be experimentally manipulated, there is evidence that conflicts between the oldest male and his sons occurred mainly when there was no access to multiple enclosures, or when single, easy-to-monopolise enrichment items were provided. Tension between the young males and the adolescent female could probably be resolved by transferring the female rather than the young males as was suggested by the keepers, so that a more natural group dynamic of related males and emigrating females can arise.

Day 2 Invited Speaker 2

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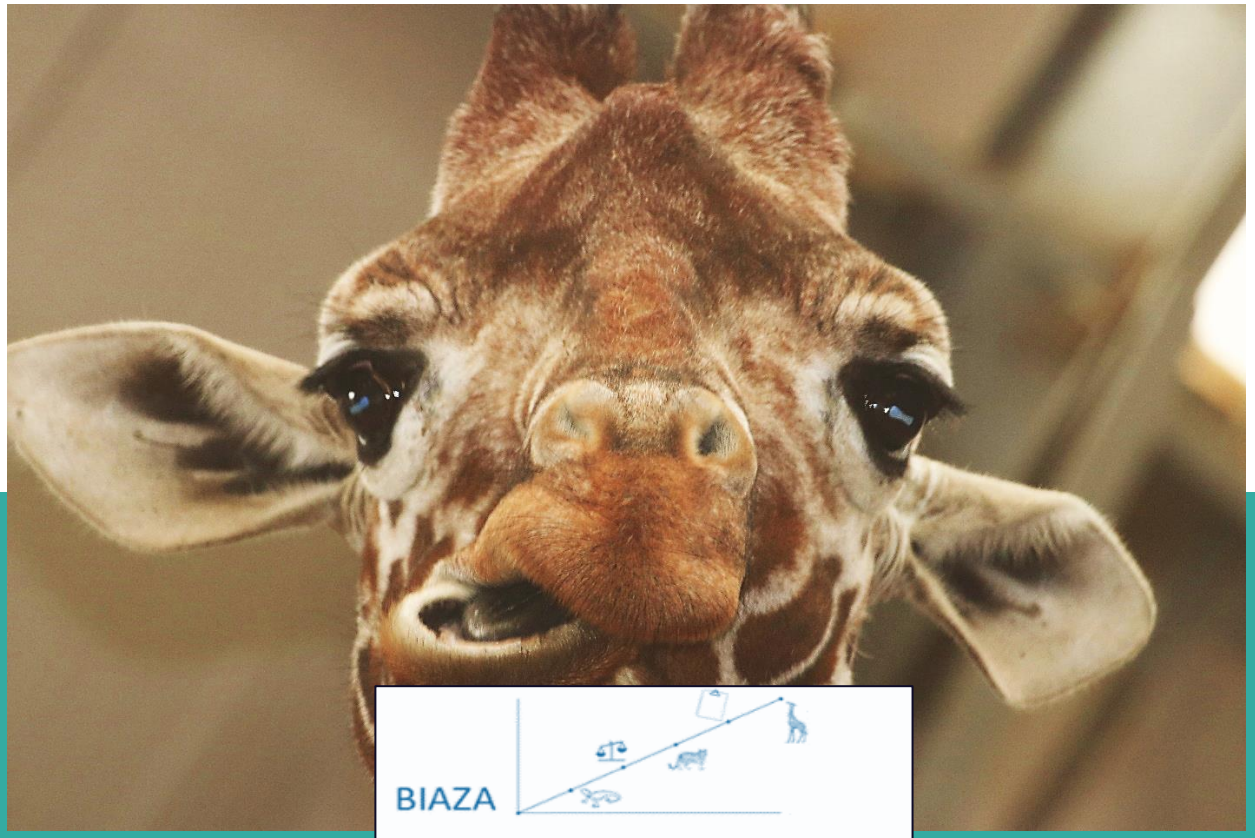
BioRescue – New conservation strategy to save critically endangered species

The last two Northern White Rhinos left are both females - Najin & Fatu. To save these charismatic animals from extinction seems impossible under these circumstances. The international BioRescue project funded by the German Federal Ministry of Education and Research aims to make the seemingly impossible a reality and is developing methods of assisted reproduction and stem cell research under the leadership of the Leibniz Institute for Zoo and Wildlife Research (Leibniz-IZW). In light of the Earth's sixth great extinction event driven by man traditional conservation strategies such as habitat protection and ex-situ breeding combined with reintroduction programs will be not sufficient to stop or even to slow down this process significantly. Currently, 22% of the mammals are at risk of extinction. The family Rhinocerotidae is particularly affected, with three of the five extant species listed as critically endangered (Sumatran, Javan, and black rhinoceros), one listed as vulnerable (greater one-horned rhinoceros), and only one, the southern white rhinoceros (SWR, *Ceratherium simum simum*), listed as near threatened. Contrarily, in 2008 the IUCN officially declared the northern counterpart of the SWR, the northern white rhinoceros (NWR, *Ceratotherium simum cottoni,* 1908) as extinct in the wild. On March, 19th, 2018 the death of the last male NWR, Sudan, brought wide public attention to the doomed fate of this subspecies and served as a clarion call for alternative measures of conservation. The long-term consequences of the loss of a keystone species for the fragile ecosystem of Central Africa are not fully predictable. However, the eradication of a megavertebrate and important landscape architect such as the NWR will cause at least a significant disturbance or even destruction to elements of the complex ecosystem. The loss of a keystone species can initiate a so called "vortex effect". The term was coined by Bob Lacey (1993) and used to name his famous Vortex Population Viability Analysis software, distributed freely by the IUCN. The vortex effect stands for the accelerated loss of species and entire species societies whose life history directly or indirectly depends on keystone species which are on the brink of extinction. In 2015 a group of 20 international scientists from five continents met in Vienna to develop a new strategic roadmap (Saragusty et al., 2016) for saving the critically endangered NWR. At that time only three

individuals (1 male, 2 females) of this subspecies were alive. The new approach combines advanced assisted reproductive technologies (ART) and stem cell associated techniques (SCAT). This combined third strategy, in addition to the two established main strategies of habitat protection and classical ex-situ conservation programs, allows for the employment of biomaterial of live and deceased individuals in form of cryopreserved gametes as well as of skin samples for fibroblast cultures. Fibroblast cultures via induced pluripotent stem cell transformation can subsequently be used for the in vitro production of artificial gametes. This third way of species protection is now being developed in the international "BioRescue" project and put into practice immediately.
The project focus on the development of suitable technologies and protocols to rescue the NWR and to provide the opportunity to establish a self-sustaining, genetically healthy NWR population which can be reintroduced to the wild. In addition to the two approaches to embryo production, an ethical risk analysis as of the integrated research approach is part of the project, too. If innovative research shifts the boundaries of what is possible in species protection, new risks that have not yet been adequately evaluated will emerge on the one hand, and ethical questions on the other, which will bring together the well-being of individuals, the prosperity of an entire subspecies and complex social-ecological questions. These new risks and ethical questions are systematically analysed and discussed in the "BioRescue" project, also involving relevant stakeholders and the interested public in the discourse.

Please join us for a panel discussion on Zoom
“Moving on from Covid- what research are zoos looking for? In need of?”



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