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Alemayehu, N. and W. Tekalign (2020). "Prevalence of crop damage and crop-raiding animals in southern Ethiopia: the resolution of the conflict with the farmers." Geojournal.
> The conflict between humans and wildlife often arises from crop raiding and has a significant impact on both subsistence humans' livelihoods and long-term wildlife survival in developing countries. The study aimed to identify crop-raiding wild animals, the prevalence of crop damage, and the conflict resolution mechanism. Data were collected by questionnaire, interview, and direct field observation to estimate the extent of the crop loss and species of an animal involved in crop-raiding. The findings identified Anubis Baboon (Papio anubis), Vervet Monkey (Chlorocebus pygerythrus), and Grivet Monkey (Chlorocebus aethiops) as the major crop pests, followed by Porcupines (Hystrix cristata), Birds and Mongoose (Helogale hirtula). Foraging typically Maize (Zea may) followed by Teff (Eragrostis tef), Enset (Ensete ventricosum), and Barley (Hordeum vulgare). Deforestation, illegal agricultural activities, and farmland distance to the forest were identified as causes of the conflict. In addition, scarecrow, chasing, and permanent guardians have been identified as traditional crop damage prevention techniques of the local people of the area. Therefore, to alleviate the existing impact of crop damage or loss by crop-pest or crop-raiding animals in the area adopting various most suitable approaches along with the awareness and involvement of local farmers would be a critical step.

Allen, C. R. B., et al. (2020). "Importance of old bulls: leaders and followers in collective movements of all-male groups in African savannah elephants (Loxodonta africana)." Sci Rep **10**(1): 13996.
> In long-lived social species, older individuals can provide fitness benefits to their groupmates through the imparting of ecological knowledge. Research in this area has largely focused on females in matrilineal societies where, for example, older female African savannah elephants (Loxodonta africana) are most effective at making decisions crucial to herd survival, and old post-reproductive female resident killer whales (Orcinus orca) lead collective movements in hunting grounds. In contrast, little is known about the role of older males as leaders in long-lived social species. By analysing leadership patterns of all-male African savannah elephant traveling groups along elephant pathways in Makgadikgadi Pans National Park, Botswana, we found that the oldest males were more likely to lead collective movements. Our results challenge the assumption that older male elephants are redundant in the population and raise concerns over the biased removal of old bulls that currently occurs in both legal trophy hunting and illegal poaching. Selective harvesting of older males could have detrimental effects on the wider elephant society through loss of leaders crucial to younger male navigation in unknown, risky environments.

Arita-Merino, N., et al. (2020). "Varying Levels of Medium-Chain Fatty Acids Affect Triacylglycerol Composition and Crystallization Behavior of African Elephant Milk Fat." European Journal of Lipid Science and Technology **122**(10).
> African elephant milk fats from different stages of lactation are studied to investigate the link between high contents of medium-chain fatty acids (MCFA), triacylglycerol (TAG) species, and crystallization in a milk fat system. The elephant milk fats contain high amounts of MCFA, specifically C8:0, C10:0, and C12:0, which mainly form medium molecular weight TAG species (C26-C34). The milk fats with the highest MCFA levels (97% and 82%) correspond to mid- and late-lactation stages. These milk fats display simpler TAG compositions and crystallization behaviors. The great majority of mid- and late-lactation milk fats are comprised of medium molecular weight (C28-C30) TAG. Both melting and crystallization are sharp events, and only beta' polymorph is observed. At early lactation, with 66% MCFA, a more diverse fatty acid composition is observed, and TAG species with medium molecular weight (C30-C34) and high molecular weight (C36-C44) are the dominant. Under dynamic conditions, crystallization and melting take place gradually over a wide temperature range, both alpha and beta'

polymorph crystals are observed. Practical Applications: Mammals of different species provide milk lipids with a wide variety of fatty acid composition yet with common stereospecific features. The study of milk lipids, other than the common bovine milk lipids, allows the investigation of crystallographic properties in relation to fatty acid composition while preserving the stereospecific arrangement. Specifically, the study of elephant milk fats from different stages of lactation provides insight in to the effect of varying contents of medium-chain fatty acids and fatty acid diversity on triacylglycerol composition and crystallization behavior.

Atuman, Y. J., et al. (2020). "Seroprevalence of Foot and Mouth Disease Virus Infection in Some Wildlife and Cattle in Bauchi State, Nigeria." Vet Med Int **2020**: 3642793.

Foot and mouth disease (FMD) is an important transboundary viral disease of both domestic and wild cloven-hoofed animals characterized by high morbidity with devastating consequence on the livestock worldwide. Despite the endemic nature of FMD in Nigeria, little is known about the epidemiology of the disease at the wildlife-livestock interface level. To address this gap, blood samples were collected between 2013 and 2015 from some wildlife and cattle, respectively, within and around the Yankari Game Reserve and Sumu Wildlife Park in Bauchi State, Nigeria. Wild animals were immobilized using a combination of etorphine hydrochloride (M99® Krüger-Med South Africa) at 0.5-2 mg/kg and azaperone (Stresnil®, Janssen Pharmaceuticals (Pty.) Ltd., South Africa) at 0.1 mg/kg using a Dan-Inject® rifle (Dan-Inject APS, Sellerup Skovvej, Denmark) fitted with a 3 ml dart syringe and for reversal, naltrexone (Trexonil® Kruger-Med South Africa) at 1.5 mg IM was used, and cattle were restrained by the owners for blood collection. Harvested sera from blood were screened for presence of antibodies against the foot and mouth disease virus (FMDV) using the PrioCHECK® 3ABC NSP ELISA kit, and positive samples were serotyped using solid-phase competitive ELISA, (IZSLER Brescia, Italy). Out of the 353 sera collected from cattle and wildlife 197 (65.7%) and 13 (24.5%) (P < 0.05), respectively, tested positive for antibodies to the highly conserved nonstructural 3ABC protein of FMDV by the FMDV-NS blocking ELISA. Classification of cattle into breed and sex showed that detectable antibodies to FMDV were higher (P < 0.05) in White Fulani 157 (72.8%) than in Red Bororo 23 (39.7%) and Sokoto Gudali 17 (33.3%) breeds of cattle, whereas in females, detectable FMDV antibodies were higher (P < 0.05) 150 (72.8%) than in males 47 (50.0%). In the wildlife species, antibodies to FMDV were detected in the waterbucks 2 (28.6%), elephant 1 (25.0%), wildebeests 4 (33.3%), and elands 6 (25.0%). Four serotypes of FMDV: O, A, SAT 1, and SAT 2 were detected from the 3ABC positive reactors in waterbucks, elephants, wildebeests, and elands. The results showed presence of antibodies to FMDV in some wildlife and cattle and suggested that wildlife could equally play an important role in the overall epidemiology of FMD in Nigeria. FMD surveillance system, control, and prevention program should be intensified in the study area.

Azeem, S., et al. (2020). "Mass Die-Off of African Elephants in Botswana: Pathogen, Poison or a Perfect Storm?" African Journal of Wildlife Research **50**(1): 149-156.

Reports of a mass die-off of ~350 elephants (Loxodonta africana) in northern Botswana over a period of two months (May-June 2020), has fuelled speculation and concern regarding the cause. Although the area in which these mortalities occurred is not protected and is considered a hotspot for human-elephant conflict and poaching, both malicious poisoning and poaching are unlikely to have played a role as other species were not affected, and elephant carcasses were found with tusks intact. In the absence of a confirmed cause we sought to identify the lines of enquiry that are most likely to lead to a definitive answer. In particular, we consider viral and bacterial agents that could precipitate species-specific mortalities on this scale, potential environmental sources of poisoning and the samples and tests that would assist in excluding/confirming these candidate causes. Whilst it may be argued that these mortalities are unlikely to negatively impact the broader elephant population of ~130 000 individuals in Botswana, the same cannot be said of the many vulnerable population pockets in other parts of Africa. For this reason, it is essential that the cause of the current die-off is identified as it is the only way to prevent similar losses of susceptible elephants elsewhere.

Baker, L. and R. Winkler (2020). "Asian elephant rescue, rehabilitation and rewilding." <u>Animal Sentience</u> **296**: 1-19.

> Thailand has fewer than 10,000 elephants left. More of them are living in captivity to serve the tourist industry under grim conditions than are living free in what is left of their wild habitat. Conservation efforts need to be focused on all surviving members of the species, captive and free, but they need to take into account the inextricable entanglement of human and nonhuman animal lives in Thailand today. There is an opportunity for rescuing, rehabilitating and reintroducing captive elephants to the wild with the help of the traditional expertise of a mahout culture that has been elephant-keeping for centuries. We advocate a state of wildness that is meaningful to the elephants and can be attained in a way in which both elephant and human cultures are valued. This would be far better than the status quo for the elephants, restoring to them a life worth living.

Bansiddhi, P., et al. (2020). "Welfare Assessment and Activities of Captive Elephants in Thailand." <u>Animals (Basel)</u> **10**(6).

> Thailand is the epicenter of elephant tourism and visiting an elephant camp is a popular activity according to the Tourist Authority of Thailand. However, the welfare of these elephants has been questioned by animal activist groups, international tour operators, and the public. Conclusions that the vast majority of captive elephants are abused often are based on anecdotal evidence and not solid science. So, it is difficult to tease apart emotion, opinion, and fact with regard to what practices are good or bad for elephant welfare. The aim of this paper was to: 1) describe the unique status of captive elephants in Thailand and associated regulations, 2) summarize current issues and challenges facing elephant tourism, 3) review studies conducted on welfare of tourist elephants in Thailand, and 4) offer recommendations for how elephants can be properly cared for under captive conditions in tourist camps. We conclude there are many ways to manage these elephants, and that not all tourist activities are bad for welfare. However, it is essential they be managed in a way that meets physical, physiological and psychological needs, and that management decisions are based on objective data.

Brand, C. M., et al. (2020). "Abundance, density, and social structure of African forest elephants (Loxodonta cyclotis) in a human-modified landscape in southwestern Gabon." <u>PLoS ONE</u> **15**(4): 1-15.

> Population monitoring is critical to effective conservation, but forest living taxa can be diffi- cult to directly observe. This has been true of African forest elephants (Loxodonta cyclotis), for which we have limited information regarding population size and social behavior despite their threatened conservation status. In this study, we estimated demographic parameters using genetic capture-recapture of forest elephants in the southern Industrial Corridor of the Gamba Complex of Protected Areas in southwestern Gabon, which is considered a global stronghold for forest elephants. Additionally, we examined social networks, predicting that we would find matrilineal structure seen in both savanna and forest elephants. Given 95% confidence intervals, we estimate population size in the sampled area to be between 754 and 1,502 individuals and our best density estimate ranges from 0.47 to 0.80 elephants per km2. When extrapolated across the entire Industrial Corridor, this estimate suggests an ele- phant population size of 3,033 to 6,043 based on abundance or 1,684 to 2,832 based on density, approximately 40–80% smaller than previously suggested. Our social network anal- ysis revealed approximately half of network components included females with different mitochondrial haplotypes suggesting a wider range of variation in forest elephant sociality than previously thought. This study emphasizes the threatened status of forest elephants and demonstrates the need to further refine baseline estimates of population size and knowledge on social behavior in this taxon, both of which will aid in determining how popula- tion dynamics in this keystone species may be changing through time in relation to increas- ing conservation threats.

Brown, J. L., et al. (2020). "Commonalities in Management and Husbandry Factors Important for Health and Welfare of Captive Elephants in North America and Thailand." <u>Animals (Basel)</u> **10**(4).

Abstract: This review paper is a synthesis of results from multiple studies that we have conducted over the past several years using similar methodologies to identify factors related to welfare of captive populations of elephants in North American zoos and Thailand tourist camps. Using multiple conservation physiology tools, we found that, despite vastly disparate management systems, there are commonalities in how environmental and husbandry factors affect physical and physiological outcomes. Elephants appear to have better welfare, based on fecal glucocorticoid metabolite (FGM) analyses, when housed under conditions that provide a more enriched, stimulating, and less restrictive environment. We also found it is essential to balance diet and exercise for good body condition and metabolic function. In Thailand, use of tools to control elephants, such as the ankus (i.e., guide, hook) and chains, did not equate to poor welfare per se, nor did riding; however, improper uses were associated with higher wound scores and FGM concentrations. Foot health was good overall in both regions, with cracks being the most common problem, and better foot scores were found in elephants kept on softer substrates. Based on these findings, science-based guidelines are being developed in Thailand, while in North America, changes are being incorporated into elephant standards and husbandry resource guides. Management across venues can be improved by encouraging elephant exploration and exercise, establishing socially compatibility groups, ensuring proper use of tools, and providing balanced diets. We contend there is no "one-size-fits-all" management strategy to guarantee good welfare for elephants, but there are essential needs that must be met regardless of where or how they are managed. Future studies are needed to find ways to better socialize elephants; determine how temperament affects coping styles and resilience; study the importance of good handler-elephant relationships; identify more ways for elephants to engage with the environment; and assess the effect of life history on subsequent physiological and psychological well-being.

Budd, K., et al. (2020). "Effects of diet, habitat, and phylogeny on the fecal microbiome of wild African savanna (Loxodonta africana) and forest elephants (L. cyclotis)." <u>Ecol Evol</u> **10**(12): 5637-5650.

The gut microbiome, or the community of microorganisms inhabiting the digestive tract, is often unique to its symbiont and, in many animal taxa, is highly influenced by host phylogeny and diet. In this study, we characterized the gut microbiome of the African savanna elephant (Loxodonta africana) and the African forest elephant (Loxodonta cyclotis), sister taxa separated by 2.6-5.6 million years of independent evolution. We examined the effect of host phylogeny on microbiome composition. Additionally, we examined the influence of habitat types (forest versus savanna) and diet types (crop-raiding versus noncrop-raiding) on the microbiome within L. africana. We found 58 bacterial orders, representing 16 phyla, across all African elephant samples. The most common phyla were Firmicutes, Proteobacteria, and Bacteroidetes. The microbiome of L. africana was dominated by Firmicutes, similar to other hindgut fermenters, while the microbiome of L. cyclotis was dominated by Proteobacteria, similar to more frugivorous species. Alpha diversity did not differ across species, habitat type, or diet, but beta diversity indicated that microbial communities differed significantly among species, diet types, and habitat types. Based on predicted KEGG metabolic pathways, we also found significant differences between species, but not habitat or diet, in amino acid metabolism, energy metabolism, and metabolism of terpenoids and polyketides. Understanding the digestive capabilities of these elephant species could aid in their captive management and ultimately their conservation.

Carlin, E., et al. (2020). "Non-Invasive Assessment of Body Condition and Stress-Related Fecal Glucocorticoid Metabolite Concentrations in African Elephants (Loxodonta africana) Roaming in Fynbos Vegetation." <u>Animals (Basel)</u> **10**(5).

Fynbos is a unique endemic vegetation type belonging to the Cape Floral Kingdom in the Western Cape Province of South Africa, representing the smallest of the six floral kingdoms in the world. Nowadays, only a few game reserves in this region support populations of African elephants (Loxodonta africana), and thus, little information exists regarding the suitability of the nutritionally poor Fynbos vegetation for these megaherbivores. Using already established non-invasive methods, the monitoring of individual body conditions and fecal glucocorticoid metabolite (fGCM) concentrations, as a measure of physiological stress, was performed to examine a herd of 13 elephants in a Western

Cape Province Private Game Reserve, during two monitoring periods (April and June 2018), following a severe drought. The results indicate that overall median body condition scores (April and June: 3.0, range 2.0-3.0) and fGCM concentrations (April: 0.46 μg/g dry weight (DW), range 0.35-0.66 μg/g DW; June: 0.61 μg/g DW, range 0.22-1.06 μg/g DW) were comparable to those of other elephant populations previously studied utilizing the same techniques. These findings indicate that the individuals obtain sufficient nutrients from the surrounding Fynbos vegetation during the months monitored. However, a frequent assessment of body conditions and stress-associated fGCM concentrations in these animals would assist conservation management authorities and animal welfare practitioners in determining ways to manage this species in environments with comparably poorer nutritional vegetation.

Chaiwattanarungruengpaisan, S., et al. (2020). "Potentially Pathogenic Leptospira in the Environment of an Elephant Camp in Thailand." Trop Med Infect Dis **5**(4).
Leptospira is the causative agent of leptospirosis, a globally emerging zoonotic disease. The infection is commonly acquired through contact with the contaminated environment. To extend the knowledge on environmental source of leptospirosis, we investigated the presence of Leptospira in an elephant camp setting where the interaction between humans, animals, and the shared environment occur particularly when engaging in recreational activities. In this study, a total of 24 environmental samples were collected from an elephant camp area in western Thailand. All samples were processed for Leptospira isolation using the EMJH medium. The identification of Leptospira species was carried out by partial 16S rRNA and secY gene sequencing. Of those 24 samples, 18 samples (75%) were culture-positive for Leptospira. The recovered leptospires were mostly derived from water and soil sampled from a river and a mud pond, the main areas for recreational activities. The majority of the isolates were classified into "Pathogens" clade (89%, 16/18) and more than half of the isolates (61%, 11/18) contained species of the "Saprophytes" clade. Notably, two soil isolates from the river beach sampling area were found to contain leptospiral DNA with high similarity to the pathogenic L. interrogans and L. santarosai. The evidence of diverse Leptospira species, particularly those belonging to the "Pathogens" clade, suggest that the shared environments of an elephant camp can serve as potential infection source and may pose a risk to the elephant camp tourists and workers.

Chel, H. M., et al. (2020). "Morphological and molecular identification of cyathostomine gastrointestinal nematodes of Murshidia and Quilonia species from Asian elephants in Myanmar." Int J Parasitol Parasites Wildl **11**: 294-301.
Gastrointestinal nematode parasites have long been recognized in Asian elephants. The most common parasites belong to the subfamily Cyathostominae of the family Strongylidae, which are small to medium-sized with a cylindrical buccal capsule surrounded by coronal leaflets. Diagnostic keys of such parasites are provided from old illustrations in the form of line drawings. However, there very few photomicrographs and no genetic information of these parasites exist. In the present study we obtained adult worm specimens from faeces of Asian elephants after anthelmintic treatment in two elephant camps in Myanmar. Here, we provided photomicrographs for five cyathostomine parasites, Murshidia falcifera, Murshidia indica, Murshidia neveulemairei, Quilonia renniei, and Quilonia travancra almost 100 years after their original drawings. In addition, we determined the mitochondrial cytochrome c oxidase subunit I (COI) gene sequences of these species. Phylogenetic analysis of the COI genes of Murshidia and Quilonia species from Asian and African elephants revealed parasite speciation in each elephant host. The present study also indicated that several Murshidia and Quilonia species were widely distributed in Asian elephants in Myanmar, providing new insight into control strategies and evolution of cyathostomine gastrointestinal parasites in elephants.

Chel, H. M., et al. (2020). "First record and analysis of the COI gene of Cobboldia elephantis obtained from a captive Asian elephant from Myanmar." Parasitol Int **75**: 102035.
The stomach bot fly species in Asian elephants has long been known as Cobboldia elephantis. However, there is no genetic information available for this species to date. Here, we report that a third-

instar fly larva was excreted from a captive Asian elephant four months after export from an elephant camp in Myanmar to a zoological garden in Japan. Morphological characteristics of the larva were coincident with published descriptions of C. elephantis. The mitochondrial cytochrome c oxidase subunit I (COI) gene was amplified from the larva by PCR using primers modified from those designed for DNA barcoding of insects and amphibians. The COI gene of C. elephantis showed 76.6 % and 83.6 % identity at the nucleotide and amino acid levels, respectively, to that of C. loxodontis, the stomach bot fly species in African elephants. Phylogenetic analysis of the COI genes of several stomach bot fly species revealed that the two Cobboldia species formed a clade separate from the stomach bot fly species found in rhinoceros and equids.

Childs-Sanford, S. E., et al. (2020). "THE VITAMIN D STATUS OF ASIAN ELEPHANTS (ELEPHAS MAXIMUS) MANAGED IN A NORTHERN TEMPERATE CLIMATE." J Zoo Wildl Med **51**(1): 1-12.
Knowledge about the normal metabolism and involvement of vitamin D in elephant calcium homeostasis is essential to understanding the possible role of vitamin D in Asian elephant (Elephas maximus) health, as well as to informing accurate diet formulation. This study provides an evaluation of analytes involved in vitamin D metabolism, in conjunction with dietary intake and ultraviolet light (UV) exposure, in Asian elephants managed in a northern temperate climate. Once monthly, for a total of 12 mo, serum from six adult Asian elephants was analyzed for 25-hydroxyvitamin D [25(OH)D], 24,25-dihydroxyvitamin D [24,25(OH)(2)D], 1,25-dihydroxyvitamin D [1,25(OH)(2)D], parathyroid hormone (PTH), total calcium (Ca), ionized calcium (iCa), phosphorus (P), and magnesium (Mg). The diet was analyzed monthly for vitamin D, Ca, and P. Monthly average vitamin D-weighted UV daily sums were determined to gauge average UV light exposure within the vitamin D action spectrum. No serum or diet parameters were affected by time or season. Average serum 25(OH)D(2) was 7.02 ± 0.85 ng/ml. 25(OH)D(3) levels were nondetectable in all samples despite supplementation of the diet with recommended levels of vitamin D(3), and UV exposure was at sufficient levels for cutaneous vitamin D synthesis for 6 mo of the year. Levels of 24,25(OH)(2)D averaged 31.7% higher than 25(OH)D, and average 1,25(OH)(2)D(2) was 11.24 ± 1.04 pg/ml. Values for PTH, Ca, iCa, P, and Mg were within expected ranges for Asian elephants. The information gained from this research expands the knowledge base for these analytes, evaluates 24,25-dihydroxyvitamin D for the first time, and provides new information regarding vitamin D metabolism and test interpretation in the Asian elephant.

Compaore, A., et al. (2020). "Correlation between increased human-elephant conflict and poaching of elephants in Burkina Faso (West Africa)." European Journal of Wildlife Research **66**(1).
Human-elephant conflict (HEC) represents a serious threat to both survival of wild elephants and human economic activities at the local level in many African regions, but has been relatively little investigated in West Africa. Here, the ecological correlates of HEC and correlation between HEC and elephant poaching, are investigated in the PONASI complex of protected areas in Burkina Faso (West Africa). Out of 144 villages surveyed, HEC was observed in 78 villages. Within this sample, we interviewed 188 local farmers who were victims of elephant damages during the period 2011–2015. Elephant raids were positively correlated with some crop types in farms (sorghum, maize, millet, and rice) and negatively with beans, and increased most significantly with increases in seeds, seedlings, plant growing and, especially, crops at maturation in the farms. Five cases of human deaths as consequence of elephant raids were also recorded. We observed a significant increase of the number of raids during the period 2011–2015, as well as of the number of elephants killed by year by poachers. Poaching was concentrated especially in the dry season (December to February), just after the end of the harvest period. There was also a clear correspondence between provinces that were more affected by elephant raids and where elephant poaching was most intense. Thus, although local poachers also likely contributed to the illegal ivory market, it was apparent that avoiding elephant raids was among the main reasons for pushing them to hunt illegally for elephants. Insufficient participation of communities hampers the PONASI protected area complex sutainable management. In order to gain the people's support for the ideals of wildlife conservation, it is essential that they would feel that their concerns are taken into account, thus by adopting policies that minimize HEC effects on local economies. © 2020,

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Crawley, J. A. H., et al. (2020). "Taming age mortality in semi-captive Asian elephants." Sci Rep **10**(1): 1889.
Understanding factors preventing populations of endangered species from being self-sustaining is vital for successful conservation, but we often lack sufficient data to understand dynamics. The global Asian elephant population has halved since the 1950s, however >25% currently live in captivity and effective management is essential to maintain viable populations. Here, we study the largest semi-captive Asian elephant population, those of the Myanma timber industry (~20% global captive population), whose population growth is heavily limited by juvenile mortality. We assess factors associated with increased mortality of calves aged 4.0-5.5 years, the taming age in Myanmar, a process affecting ~15,000 captive elephants to varying degrees worldwide. Using longitudinal survival data of 1,947 taming-aged calves spanning 43 years, we showed that calf mortality risk increased by >50% at the taming age of four, a peak not seen in previous studies on wild African elephants. Calves tamed at younger ages experienced higher mortality risk, as did calves with less experienced mothers. Taming-age survival greatly improved after 2000, tripling since the 1970's. Management should focus on reducing risks faced by vulnerable individuals such as young and first-born calves to further improve survival. Changes associated with reduced mortality here are important targets for improving the sustainability of captive populations.

de Flamingh, A., et al. (2020). "Accurate Sex Identification of Ancient Elephant and Other Animal Remains Using Low-Coverage DNA Shotgun Sequencing Data." G3 (Bethesda) **10**(4): 1427-1432.
Sex identification of ancient animal biological remains can benefit our understanding of historical population structure, demography and social behavior. Traditional methods for sex identification (e.g., osteological and morphometric comparisons) may be ineffective when animal remains are not well preserved, when sex distinguishing characteristics have not yet developed, or where organisms do not exhibit sex-associated phenotypic dimorphisms. Here we adapt a method developed for human sex determination so that it can be used to identify the sex of ancient and modern animal taxa. The method identifies sex by calculating the ratio of DNA reads aligning to the X chromosome to DNA reads aligning to autosomes (termed the Rx ratio). We tested the accuracy of this method using low coverage genomes from 15 modern elephants (Loxodonta africana) for which sex was known. We then applied this method to ancient elephant ivory samples for which sex was unknown, and describe how this method can be further adapted to the genomes of other taxa. This method may be especially useful when only low-coverage genomic data are obtainable. Furthermore, because this method relies on only the X and not the Y chromosome, it can be used to determine the sex of organisms for which a reference genome was obtained from a female or for which only the X chromosome is reported. Such taxa include the domestic cat, sheep, goat, and horse; and non-domesticated animals such as the Sumatran orangutan, western lowland gorilla and meerkat.

de Flamingh, A., et al. (2020). "Sourcing Elephant Ivory from a Sixteenth-Century Portuguese Shipwreck." Curr Biol.
The oldest known shipwreck in southern Africa was found in Namibia in 2008.(1-4) Forty tons of cargo, including gold and silver coins, helped identify the ship as the Bom Jesus, a Portuguese nau (trading vessel) lost in 1533 while headed to India.(4-6) The cargo included >100 elephant tusks,(7) which we examined using paleogenomic and stable isotope analyses. Nuclear DNA identified the ivory source as African forest (Loxodonta cyclotis) rather than savanna (Loxodonta africana) elephants. Mitochondrial sequences traced them to West and not Central Africa and from ≥17 herds with distinct haplotypes. Four of the haplotypes are known from modern populations; others were potentially lost to subsequent hunting of elephants for ivory. Stable isotope analyses ($\delta(13)C$ and $\delta(15)N$) indicated that the elephants were not from deep rainforests but from savanna and mixed habitats. Such habitats surround the Guinean forest block of West Africa(8) and accord with the locations of major historic Portuguese trading ports.(9)(,)(10) West African forest elephants currently range into savanna habitats;(11-13) our findings suggest that this was not consequent to regional decimation of savanna elephants for their

ivory in the 19(th) and 20(th) centuries. During the time of the Bom Jesus, ivory was a central driver in the formation of maritime trading systems connecting Europe, Africa, and Asia. Our integration of paleogenomic, archeological, and historical methods to analyze the Bom Jesus ivory provides a framework for examining vast collections of archaeological ivories around the world, in shipwrecks and other contexts.

Denninger Snyder, K. and D. Rentsch (2020). "Rethinking assessment of success of mitigation strategies for elephant-induced crop damage." Conserv Biol.
>   Crop damage is the most common impact of negative interactions between people and elephants and poses a significant threat to rural livelihoods and conservation efforts. Numerous approaches to mitigate and prevent crop damage have been implemented throughout Africa and Asia. Despite the documented high efficacy of many approaches, losses remain common, and in many areas, damage is intensifying. We examined the literature on effectiveness of crop-damage-mitigation strategies and identified key gaps in evaluations. We determined there is a need to better understand existing solutions within affected communities and to extend evaluations of effectiveness beyond measurement of efficacy to include rates of and barriers to adoption. We devised a conceptual framework for evaluating effectiveness that incorporates the need for increased emphasis on adoption and can be used to inform the design of future crop-damage mitigation assessments for elephants and conflict species more widely. The ability to prevent crop loss in practice is affected by both the efficacy of a given approach and rates of uptake among target users. We identified the primary factors that influence uptake as local attitudes, sustainability, and scalability and examined each of these factors in detail. We argue that even moderately efficacious interventions may make significant progress in preventing damage if widely employed and recommend that wherever possible scientists and practitioners engage with communities to build on and strengthen existing solutions and expertise. When new approaches are required, they should align with local attitudes and fit within limitations on labor, financial requirements, and technical capacity.

Derham, T. and F. Mathews (2020). "Elephants as refugees." People and Nature **2**: 103-110.
>   1. Habitat loss and climate change are displacing animals at alarming rates. In re- sponse, authors in the humanities and the sciences have described animals rhe- torically as 'refugees'. Such a description implies a strong call to action.

2. However, the term 'refugee' may serve as more than mere rhetoric, indicating in a more literal way the response most proper to some persecuted, traumatized and displaced animals, and prioritizing those animals.
3. We test the claim that animals can be refugees using widely accepted criteria in the Refugee Convention. If refugees are those who, due to a well-founded fear of persecution for reasons of their group identity, are unwilling or unable to avail themselves of the protection of their country, then some animals may be refu- gees. Recent behavioural research on African elephants Loxodonta africana dem- onstrates that many elephants meet the criteria, even without recourse to the claim that they are persons.
4. We outline the essential requirements of an animal refugee policy. We find that current biodiversity conservation policy is likely inadequate to provide for animal refugees, although important lessons can be taken from the collective experience of conservation scientists and managers.
5. An obligation to animal refugees poses new challenges, both theoretical and prac- tical, for ecological restoration, conservation and human–animal relations.

Dharmarathne, C., et al. (2020). "Project orange elephant is a conflict specific holistic approach to mitigating human-elephant conflict in Sri Lanka." Commun Biol **3**(1): 43.
>   Human-wildlife conflicts are an increasing problem as human land use encroaches on wildlife habitats. Augmenting farmers' crops with orange trees through Project Orange Elephant has proven to be a simple and effective method for mitigating human-elephant conflicts in Sri Lanka. Similar endeavours could be applied elsewhere in the world.

Chathuranga Dharmarathne et al. discuss an innovative conservation project to reduce human-elephant

conflict in Sri Lanka. This project uses citrus trees to repel elephants from farms, thereby reducing crop loss among farmers and providing additional income.

eng for the Sri Lanka Wildlife Conservation Society.

Dierenfeld, E. S., et al. (2020). "Milk Composition of Asian Elephants (Elephas maximus) in a Natural Environment in Myanmar during Late Lactation." Animals (Basel) **10**(4).

> The nutritional content of milk from free-living Asian elephants has not previously been reported, despite being vital for better management of captive populations. This study analyzed both milk composition and consumed plant species of Asian elephants managed in their natural environment in Myanmar. Longitudinal samples (n = 36) were obtained during both the wet and the dry season from six mature females in mid to late lactation in 2016 and 2017. Milk composition averaged 82.44% water, with 17.56% total solids containing 5.23% protein, 15.10% fat, 0.87% ash, and 0.18 μg/mL vitamin E. Solids and protein increased with lactation month. Total protein in milk was higher during the wet vs. the dry season. Observed factors linked with maternal (age, parity, size and origin) and calf traits (sex) had significant associations with milk nutrient levels. Primary forages consumed contained moderate protein and fiber. Higher dietary protein during the wet season (11-25%) compared to the dry season (6-19%) may be linked with increased milk protein observed. Our results call for further field studies of milk and diet composition, over entire seasons/lactation periods, and across maternal and calf traits, to improve feeding management, with an overall goal of maximized health and survival.

Dow, T. L., et al. (2020). "UNDERSTANDING PROLACTIN REGULATION AND DETERMINING THE EFFICACY OF CABERGOLINE AND DOMPERIDONE TO MITIGATE PROLACTIN-ASSOCIATED OVARIAN CYCLE PROBLEMS IN ZOO AFRICAN ELEPHANTS (LOXODONTA AFRICANA)." J Zoo Wildl Med **51**(1): 13-24.

> Perturbations in serum prolactin secretion, both over- and underproduction, are observed in zoo African elephants (Loxodonta africana) that exhibit abnormal ovarian cycles. Similar prolactin problems are associated with infertility in other species. Pituitary prolactin is held under constant inhibition by a hypothalamic-derived neurotransmitter, dopamine; thus, regulation by exogenous treatment with agonists or antagonists may be capable of reinitiating normal ovarian cycles. This study tested the efficacy of oral administration of cabergoline (agonist) and domperidone (antagonist) as possible treatments for hyperprolactinemia or chronic low prolactin, respectively. Hyperprolactinemic (overall mean prolactin, >30 ng/ml), acyclic elephants were administered oral cabergoline (2 mg, n = 4) or placebo (dextrose capsule, n = 4) twice weekly. Overall mean prolactin concentration decreased in treated females compared with controls (32.22 ± 14.75 vs 77.53 ± 0.96 ng/ml; P = 0.01). Interestingly, overall mean progestagen concentrations also increased slightly (P < 0.05) in treated females (0.15 ± 0.01 ng/ml) compared with controls (0.07 ± 0.01 ng/ml), but no reinitation of normal cyclic patterns was observed. Chronic low prolactin (overall mean prolactin, <10 ng/ml), acyclic females were orally administered domperidone (2 g/day, n = 4) or placebo (dextrose capsule, n = 4) for 4 wk, followed by 8 wk of no treatment (four cycles) to simulate the prolactin pattern observed in normal cycling elephants. Overall mean prolactin concentrations increased (P = 0.005) during domperidone treatment (21.77 ± 3.69 ng/ml) compared with controls (5.77 ± 0.46 ng/ml), but progestagen concentrations were unaltered. Prolactin regulation by dopamine was confirmed by expected responses to dopamine agonist and antagonist treatment. Although prolactin concentrations were successfully reduced by cabergoline, and domperidone initiated the expected cyclic prolactin pattern, neither treatment induced normal ovarian activity.

Downs, C. J., et al. (2020). "The Effects of Body Mass on Immune Cell Concentrations of Mammals." Am Nat **195**(1): 107-114.

> Theory predicts that body mass should affect the way organisms evolve and use immune defenses. We investigated the relationship between body mass and blood neutrophil and lymphocyte concentrations among more than 250 terrestrial mammalian species. We tested whether existing theories (e.g., protecton theory, immune system complexity, and rate of metabolism) accurately predicted the scaling

of immune cell concentrations. We also evaluated the predictive power of body mass for these leukocyte concentrations compared to sociality, diet, life history, and phylogenetic relatedness. Phylogeny explained >70% of variation in both lymphocytes and neutrophils, and body mass appeared more informative than other interspecific trait variation. In the best-fit mass-only model, neutrophils scaled hypermetrically (b = 0.11) with body mass, whereas lymphocytes scaled just shallow of isometrically. Extrapolating to total cell numbers, this exponent means that an African elephant circulates 13.3 million times the neutrophils of a house mouse, whereas their masses differ by only 250,000-fold. We hypothesize that such high neutrophil numbers might offset the (i) higher overall parasite exposure that large animals face and/or (ii) the higher relative replication capacities of pathogens to host cells.

Dror, S., et al. (2020). "Are Asian elephants afraid of honeybees? Experimental studies in northern Thailand." Mammalian Biology **100**(4): 356-363.

In many parts of South and Southeast Asia, rural farmers living at the borders of protected areas frequently encounter Asian elephants (Elephas maximus) raiding their crops and threatening farmers lives and livelihoods. Traditional deterrent methods often have limited success as elephants become habituated or alternate their movement and behavior. While African bees (Apis mellifera scutellate) have been shown to effectively and sustainably deter African elephants (Loxodonta africana) little is known about their Asian counterparts. We conducted two experiments to estimate the effectiveness of bees as an Asian elephant deterrent method. We analyzed the behavioral reaction of seven captive Asian elephants when confronted with a fence ofA. melliferahives blocking their way to a desired source of food. In addition, we explored the defensive reaction of fiveA. ceranahives and sixA. melliferahives to an artificial disturbance during both day and night time. The elephants crossed the beehive fence in 51% of the cases, the probability of crossing increased over time and the number of exposures had a significant effect on an elephant's crossing probability, indicating that elephants became habituated to the presence of the beehive fence. In the bee experiment, only one out of fiveA. ceranahives and one out of sixA. melliferahives reacted to the disturbance during the daytime, while during nighttime, none of them reacted defensively after being disturbed. We, therefore, conclude that neitherA. melliferanorA. ceranabees are likely to be effective in deterring wild Asian elephants from entering crop fields.

Edwards, K. L., et al. (2020). "Serum Health Biomarkers in African and Asian Elephants: Value Ranges and Clinical Values Indicative of the Immune Response." Animals (Basel) **10**(10).

Serum biomarkers indicative of inflammation and disease can provide useful information regarding host immune processes, responses to treatment and prognosis. The aims of this study were to assess the use of commercially available anti-equine reagents for the quantification of cytokines (tumor necrosis factor-alpha (TNF-α), interferon-gamma (IFN-γ), interleukins (IL) 2, 6, and 10) in African (Loxodonta africana, n = 125) and Asian (Elephas maximus, n = 104) elephants, and alongside previously validated anti-human reagents for acute-phase proteins (serum amyloid A and haptoglobin), calculate species-specific biomarker value ranges. In addition, we used opportunistically collected samples to investigate the concentrations of each biomarker during identified clinical cases of illness or injury, as a first step to understanding what biomarkers may be useful to managing elephant health. Immune biomarkers were each elevated above the calculated species-specific value ranges in at least one clinical case, but due to variability in both clinical and non-clinical samples, only serum amyloid A was significantly higher in clinical compared to non-clinical paired samples, with tendencies for higher TNF-α and IL-10. We also detected increased secretion of serum amyloid A and all five cytokines following routine vaccination of a single Asian elephant, indicating that these biomarkers can be beneficial for studying normal immune processes as well as pathology. This study indicates that assays developed with commercial reagents can be used to quantify health biomarkers in wildlife species and identifies several that warrant further investigation to elucidate immune responses to various pathologies.

England, M. E., et al. (2020). "Culicoides species composition and molecular identification of host blood meals

at two zoos in the UK." <u>Parasit Vectors</u> **13**(1): 139.

> BACKGROUND: Culicoides biting midges are biological vectors of arboviruses including bluetongue virus (BTV), Schmallenberg virus (SBV) and African horse sickness virus (AHSV). Zoos are home to a wide range of 'at risk' exotic and native species of animals. These animals have a high value both in monetary terms, conservation significance and breeding potential. To understand the risk these viruses pose to zoo animals, it is necessary to characterise the Culicoides fauna at zoos and determine which potential vector species are feeding on which hosts. METHODS: Light-suction traps were used at two UK zoos: the Zoological Society of London (ZSL) London Zoo (LZ) and ZSL Whipsnade Zoo (WZ). Traps were run one night each week from June 2014 to June 2015. Culicoides were morphologically identified to the species level and any blood-fed Culicoides were processed for blood-meal analysis. DNA from blood meals was extracted and amplified using previously published primers. Sequencing was then carried out to determine the host species. RESULTS: A total of 11,648 Culicoides were trapped and identified (n = 5880 from ZSL WZ; n = 5768 from ZSL LZ), constituting 25 different species. The six putative vectors of BTV, SBV and AHSV in northern Europe were found at both zoos and made up the majority of the total catch (n = 10,701). A total of 31 host sequences were obtained from blood-fed Culicoides. Culicoides obsoletus/C. scoticus, Culicoides dewulfi, Culicoides parroti and Culicoides punctatus were found to be biting a wide range of mammals including Bactrian camels, Indian rhinoceros, Asian elephants and humans, with Culicoides obsoletus/C. scoticus also biting Darwin's rhea. The bird-biting species, Culicoides achrayi, was found to be feeding on blackbirds, blue tits, magpies and carrion crows. CONCLUSIONS: To our knowledge, this is the first study to directly confirm blood-feeding of Culicoides on exotic zoo animals in the UK and shows that they are able to utilise a wide range of exotic as well as native host species. Due to the susceptibility of some zoo animals to Culicoides-borne arboviruses, this study demonstrates that in the event of an outbreak of one of these viruses in the UK, preventative and mitigating measures would need to be taken.

Ertl, N., et al. (2020). "Theory of medical scoring systems and a practical method to evaluate Asian elephant (Elephas maximus) foot health in European zoos." <u>Animal Welfare</u> **29**(2): 163-176.

> Several established models in human and veterinary medicine exist to evaluate an individual health or disease status. Many of these seem unsuitable for further epidemiological research aimed at discovering underlying influential factors. As a case example for score development and choice, the present study analyses different approaches to scoring the foot health of Asian elephants (Elephas maximus) living in European facilities. Sum scores with varying degree of detail, and without or with a weighting method, were compared using descriptive statistics, ie kurtosis, skewness, Shannon entropy, total redundancy, their maximum and their actual ranges. With increasing score complexity, a higher level of differentiation was reached. In parallel, the distribution of score frequencies in the population shifted systematically: with the least complex scoring model the pattern indicated a severely unhealthy population with an opposite skew to a hypothetically healthy population, whereas the most complex scoring model indicated a mildly affected population with a skew corresponding to that expected for a healthy population. We propose the latter, in the form of the Particularised Severity Score (ParSev), which accounts for every nail and pad individually and weights the sub-scores by squaring, as the most relevant score for further investigations, either in assessing changes within an elephant population over time, or correlating foot health in epidemiological studies to potentially influencing factors. Our results emphasise the relevance of choosing appropriate scoring models for welfare-associated evaluations, due to implications for the applicability as well as the perceived welfare status of the test population. © 2020 Universities Federation for Animal Welfare

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Evans, L. J., et al. (2020). "Natural and anthropogenic drivers of Bornean elephant movement strategies." Global Ecology and Conservation **22**.

Endangered Bornean elephants are severely threatened by ongoing habitat transformation and increasing levels of human-elephant conflict. Understanding how elephants move across intact and transformed landscapes, as well as within them, is therefore of vital importance for the successful implementation of conservation management initiatives. We combined remote sensing and GPS telemetry data to identify broad habitat utilization and key movement areas to aid elephant management and conflict mitigation in three spatially-isolated populations in central and eastern Sabah, Malaysian Borneo. Home ranges were estimated using Brownian Bridge Movement Models and specific behavioral movement traits were identified by pathway analyses. These behavioral traits enabled a fine-scale evaluation of movements between and adjacent to forest patches and the role of large-scale agriculture in shaping elephant movements. Both natural (topological) and anthropogenic (agricultural) landscape features were found to have a broad influence on elephant movements. All elephant populations exhibited human-mediated behavioral responses, regardless of disturbance level. Throughout their range, elephants appeared to actively select relatively degraded forests, as measured by aboveground carbon density. However, elephants actively avoided urbanized areas, including roads and villages. Throughout the elephant range, high-speed, low-trajectory movements were found at low aboveground carbon locations, with 27% of all such movements located in large-scale agriculture. Our results suggest that agriculture impacts movement strategies of elephants, with evidence of repeat agricultural use pointing towards an active rationale for this behavior. Elephants were also found to use ridgelines as movement pathways, providing further context for the protection of such forested areas. The Lower Kinabatangan population, located in small remnant forests, travelled further to meet their ecological needs, suggesting the population is under added strain. Our work represents the broadest landscape assessment of Bornean elephant movements to-date and has important implications for both future work and habitat-level protected area management strategies. © 2020 The Authors

Evison, E., et al. (2020). "Social and environmental impacts on sleep in captive Asian elephants (Elephas maximus)." Zoo Biol **39**(6): 397-404.

Modern zoos strive to improve standards of animal management, husbandry and welfare of their animals as part of a continual evaluation process. Elephants (Elephantidae) have received particular attention in recent years due to the challenge of providing environments which promote natural behavior and opportunities for social interaction. A number of measures have been proposed to measure wellbeing, with sleep quality increasingly being used. Sleep is a vital aspect of life for cell replenishment as well as optimal development of young. Sleep deprivation can lead to immunosuppression and illness; therefore animal managers have a responsibility to ensure they reduce the potential for disturbance through noise, light, or other environmental factors. The social environment also plays an essential role in wellbeing, particularly for species that live in multi-generational family

units. In this study the nocturnal behavior of a multi-generational captive herd was observed to determine impacts of husbandry changes on sleep duration and bout length (measured as recumbent rest). As expected, average total duration of sleep was higher in younger elephants and rates were comparable to those reported in other studies of Asian elephants. Overnight access to an outdoor paddock in warmer weather increased overall average bout length of sleep in the herd. Average total duration of sleep also increased for the herd following the movement of an unrelated adult female who had previously shown weak bonds with other herd members. This indicates that social compatibility is a vital component of elephant welfare, impacting not only behavioral interactions but sleep quality and duration.

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Ewart, K. M., et al. (2020). "Expediting the sampling, decalcification, and forensic DNA analysis of large elephant ivory seizures to aid investigations and prosecutions." <u>Forensic Sci Int Genet</u> **44**: 102187.

The illegal ivory trade continues to drive elephant poaching. Large ivory seizures in Africa and Asia are still commonplace. Wildlife forensics is recognised as a key enforcement tool to combat this trade. However, the time and resources required to effectively test large ivory seizures is often prohibitive. This limits or delays testing, which may impede investigations and/or prosecutions. Typically, DNA analysis of an ivory seizure involves pairing and sorting the tusks, sampling the tusks, powdering the sample, decalcification, then DNA extraction. Here, we optimize the most time-consuming components of this process: sampling and decalcification. Firstly, using simulations, we demonstrate that tusks do not need to be paired to ensure an adequate number of unique elephants are sampled in a large seizure. Secondly, we determined that directly powdering the ivory using a Dremel drill with a high-speed cutter bit, instead of cutting the ivory with a circular saw and subsequently powdering the sample in liquid nitrogen with a freezer mill, produces comparable results. Finally, we optimized a rapid 2-h decalcification protocol that produces comparable results to a standard 3-day protocol. We tested/optimised the protocols on 33 raw and worked ivory samples, and demonstrated their utility on a case study, successfully identifying 94% of samples taken from 123 tusks. Using these new rapid protocols, the entire sampling and DNA extraction process takes less than one day and requires less-expensive equipment. We expect that the implementation of these rapid protocols will promote more consistent and timely testing of ivory seizures suitable for enforcement action.

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Fazio, J. M., et al. (2020). "Utilizing Camera Traps, Closed Circuit Cameras and Behavior Observation Software to Monitor Activity Budgets, Habitat Use, and Social Interactions of Zoo-Housed Asian Elephants (Elephus maximus)." <u>Animals (Basel)</u> **10**(11).

Accredited zoos and aquariums value superior animal husbandry and strive to ensure that the physical, psychological, and social needs of animals are met. In North America, the Association of Zoos and Aquariums (AZA) relies on species-specific standards to ensure facilities provide the best care for collection animals. The AZA also makes explicit recommendations for long-term monitoring of welfare. Data collected through behavioral observations can be used to modify management as animals respond over time to social, environmental, or physical changes. In long-lived, social species like elephants, it is particularly important to document herd dynamics, calf development, geriatric health, and social bonds throughout their lifetimes. The Smithsonian's National Zoological Park housed one male and six female Asian elephants in dynamic social groupings. Behavioral observations were conducted on all elephants for two years using two methods involving ZooMonitor, closed circuit cameras, and camera traps. The goal was to compare how these two methods function to provide individual activity budgets, habitat use, and social interactions. Methodologies such as these, alone or in combination, have the potential to produce valuable data about potential changes in welfare over time in a zoological setting and can be performed either by staff or volunteers with high reliability.

Fernando, P., et al. (2020). "The elephant at the fence: almsman, panhandler, friend or foe?" <u>European Journal of Wildlife Research</u> **66**(6).

Feeding of wild Asian elephants at the Udawalawe National Park perimeter electric fence by the general public is longstanding. We monitored the elephants and feeding activities, and conducted questionnaire surveys of stakeholders. Over 50 individual adult male elephants engaged in the activity. The exclusive male presence was consistent with a high-risk high-gain male strategy. The elephants were mostly offered fruits and vegetables. Over a thousand people a day watched and fed the elephants. Most people bought food for elephants from roadside stalls and vendors had significantly more sales if elephants were present. The feeding of elephants brought significant economic benefit to communities bordering the park. We found the impacts of feeding on the elephants and environment to be largely neutral. Impacts on people and conservation were mainly positive. Actions taken by authorities to stop the feeding have targeted the elephants and resulted in the decrease of feeding but not its elimination. Managing the activity instead would help increase economic benefits and ensure safe interaction between people and elephants. Such management, by directly benefitting local communities, could make them partners in the conservation process and form the basis of an effective

outreach program. © 2020, The Author(s).

Finch, K., et al. (2020). "Longitudinal Improvements in Zoo-Housed Elephant Welfare: A Case Study at ZSL Whipsnade Zoo." Animals (Basel) **10**(11).

> Over the last two decades, criticisms were raised regarding the welfare experienced by elephants in European and North American zoos. Concerns regarding the welfare of zoo-housed elephants in the UK and Europe were consolidated in the publication of several key reports, and media interest peaked. Throughout this study we aim to outline the behavioural measures of welfare observed in the current group of Asian elephants (Elephas maximus) at Zoological Society of London (ZSL) Whipsnade Zoo, using key welfare indicators for this species and comparing them to previous published work. Following the instigation of a species-specific research programme, empirical behavioural data were available to quantify any developments in care and welfare. The collection of behavioural information revealed that individuals in our study group engage in low levels of stereotypic behaviour, have formed and maintain strong associations with one another and display a high proportion of engagement in lying rest. We outline that by applying simple, low-cost methods of behavioural data collection and analysis, it is possible to collect evidence that allows us to evaluate individual level welfare. This facilitates the adoption of an evidence-based approach to zoo management as well as demonstrating compliance with updated legislation for this species.

Franco Dos Santos, D. J., et al. (2020). "SEX DIFFERENCES IN THE REFERENCE INTERVALS OF HEALTH PARAMETERS IN SEMICAPTIVE ASIAN ELEPHANTS (ELEPHAS MAXIMUS) FROM MYANMAR." J Zoo Wildl Med **51**(1): 25-38.

> The reference intervals of health parameters are valuable tools for veterinarians and conservationists to monitor the health status and viability of endangered species. Natural variation in the health of the long-lived Asian elephant (Elephas maximus) is poorly understood, particularly in relation to differences between males and females. Longitudinal health data were collected from clinical examination, hematology, and serum chemistry analyses over 3 yr from 227 healthy individually marked Asian elephants varying in age and sex. The study population was semicaptive and used in Myanmar's timber industry, but maintained natural feeding and breeding behavior. Body condition score (BCS) and blood pressure were investigated in clinical examinations. Hematological parameters included hematocrit, hemoglobin, total white blood cell count, and differential blood cell counts. Serum chemistry parameters included blood urea nitrogen, creatinine, total protein, albumin, globulins, aspartate aminotransferase, alkaline phosphatase, triglycerides, creatine kinase, glucose, calcium, potassium, sodium, and chloride. To the knowledge of the authors, this is the first description of BCS in an elephant population outside of zoos, and of blood pressure in this species using a novel adaptation of the Intelli Wrap Cuff pressure monitor. Several differences between the sexes were observed, with females generally having higher BCS and triglycerides, and males displaying higher alkaline phosphatase and glucose levels. This study provides important clinical tools that can be used to assess the health status and improve management in this endangered species.

Fuery, A., et al. (2020). "Lethal Hemorrhagic Disease and Clinical Illness Associated with Elephant Endotheliotropic Herpesvirus 1 Are Caused by Primary Infection: Implications for the Detection of Diagnostic Proteins." J Virol **94**(3).

> Elephant endotheliotropic herpesvirus (EEHV) can cause lethal hemorrhagic disease in juvenile Asian elephants, both in captivity and in the wild. Most deaths associated with the virus are caused by two chimeric variants of EEHV1 (EEHV1A and EEHV1B), while two other EEHVs endemic within Asian elephants (EEHV4 and EEHV5) have been recognized but cause death less often. Whether lethal EEHV infections are due to primary infection or reactivation of latent virus remains unknown, and knowledge of the anti-EEHV antibody levels in young elephants is limited. To close these gaps, we sought to develop a serologic assay capable of distinguishing among infections with different EEHVs using a luciferase immunoprecipitation system (LIPS) for antibody profiling and a panel of conserved EEHV recombinant proteins and proteins unique to EEHV1. The results showed that elephants dying

from EEHV1 hemorrhagic disease or ill from EEHV infection were seronegative for the EEHV species that caused the disease or illness, indicating that the events were associated with primary infection rather than reactivation of latent virus. We also demonstrated that waning of EEHV1-specific antibodies can occur in the first 2 years of life, when a threshold protective level of antibody may be needed to prevent severe EEHV1-related disease. Use of the LIPS assay to identify putative "diagnostic" proteins would be a valuable asset in determining the EEHV immune status of young elephants and responses to candidate EEHV vaccines in the future. IMPORTANCE Whether clinical illness and deaths associated with elephant endotheliotropic herpesvirus (EEHV) infection result from primary infection or reactivation of latent virus is a longstanding question in the field. By applying a relatively new assay, the luciferase immunoprecipitation system (LIPS), combined with the genomic sequences of the viruses, we gained the insights and tools needed to resolve this issue. Our EEHV1-specific LIPS assay should be useful for assessing the vulnerability of elephant calves to infection with different EEHVs and evaluating antibody responses to anti-EEHV vaccines. A significant proportion of the Asian elephant population is under some form of human care. Hence, the ability to screen for EEHV immune status in elephant calves should have a major impact on the management of these animals worldwide.

Furlan, J. P. R., et al. (2020). "International high-risk clone of multidrug-resistant CTX-M-8-producing Escherichia coli C-ST410 infecting an elephant (Loxodonta africana) in a zoo." J Glob Antimicrob Resist **22**: 643-645.

Gatti, R. C. and A. Velichevskaya (2020). "Certified "sustainable" palm oil took the place of endangered Bornean and Sumatran large mammals habitat and tropical forests in the last 30 years." Science of the Total Environment **742**.
> Tropical forests inhabited by endangered orangutans, rhinos, tigers, and elephants in South-east Asia are threatened by deforestation, including oil palm expansion. Certification has been proposed to label sustainable palm oil production. However, from a remotely sensed time-series and imagery analysis (1984-2020), we discovered that most of the currently certified grower supply bases and concessions in Sumatra and Borneo are located in the 1990s large mammals habitat and in areas that were biodiverse tropical forests less than 30 years ago. In light of this dramatic evidence, we suggest that certification schemes claim for the "sustainable" production of palm oil just because they neglect a very recent past of deforestation and habitat degradation. (C) 2020 Elsevier B.V. All rights reserved.

Glaeser, S. S., et al. (2020). "Effects of physiological changes and social life events on adrenal glucocorticoid activity in female zoo-housed Asian elephants (Elephas maximus)." PLoS ONE **15**(11): e0241910.
> Ensuring good health and welfare is an increasingly important consideration for conservation of endangered species and includes breeding of individuals managed under human care. Understanding how factors in the captive environment affect individual animal wellbeing can be aided by long-term monitoring of biological functioning. This study involved longitudinal assessments (4 to 28 years) of reproductive and adrenal hormones in zoo-housed female Asian elephants (Elephas maximus) (age range 4 to ~71 years) to elucidate patterns in adrenal glucocorticoid (GC) activity in association with reproductive and demographic factors, and examine individual response to major social changes. Concentrations of serum and urinary cortisol covaried more consistently with physiological changes (ovarian cycle phase, puberty, pregnancy, lactational anestrus, and age) than with social life events (births, deaths, and facility transfers). Cortisol fluctuated across the ovarian cycle with mean concentrations being higher in the follicular than in the luteal phase, and concentrations were highest in lactational anestrous compared to all other reproductive states. The elephants in this study exhibited substantial individuality in adrenal GC response to major social change, reinforcing the need to assess welfare on an individual basis and to consider factors influencing the impact of perceived stressors, such as social relationships, social support, temperament, and life history. Outcomes from this study deepen our understanding of Asian elephant physiology and highlight the importance of taking intrinsic patterns of hormone secretion into account when evaluating the impact of external factors. Finally, a better understanding of the impact of social change and resiliency in response to real and perceived

stressors allows us to improve social management to enhance welfare in both captive settings and free-ranging environments.

Goldenberg, S. Z. and G. Wittemyer (2020). "Elephant behavior toward the dead: A review and insights from field observations." <u>Primates</u> **61**(1): 119-128.
Many nonhuman animals have been documented to take an interest in their dead. A few socially complex and cognitively advanced taxa-primates, cetaceans, and proboscideans-stand out for the range and duration of behaviors that they display at conspecific carcasses. Here, we review the literature on field observations of elephants at carcasses to identify patterns in behaviors exhibited. We add to this literature by describing elephant responses to dead elephants in the Samburu National Reserve, northern Kenya. The literature review indicated that behavior of elephants at carcasses most often included approaches, touching, and investigative responses, and these occurred at varying stages of decay, from fresh carcasses to scattered and sun-bleached bones. During our own observations, we also witnessed elephants visiting and revisiting carcasses during which they engaged in extensive investigative behavior, stationary behavior, self-directed behavior, temporal gland streaming, and heightened social interactions with other elephants in the vicinity of a carcass. Elephants show broad interest in their dead regardless of the strength of former relationships with the dead individual. Such behaviors may allow them to update information regarding their social context in this highly fluid fission-fusion society. The apparent emotionality and widely reported inter-individual differences involved in elephant responses to the dead deserve further study. Our research contributes to the growing discipline of comparative thanatology to illuminate the cognition and context of nonhuman animal response to death, particularly among socially complex species.

Goldenberg, S. Z. and G. Wittemyer (2020). "Elephant behavior toward the dead: A review and insights from field observations." <u>Primates</u> **61**(1): 119-128.
Many nonhuman animals have been documented to take an interest in their dead. A few socially complex and cognitively advanced taxa—primates, cetaceans, and proboscideans—stand out for the range and duration of behaviors that they display at conspecific carcasses. Here, we review the literature on field observations of elephants at carcasses to identify patterns in behaviors exhibited. We add to this literature by describing elephant responses to dead elephants in the Samburu National Reserve, northern Kenya. The literature review indicated that behavior of elephants at carcasses most often included approaches, touching, and investigative responses, and these occurred at varying stages of decay, from fresh carcasses to scattered and sun-bleached bones. During our own observations, we also witnessed elephants visiting and revisiting carcasses during which they engaged in extensive investigative behavior, stationary behavior, self-directed behavior, temporal gland streaming, and heightened social interactions with other elephants in the vicinity of a carcass. Elephants show broad interest in their dead regardless of the strength of former relationships with the dead individual. Such behaviors may allow them to update information regarding their social context in this highly fluid fission–fusion society. The apparent emotionality and widely reported inter-individual differences involved in elephant responses to the dead deserve further study. Our research contributes to the growing discipline of comparative thanatology to illuminate the cognition and context of nonhuman animal response to death, particularly among socially complex species. © 2019, This is a U.S. government work and not under copyright protection in the U.S.; foreign copyright protection may apply.

Goosen, W. J., et al. (2020). "The VetMAX™ M. tuberculosis complex PCR kit detects MTBC DNA in antemortem and postmortem samples from white rhinoceros (Ceratotherium simum), African elephants (Loxodonta africana) and African buffaloes (Syncerus caffer)." <u>BMC Vet Res</u> **16**(1): 220.
BACKGROUND: Bovine tuberculosis and tuberculosis are chronic infectious diseases caused by the Mycobacterium tuberculosis complex members, Mycobacterium bovis and Mycobacterium tuberculosis, respectively. Infection with M. bovis and M. tuberculosis have significant implications for wildlife species management, public health, veterinary disease control, and conservation endeavours. RESULTS: Here

we describe the first use of the VetMAX™ Mycobacterium tuberculosis complex (MTBC) DNA quantitative real-time polymerase chain reaction (qPCR) detection kit for African wildlife samples. DNA was extracted from tissues harvested from 48 African buffaloes and MTBC DNA was detected (test-positive) in all 26 M. bovis culture-confirmed animals with an additional 12 PCR-positive results in culture-negative buffaloes (originating from an exposed population). Of six MTBC-infected African rhinoceros tested, MTBC DNA was detected in antemortem and postmortem samples from five animals. The PCR was also able to detect MTBC DNA in samples from two African elephants confirmed to have M. bovis and M. tuberculosis infections (one each). Culture-confirmed uninfected rhinoceros and elephants' samples tested negative in the PCR assay. CONCLUSIONS: These results suggest this new detection kit is a sensitive screening test for the detection of MTBC-infected African buffaloes, African elephants and white rhinoceros.

Goosen, W. J., et al. (2020). "The Xpert MTB/RIF Ultra assay detects Mycobacterium tuberculosis complex DNA in white rhinoceros (Ceratotherium simum) and African elephants (Loxodonta africana)." Sci Rep **10**(1): 14482.

The study describes the novel use of the Xpert MTB/RIF Ultra assay for detection of Mycobacterium tuberculosis complex (MTBC) DNA in samples from white rhinoceros (Ceratotherium simum) and African elephants (Loxodonta africana). Culture negative respiratory sample matrices were spiked to determine if the Ultra could detect MTBC DNA in rhinoceros and elephant samples. Rhinoceros bronchial alveolar lavage fluid (BALF) was found to have an inhibitory effect on the Ultra. In this study, the limit of detection (LOD) of M. tuberculosis H37Rv in all spiked animal samples were 2 CFU/ml compared to 15.6 CFU/ml for humans, while the LOD for M. bovis SB0121 was 30 CFU/ml compared to 143.4 CFU/ml for M. bovis BCG in humans. Screening was performed on stored tissue and respiratory samples from known MTBC-infected animals and MTBC DNA was detected in 92% of samples collected from six rhinoceros and two elephants. Conversely, 83% of culture-negative tissue and respiratory samples from uninfected animals tested negative on the Ultra. In conclusion, the Ultra assay appears to be a sensitive and rapid diagnostic test for the detection of MTBC DNA from tissue and respiratory samples collected from African elephants and rhinoceros. Furthermore, the Ultra assay could provide a new tool for the detection of MTBC in various sample types from other wildlife species.

Greene, A. M., et al. (2020). "Asian elephant self-medication as a source of ethnoveterinary knowledge among Karen mahouts in northern Thailand." J Ethnopharmacol **259**: 112823.

ETHNOPHARMACOLOGICAL RELEVANCE: Ethnoveterinary medicine is often assumed to be a subset of human medicinal knowledge. Here we investigate the possibility that some ethnoveterinary medicine rather originates from observations of animal self-medication. We document and analyze the ethnoveterinary medicine used by Karen mahouts for elephant care and attempt to determine whether this knowledge originated from humans or elephants. MATERIALS AND METHODS: Elephant camp owners and mahouts in four communities in northern Thailand were interviewed about their knowledge and use of plants for ethnoveterinary elephant care. For each ethnoveterinary plant, data were collected on Karen human medicinal uses and whether elephants independently consume them. Based on overlaps between ethnoveterinary use, human medicinal use and elephant dietary use, plants were classified into three categories: those that originated from Karen human medicine, those that originated from Asian elephant self-medication, and those which were present in both human and elephant knowledge traditions. RESULTS: The use of 34 plants (32 identified at least to genus) and two additional non-plant remedies (salt and human urine) were reported to be used in ethnoveterinary elephant medicine. A total of 44 treatments in 11 use categories were recorded: tonic, wounds, compress, eye problems, indigestion, broken bones, galactagogue, snakebite, fatigue, skin and musth regulation. Of the ethnoveterinary plants, 55% had the same use in human medicine, 43% had different uses and 2% had no use. Elephants consume 84% of the ethnoveterinary plants as part of their natural diet. DISCUSSION: Analysis indicates that 32% of plant uses likely originated from Karen human medicine, 60% of plant uses likely existed independently in both human and elephant knowledge systems, and 8% of plant uses likely originated from elephant self-medicating behavior. The tonic use

category shows the strongest evidence of influence from observations of elephant self-medication. The use of tonic medicines appears to be increasing as a way to mitigate the unnaturally limited diet of elephants in tourist camps. CONCLUSION: Ethnoveterinary medicine for elephant care is influenced by both human medicinal knowledge and elephant knowledge of plants for self-medication. The ethnoveterinary knowledge domain appears to be the result of an interactive process linked to convergent evolution or co-evolution between humans and Asian elephants.

Greene, A. M., et al. (2020). "Asian elephant self-medication as a source of ethnoveterinary knowledge among Karen mahouts in northern Thailand." J Ethnopharmacol **259**.

Ethnopharmacological relevance: Ethnoveterinary medicine is often assumed to be a subset of human medicinal knowledge. Here we investigate the possibility that some ethnoveterinary medicine rather originates from observations of animal self-medication. We document and analyze the ethnoveterinary medicine used by Karen mahouts for elephant care and attempt to determine whether this knowledge originated from humans or elephants. Materials and methods: Elephant camp owners and mahouts in four communities in northern Thailand were interviewed about their knowledge and use of plants for ethnoveterinary elephant care. For each ethnoveterinary plant, data were collected on Karen human medicinal uses and whether elephants independently consume them. Based on overlaps between ethnoveterinary use, human medicinal use and elephant dietary use, plants were classified into three categories: those that originated from Karen human medicine, those that originated from Asian elephant self-medication, and those which were present in both human and elephant knowledge traditions. Results: The use of 34 plants (32 identified at least to genus) and two additional non-plant remedies (salt and human urine) were reported to be used in ethnoveterinary elephant medicine. A total of 44 treatments in 11 use categories were recorded: tonic, wounds, compress, eye problems, indigestion, broken bones, galactagogue, snakebite, fatigue, skin and musth regulation. Of the ethnoveterinary plants, 55% had the same use in human medicine, 43% had different uses and 2% had no use. Elephants consume 84% of the ethnoveterinary plants as part of their natural diet. Discussion: Analysis indicates that 32% of plant uses likely originated from Karen human medicine, 60% of plant uses likely existed independently in both human and elephant knowledge systems, and 8% of plant uses likely originated from elephant self-medicating behavior. The tonic use category shows the strongest evidence of influence from observations of elephant self-medication. The use of tonic medicines appears to be increasing as a way to mitigate the unnaturally limited diet of elephants in tourist camps. Conclusion: Ethnoveterinary medicine for elephant care is influenced by both human medicinal knowledge and elephant knowledge of plants for self-medication. The ethnoveterinary knowledge domain appears to be the result of an interactive process linked to convergent evolution or co-evolution between humans and Asian elephants. © 2020 Elsevier B.V.

Grenus, B. G., et al. (2020). "EVALUATION OF THE EFFICACY OF TWO DIFFERENT SAMPLING SITES FOR THE DETECTION OF ELEPHANT ENDOTHELIOTROPIC HERPESVIRUS (EEHV) IN THREE ASIAN ELEPHANTS (ELEPHAS MAXIMUS) IN IRELAND." J Zoo Wildl Med **51**(2): 303-307.

Elephant endotheliotropic herpesvirus (EEHV) causes a disease that primarily affects juvenile Asian (Elephas maximus) elephants, causing acute hemorrhage and death. Due to the severity of the disease, many zoos have developed EEHV active surveillance programs. Currently, trunk washes are the standard for testing elephants for shedding of EEHV, but it has also been detected from other mucosal surfaces. This study compared the efficacy of oral swabs and trunk washes for the detection of EEHV shedding using previously validated quantitative polymerase chain reaction (qPCR) methods. Oral swab and trunk wash samples from three juvenile elephants at the Dublin Zoo in Ireland were collected in tandem and tested from April to September 2017. Of the 51 paired samples, 21 trunk wash samples were positive for EEHV1, while only 2 of the oral swab samples were positive for EEHV1, suggesting that trunk wash samples are more effective for detecting shedding of EEHV in Asian elephants compared with oral swabs.

Grotto, C. E., et al. (2020). "Physiological measure of animal welfare in relation to semi-captive African

Elephant (Loxodonta africana) interaction programs." <u>African Zoology</u> **55**(3): 245-249.

> Elephant interaction programs, specifically ones that provide elephant back riding, have come under public scrutiny, and little information exists to show whether these activities affect animal welfare. This study examined the impact of human interactions and ride-based activities on physiological stress-related indicators in African elephants. Fifteen trained semi-captive elephants, as well as free-ranging elephants roaming under the same ecological conditions, were monitored. Faecal samples were collected over a nine-month period from both groups and these were analysed using an enzyme immunoassay detecting faecal glucocorticoid metabolites (fGCMs) with a 5 beta-alpha-ol-11-one structure. Elephants that participated in elephant-back-safari (EBS) activities showed significant decreases in fGCM concentrations when EBS were discontinued. Similarly, fGCM concentrations of the trained semi-captive individuals that did not participate in EBS showed decreased steroid concentrations over the same time. Overall, fGCM concentrations of the trained semi-captive herd and the free-ranging herd did not differ significantly. The collected data will help to better understand the physiological and behavioural requirements of semi-captive elephants with frequent exposure to humans. The findings will also help to optimise management strategies for wild elephant populations and elephants living in controlled environments on reserves exposed to wildlife tourism.

Grzyb, J. and K. Pawlak (2020). "Impact of bacterial aerosol, particulate matter, and microclimatic parameters on animal welfare in Chorzów (Poland) zoological garden." <u>Environ Sci Pollut Res Int</u>.

> Zoos are very popular facilities visited by entire families with children, who come there to watch live animals. Zoos also provide workplaces for a large number of people directly looking after the animals. For places designed to house animals, regardless of whether they are farm animals, pets, or zoo animals, a higher concentration of both dust and potentially harmful bioaerosols can be expected. Unfortunately, there are almost no studies concerning the concentration of bacterial bioaerosols and particulate matter in animal shelters that would answer the question whether the level of these pollutants is constant or variable and dependent on a particular zoo, group of animals, their number in enclosures, or season. This study aimed to assess the levels of bacterial aerosol in rooms intended for animals (giraffes, camels, elephants, kangaroos, and colobinae) in the Silesian Zoological Garden in Chorzów (Poland). The bioaerosol samples were collected using a six-stage Andersen cascade impactor to assess the concentrations and size distribution of airborne bacteria. Particulate matter (PM10) was assessed using an electronic dust meter. Measurements of microclimate parameters were carried out using the Airflow™ Instruments Velocity Meter TA440, while gas concentrations were determined applying GFG Microtector II G450. The results showed that the concentration of airborne bacteria varied significantly between facilities for the analyzed animal groups. The lowest concentration of the total bacterial aerosol was observed in enclosures for colobinae (approx. 850 CFU/m(3)), while the highest-in rooms for elephants (approx. 105,600 CFU/m(3)). The average share of respirable fraction of bacteria was quite high, with values ranging from 62.9 (colobinae) to 86.9% (elephants), indicating potential harmfulness to the health of exposed people. PM10 concentrations were relatively low (10-86 µg/m(3)) and did not exceed the limit values for occupational exposure. Moreover, the levels of bacterial bioaerosol in almost all cases did not exceed the limit values. As the animals constitute a significant source of bioaerosol, attention should be paid to thorough cleaning of animals and their shelters, as well as maintaining appropriate levels of microclimate parameters in the facilities.

Guntawang, T., et al. (2020). "In vivo characterization of target cells for acute elephant endotheliotropic herpesvirus (EEHV) infection in Asian elephants (Elephas maximus)." <u>Sci Rep</u> **10**(1): 11402.

> Elephant endotheliotropic herpesvirus-hemorrhagic disease (EEHV-HD) is a dangerous viral infectious disease in young Asian elephants. Despite hypotheses underlying pathogenesis of the disease, it is unclear which cell types the virus targets during acute or persistent infections. This study investigated the tissues and target cells permissive for EEHV infection and replication in vivo. Rabbit polyclonal antibodies against the non-structural proteins of EEHV, DNA polymerase (EEHV DNAPol), were generated and validated. These were used to examine EEHV infection and replication in various tissues of acute EEHV-HD cases and compared to an EEHV-negative control. The results indicated

that viral antigens were distributed throughout the epithelia of the alimentary tract and salivary glands, endothelia and smooth muscle cells, and monocytic lineage cells of the EEHV-infected elephants. Moreover, EEHV DNAPol proteins were also found in the bone marrow cells of the EEHV1A-HD and EEHV1A/4-HD cases. This study demonstrated for the first time the target cells that favor in vivo EEHV replication during acute infection, providing a promising foundation for investigating EEHV propagation in vitro.

Haile, M., et al. (2020). "Comparison of the Antioxidant Activities and Volatile Compounds of Coffee Beans Obtained Using Digestive Bio-Processing (Elephant Dung Coffee) and Commonly Known Processing Methods." Antioxidants (Basel) **9**(5).

There are different types of coffee processing methods. The wet (WP) and dry processing (DP) methods are widely practiced in different parts of coffee-growing countries. There is also a digestive bioprocessing method in which the most expensive coffee is produced. The elephant dung coffee is produced using the digestive bioprocessing method. In the present experiment, the antioxidant activity and volatile compounds of coffee that have been processed using different methods were compared. The antioxidant activity, total phenolic content (TPC), total flavonoid content (TFC), and total tannin content (TTC) of green coffee beans from all treatments were higher as compared to roasted coffee beans. Regarding the green coffee beans, the 2,2-diphenyl-1-picrylhydrazyl (DPPH) radical scavenging activity of elephant dung coffee beans was higher as compared to that of the DP and WP coffee beans. The green coffee beans had higher DPPH activity and ferric reducing antioxidant power (FRAP) value compared to the roasted coffee beans. The green beans of elephant dung coffee had a high TPC than the beans obtained by WP and DP methods. TFC in elephant dung coffee in both green and roasted condition was improved in contrast to the beans processed using dry and wet methods. The elephant dung coffee had an increased TTC in comparison to the DP and WP coffee (green beans). About 37 volatile compounds of acids, alcohols, aldehydes, amide, esters, ethers, furans, furanones, ketones, phenols, pyrazines, pyridines, Heterocyclic N, and pyrroles functional classes have been found. Some of the most abundant volatile compounds detected in all treatments of coffee were 2-furanmethanol, acetic acid, 2-methylpyrazine, 2,6-dimethylpyrazine, pyridine, and 5-methylfurfural. Few volatile compounds have been detected only in elephant dung coffee. The principal component analysis (PCAs) was performed using the percentage of relative peak areas of the volatile compound classes and individual volatile compounds. This study will provide a better understanding of the impacts of processing methods on the antioxidants and volatile compounds of coffee.

Hambrecht, S., et al. (2020). "Diurnal variation of salivary cortisol in captive African elephants (Loxodonta africana) under routine management conditions and in relation to a translocation event." Zoo Biol **39**(3): 186-196.

The present study assessed the diurnal variation in salivary cortisol in captive African elephants during routine management (baseline) and in relation to a potential stressor (translocation) to evaluate to what extent acute stress may affect diurnal cortisol patterns. Under baseline conditions, we collected morning and afternoon saliva samples of 10 animals (three zoos) on different days in two study periods (n = 3-10 per animal, daytime and period). Under stress conditions, we sampled the transported cow (newcomer) and the two cows of the destination zoo before and after the transport in the morning and afternoon (n = 3-9 per animal, daytime and transport phase), as well as after the first introduction of the newcomer to the bull (n = 1 per animal). Cortisol was measured in unextracted samples by enzyme immunoassay. Under baseline conditions, we observed the expected diurnal variation with higher cortisol levels in the morning than in the afternoon. Under stress conditions, neither a significant difference between pre- and posttransport, nor between morning and afternoon levels was found. The percentage difference between morning and afternoon cortisol after the transport, however, was remarkably lower than before the transport in the newcomer potentially indicating a stress response to familiarization. Saliva samples taken immediately after the introduction of the newcomer to the bull revealed a marked cortisol increase. Our findings indicate that stressors may disturb the diurnal cortisol rhythm. Furthermore, provided that samples can be collected promptly, salivary cortisol is a useful

minimally invasive measure of physiological stress in the African elephant.

Hamdan, A., et al. (2020). "A preliminary study of mirror-induced self-directed behaviour on wildlife at the Royal Belum Rainforest Malaysia." <u>Sci Rep</u> **10**(1): 14105.

> Mirror-induced behaviour has been described as a cognitive ability of an animal to self-direct their image in front of the mirror. Most animals when exposed to a mirror responded with a social interactive behaviour such as aggressiveness, exploratory and repetitive behaviour. The objective of this study is to determine the mirror-induced self-directed behaviour on wildlife at the Royal Belum Rainforest, Malaysia. Wildlife species at the Royal Belum Rainforest were identified using a camera traps from pre-determined natural saltlick locations. Acrylic mirrors with steel frame were placed facing the two saltlicks (Sira Batu and Sira Tanah) and the camera traps with motion-detecting infrared sensor were placed at strategically hidden spot. The behavioural data of the animal response to the mirror were analysed using an ethogram procedure. Results showed that barking deer was the species showing the highest interaction in front of the mirror. Elephants displayed self-directed response through inspecting behaviour via usage of their trunk and legs while interacting to the mirror. Interestingly, the Malayan tapir showed startled behaviour during their interaction with the mirror. However, the absence of interactive behaviour of the Malayan tiger signalled a likelihood of a decreased social response behaviour. These results suggested that the ability to self-directed in front of the mirror is most likely related to the new approach to study the neural mechanism and its level of stimulus response in wildlife. In conclusion, research on mirror-induced self-directed behaviour in wildlife will have profound implications in understanding the cognitive ability of wildlife as an effort to enhance the management strategies and conservation.

Hariohay, K. M., et al. (2020). "Human-elephant interactions in areas surrounding the Rungwa, Kizigo, and Muhesi Game Reserves, central Tanzania." <u>Oryx</u> **54**(5): 612-620.

> This study assesses the patterns of crop damage by elephantsLoxodonta africanain areas adjacent to the Rungwa, Kizigo and Muhesi Game Reserves in Tanzania. We used a questionnaire survey to collect data from a total of 210 household heads from seven villages, with 30 household heads in each village, during June-August 2015. Proximity was a significant factor influencing losses, with crop farms within < 1 km from the reserves having higher losses, followed by those 1-5 km and > 5 km distant. Most households (81.0%) < 1 km from a reserve reported crop damage whereas those within 1-5 km

(65.9%) and > 5 km (20.0%) reported less damage. Most of the losses (79.8%) occurred in the first half of the year (the wet season). Immigrants reported higher average losses to crops than Indigenous respondents. Noise making, flashlights, setting fire around fields and disturbance by shooting were the methods used to deter elephants from entering crop fields. We recommend that communities around these game reserves avoid areas that are < 1 km from the reserve boundary, plant crops such as chilli, use honeybeeApis melliferafences to deter elephants from their crops, and receive education on available mitigation methods, to help minimize crop losses to elephants.

Haynes, G., et al. (2020). "A Study of Fractured Proboscidean Bones in Recent and Fossil Assemblages." Journal of Archaeological Method and Theory.

Reliable methods are needed to distinguish anthropogenic from non-anthropogenic causes of proboscidean limb bone breakage in fossil assemblages because of theoretical uncertainty about human-proboscidean relationships in the Pleistocene. This paper compares experimentally broken bones of African elephants (Loxodonta africana) and mammoths (Mammuthusspp.) after establishing that limb bone fracture dynamics are the same for those proboscidean taxa. We show that features thought exclusively diagnostic of percussive fracturing of green proboscidean long bones such as notched fracture edges, smooth fracture surfaces, and curvilinear fracture outlines also can be created on non-green bones and on bones affected by non-anthropogenic processes. The information reported here can be applied in analyses or re-analyses of fossil proboscidean bone assemblages and may either support or potentially alter current interpretations of hominin behavior.

He, C., et al. (2020). "Population viability analysis of small population: a case study for Asian elephant in China." Integr Zool.

Small populations are at risk of extinction from deterministic and stochastic factors. Less than 250 Asian elephants (Elephas maximus) remain in China, and are distributed in a few isolated areas; yet, population viability analyses of this endangered population have not been conducted. Here, the current genetic status of the Pu'Er-Mengyang Asian elephant populations in China was analyzed, and the risk of extinction was predicted over the next 500 years. Factors affecting the viability of this population were determined through simulations. The genetic diversity of the population was very low (mean allele number: 3.1; expected heterozygosity: 0.463), even though a recent population bottleneck was not detected. The effective population size was approximately 24.1 adult elephants. Enough adult breeding individuals exist to maintain population viability. VORTEX simulation model showed that this population would not go extinct in the next 500 years. However, illegal poaching and harvesting could negatively affect population size. A sensitivity analysis showed that the mean stochastic growth rate of the study population is sensitive to sex ratio, number of breeding females, mortality of females of different age classes, carrying capacity, and lethal equivalents. Based on our results, we suggest that action should be taken to alleviate inbreeding and any further loss of genetic diversity, by connecting fragmented elephant habitat or by translocating individual elephants. In addition, human-elephant conflict should be mitigated using various modern approaches, including crop guarding techniques, and by encouraging farmers to switch to crops and income sources not vulnerable to elephant raids.

He, C., et al. (2020). "Population viability analysis of small population: a case study for Asian elephant in China." Integr Zool **15**(5): 350-362.

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Hengtrakul, P., et al. (2020). "Biological and environmental factors associated with the detection of elephant endotheliotropic herpesvirus in Asian elephants (Elephas maximus) in Thailand." J Vet Med Sci **82**(12): 1808-1815.

Elephant endotheliotropic herpesvirus (EEHV) infection is one of the most common diseases in young elephants, causing severe fatal hemorrhagic disease. Subclinical infection was previously described; however, information about the factors associated with virus shedding and reactivation were scarce. To identify the biological and environmental factors related with EEHV detection, blood and oral swab samples were collected from nine captive Asian elephants in Thailand for one year and tested for EEHV presence using real-time PCR. Data including hematological values, management, environmental temperature, and serum cortisol levels were also recorded and analyzed. Results showed that the viral detection frequency ranged from 0-25%. The highest detection frequency was found in the two youngest elephants, aged less than 15 years. Three types of viruses, EEHV1, EEHV4, and EEHV5, were found in this study, which also detected mixed infection in five elephants. Additionally, the study found that sample type, changes in hematological values, management and health issues, and serum cortisol levels were not associated with herpesvirus detection in the elephants. However, EEHV detection percentage was significantly increased in the summer (mid-Feb to mid-May), possibly due to body fitness reduction from food source limitation and low nutrient content. To obtain a broad aspect of EEHV management, long-term EEHV monitoring is highly recommended in every captive elephant herd.

Hertel, A. G., et al. (2020). "A guide for studying among-individual behavioral variation from movement data in the wild." Mov Ecol **8**: 30.

Animal tracking and biologging devices record large amounts of data on individual movement behaviors in natural environments. In these data, movement ecologists often view unexplained variation around the mean as "noise" when studying patterns at the population level. In the field of behavioral ecology, however, focus has shifted from population means to the biological underpinnings of variation around means. Specifically, behavioral ecologists use repeated measures of individual behavior to partition behavioral variability into intrinsic among-individual variation and reversible behavioral plasticity and to quantify: a) individual variation in behavioral types (i.e. different average behavioral expression), b) individual variation in behavioral plasticity (i.e. different responsiveness of individuals to environmental gradients), c) individual variation in behavioral predictability (i.e. different residual within-individual variability of behavior around the mean), and d) correlations among these components and correlations in suites of behaviors, called 'behavioral syndromes'. We here suggest that partitioning behavioral variability in animal movements will further the integration of movement ecology with other fields of behavioral ecology. We provide a literature review illustrating that individual differences in movement behaviors are insightful for wildlife and conservation studies and give recommendations regarding the data required for addressing such questions. In the accompanying R tutorial we provide a guide to the statistical approaches quantifying the different aspects of among-individual variation. We use movement data from 35 African elephants and show that elephants differ in a) their average behavior for three common movement behaviors, b) the rate at which they adjusted movement over a temporal gradient, and c) their behavioral predictability (ranging from more to less predictable individuals). Finally, two of the three movement behaviors were correlated into a behavioral syndrome (d), with farther moving individuals having shorter mean residence times. Though not explicitly tested here,

individual differences in movement and predictability can affect an individual's risk to be hunted or poached and could therefore open new avenues for conservation biologists to assess population viability. We hope that this review, tutorial, and worked example will encourage movement ecologists to examine the biology of individual variation in animal movements hidden behind the population mean.

Hlokwe, T. M. and R. M. Mogano (2020). "Utility of xpert® MTB/RIF ultra assay in the rapid diagnosis of bovine tuberculosis in wildlife and livestock animals from South Africa." Prev Vet Med **177**: 104980.
> Members of the Mycobacterium tuberculosis complex (MTBC) bacteria, mainly Mycobacterium bovis (M. bovis), cause bovine tuberculosis (bTB) in livestock and wildlife animals. Confirmation of the disease is through culture and verification of the causative agent by molecular tests. In this study, we assessed the utility of the Xpert ® MTB/RIF Ultra assay, an automated molecular test originally designed to improve the detection of tuberculosis (TB) and rifampicin resistance in clinical sputum samples of human origin, by conducting a comparative evaluation with a culture based method routinely used at the Onderstepoort Veterinary Research (OVR). A total of 167 samples (tissue, n = 165; pus, n = 1; abscess, n = 1) from different wildlife and livestock animals (from 65 individual animals) were analyzed. Mycobacterium tuberculosis complex species was isolated in 63 (37.72 %) of the 167 samples, and was detected in 79 (47.3 %) of the samples by Xpert ® MTB/RIF Ultra assay. Based on the standard culture test, the diagnostic sensitivity and specificity of the Xpert ® MTB/RIF Ultra assay was found to be 95.24 % and 82 % respectively. All animals that were confirmed bTB positive by culture method were also found to be positive with the Xpert ® MTB/RIF Ultra assay in at least one sample (indicating a 100 % sensitivity of the method at the animal level). Non-tuberculous mycobacteria were isolated in 9 (3.4 %) of the samples analysed and none were detected by Xpert ® MTB/RIF Ultra assay, highlighting that this molecular test is highly specific. Xpert ® MTB/RIF Ultra assay was found to have great potential for the rapid diagnosis of the bTB in animals, hence allowing early intervention by regulatory authorities.

Horgan, F. G. and E. P. Kudavidanage (2020). "Farming on the edge: Farmer training to mitigate human-wildlife conflict at an agricultural frontier in south Sri Lanka." Crop Protection **127**.
> Efforts to increase food production across Asia have relied on the intensification of established farms, as well as the expansion of farming activities into previously wild areas. Farms at agricultural frontiers face distinct challenges from those in historically farmed regions and require distinct support structures. We interviewed 324 rice farmers at seven sites in southern Sri Lanka to determine challenges to rice production in the region and the propensity for human wildlife conflict. Farmers (80%) reported wildlife including peafowl (Pavo cristatus) and other birds, as well as free-ranging (semi-)domestic animals such as buffalo (Bubalus bubalis), as their principal biotic constraints across sites, with relatively few farmers regarding weeds, insect pests, or diseases as a constraint (mentioned by 25% of farmers in total). Farmers near wilderness areas reported elephants (Elephas maximus) and wild boar (Sus scrofa) as major constraints to rice production. 64% of farmers had received training from government and other support agencies during the five years prior to our survey. Training mainly addressed insect pests and diseases and focused on lethal product-based solutions (88% of training). Farmers did not receive support or advice to mitigate crop foraging and human-wildlife conflict; instead, farmers relied heavily on repellence (human activated) responses, such as early warning systems and active scaring. We suggest that Agriculture, Development and Wildlife authorities might increase intergovernmental cooperation and coordination of farmer training to better manage crop foraging in our study region. We present a review of possible non-lethal, farm-based methods that could be promoted during training programs for farmers facing challenges from wildlife in such a biologically diverse region. Currently, a wide range of low-cost avoidance, barrier and deterrence systems (that are not monitored or activated by humans) are available. These can be used to avoid harmful repellence practices. © 2019 Elsevier Ltd

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Jackson, J., et al. (2020). "Changes in age-structure over four decades were a key determinant of population growth rate in a long-lived mammal." J Anim Ecol.
A changing environment directly influences birth and mortality rates, and thus population growth rates. However, population growth rates in the short term are also influenced by population age-structure. Despite its importance, the contribution of age-structure to population growth rates has rarely been explored empirically in wildlife populations with long-term demographic data. Here we assessed how changes in age-structure influenced short-term population dynamics in a semi-captive population of Asian elephants Elephas maximus. We addressed this question using a demographic dataset of female Asian elephants from timber camps in Myanmar spanning 45 years (1970-2014). First, we explored temporal variation in age-structure. Then, using annual matrix population models, we used a retrospective approach to assess the contributions of age-structure and vital rates to short-term population growth rates with respect to the average environment. Age-structure was highly variable over the study period, with large proportions of juveniles in the years 1970 and 1985, and made a substantial contribution to annual population growth rate deviations. High adult birth rates between 1970 and 1980 would have resulted in large positive population growth rates, but these were prevented by a low proportion of reproductive-aged females. We highlight that an understanding of both age-specific vital rates and age-structure is needed to assess short-term population dynamics. Furthermore, this example from a human-managed system suggests that the importance of age-structure may be accentuated in populations experiencing human disturbance where age-structure is unstable, such as those in captivity or for endangered species. Ultimately, changes to the environment drive population dynamics by influencing birth and mortality rates, but understanding demographic structure is crucial for assessing population growth.

Jakeer, S., et al. (2020). "Metagenomic analysis of the fecal microbiome of an adult elephant reveals the diversity of CAZymes related to lignocellulosic biomass degradation." Symbiosis **81**(3): 209-222.
The resident microbial population responsible for lignocellulosic biomass assimilation in the gastrointestinal tract of animals is a rich source for discovering novel biocatalysts finding application in the production of value-added commodities. Herbivorous animals, such as elephants, consume a variety of lignocellulosic materials in bulk amounts to support their high energy requirements. Since the interdependence of host diet and its microbiome is well established, it is necessary to explore the

potential resident microbes of obligate herbivores like elephants belonging to different age classes and habitats for mining enzymes involved in complex biomass deconstruction. In the present study, metagenomic analysis of an adult elephant fecal sample using whole-genome shotgun library preparation indicated the dominant representation of microbes belonging to the phylum Proteobacteria. Subsystem- and KEGG-based analyses revealed a high potential for carbohydrate metabolism and membrane transport. CAZy database analysis identified similar to 55,000 ORFs that had either catalytic domains or carbohydrate-binding modules (CBMs) in the metagenomic data set. Moreover, CBMs and carbohydrate-active enzymes (CAZymes), such as glycoside hydrolases (GHs), glycosyltransferases (GTs), carbohydrate esterases (CEs) were most abundant in microbes of phylum Proteobacieria, and among them, the majority of GHs and GTs were from Bacillus subtilis and Escherichia coli. A comparative GH analysis with other gut metagenomic datasets of herbivorous animals revealed the presence of several unique GHs of the beta-glucosidase, endoglucanase, and exoglucanase families thus providing a comprehensive understanding of the diverse CAZymes present in the gut microbiome of an adult elephant.

Janiak, M. C., et al. (2020). "Genetic evidence of widespread variation in ethanol metabolism among mammals: revisiting the 'myth' of natural intoxication." Biology Letters **16**(4).
Humans have a long evolutionary relationship with ethanol, pre-dating anthropogenic sources, and possess unusually efficient ethanol metabolism, through a mutation that evolved in our last common ancestor with African great apes. Increased exposure to dietary ethanol through fermenting fruits and nectars is hypothesized to have selected for this in our lineage. Yet, other mammals have frugivorous and nectarivorous diets, raising the possi- bility of natural ethanol exposure and adaptation in other taxa. We conduct a comparative genetic analysis of alcohol dehydrogenase class IV (ADH IV) across mammals to provide insight into their evolutionary history with ethanol. We find genetic variation and multiple pseudogenization events in ADH IV, indicating the ability to metabolize ethanol is variable. We suggest that ADH enzymes are evolutionarily plastic and show promise for revealing dietary adaptation. We further highlight the derived condition of humans and draw attention to problems with modelling the physiological responses of other mammals on them, a practice that has led to potentially erroneous con- clusions about the likelihood of natural intoxication in wild animals. It is a fallacy to assume that other animals share our metabolic adaptations, rather than taking into consideration each species' unique physiology.

Jeffrey, A., et al. (2020). "NONINVASIVE SAMPLING FOR DETECTION OF ELEPHANT ENDOTHELIOTROPIC HERPESVIRUS AND GENOMIC DNA IN ASIAN (ELEPHAS MAXIMUS) AND AFRICAN (LOXODONTA AFRICANA) ELEPHANTS." J Zoo Wildl Med **51**(2): 433-437.
Elephant endotheliotropic herpesvirus (EEHV) hemorrhagic disease (EEHV-HD) threatens Asian elephant (Elephas maximus) population sustainability in North America. Clusters of cases have also been reported in African elephants (Loxodonta africana). Risk to range country elephant populations is unknown. Currently, EEHV detection depends upon sampling elephants trained for invasive blood and trunk wash collection. To evaluate noninvasive sample collection options, paired invasively collected (blood, trunk wash and oral swabs), and noninvasively collected (chewed plant and fecal) samples were compared over 6 wk from 9 Asian elephants and 12 African elephants. EEHV shedding was detected simultaneously in a paired trunk wash and fecal sample from one African elephant. Elephant γ herpesvirus-1 shedding was identified in six chewed plant samples collected from four Asian elephants. Noninvasively collected samples can be used to detect elephant herpesvirus shedding. Longer sampling periods are needed to evaluate the clinical usefulness of noninvasive sampling for EEHV detection.

Jiang, F., et al. (2020). "Assessing the impact of climate change on the spatio-temporal distribution of foot-and-mouth disease risk for elephants." Global Ecology and Conservation **23**.
Elephants are the largest extant terrestrial animals and are important for maintaining regional ecosystem balance and community diversity. However, poaching, population growth, habitat

fragmentation, and viruses are major threats to global elephant populations. Foot-and-mouth disease (FMD) is one of the major threats to the health of elephants. Global warming has a serious impact on wildlife and accelerates the spread of viruses. In this study, the effects of climate change on the risk of disease in elephants were evaluated based on 1833 sites with reported FMD cases. Maximum entropy (MaxEnt) was used to model the current and future geographic distributions of FMD and to assess the risk of FMD in elephants under climate change. The results showed that the average annual temperature and annual precipitation were higher in elephant habitats than in the range of the FMD virus. The mean temperature in the driest quarter, temperature seasonality, annual mean temperature, and precipitation in the driest month had relatively large contributions to the risk of FMD, with a cumulative contribution rate of 82.8%. Both Asian elephants and African elephants had high overlap with the FMD virus with respect to altitude, annual mean temperature, and annual precipitation. An overall high risk of disease was detected at a certain band, mainly concentrated from 10 degrees N to 50 degrees N in the northern hemisphere and from 10 degrees S to 35 degrees S in the southern hemisphere. The risk of FMD was higher for the Asian elephant than the African elephant. The FMD risk increased gradually from the southeast to northwest in habitats of the Asian elephant, and presented a pattern of high northesouth risk and low intermediate risk in the habitats of the African elephant. The area proportions of high risk, medium risk, and low risk in the distribution of both the Asian elephant and African elephant were all higher than the proportions of all risk types worldwide. Under global warming, the FMD risk was not expected to change significantly in most of the habitat areas of the Asian elephant or the African elephant in the 2050s and 2070s. Moreover, the areas and proportions of high risk, medium risk, and low risk were likely to change slightly. These results could benefit the conservation of elephants and provide relevant data for the prevention of FMD in high-risk areas under climate change. (c) 2020 The Author(s). Published by Elsevier B.V. This is an open access article under the CC BY license (http://creativecommons.org/licenses/by/4.0/).

Jim, H. L., et al. (2020). "Investigating Indirect and Direct Reputation Formation in Asian Elephants (Elephas maximus)." <u>Front Psychol</u> **11**: 604372.
>	Reputation is a key component in social interactions of group-living animals and appears to play a role in the establishment of cooperation. Animals can form a reputation of an individual by directly interacting with them or by observing them interact with a third party, i.e., eavesdropping. Elephants are an interesting taxon in which to investigate eavesdropping as they are highly cooperative, large-brained, long-lived terrestrial mammals with a complex social organisation. The aim of this study was to investigate whether captive Asian elephants (Elephas maximus) could form reputations of humans through indirect and/or direct experience in two different paradigms: (1) a cooperative string-pulling task and (2) a scenario requiring begging. Fourteen captive Asian elephants in Thailand participated in an experimental procedure that consisted of three parts: baseline, observation, and testing. In the observation phase, the subject saw a conspecific interact with two people-one cooperative/generous and one non-cooperative/selfish. The observer could then choose which person to approach in the test phase. The elephants were tested in a second session 2-5 days later. We found no support for the hypothesis that elephants can form reputations of humans through indirect or direct experience, but these results may be due to challenges with experimental design rather than a lack of capacity. We discuss how the results may be due to a potential lack of ecological validity in this study and the difficulty of assessing motivation and attentiveness in elephants. Furthermore, we highlight the importance of designing future experiments that account for the elephants' use of multimodal sensory information in their decision-making.

Kambe, J., et al. (2020). "Analysis of infant microbiota composition and the relationship with breast milk components in the Asian elephant (Elephas maximus) at the Zoo." <u>J Vet Med Sci</u>.
>	The prevention of diseases through health control is essential at zoos. Recently, the gut microbiota, which is an ecosystem consisting of the bacteria living in the digestive tract, has been found to be one of the key systems that mediates animal health. However, there is little basic knowledge about gut microbiota in zoo animals, particularly the relationship between mothers and infants during lactation.

Here, we investigated the formation of the gut microbiota during infancy in an Asian elephant (Elephas maximus) in Okinawa Zoo and compared the composition between infant and mother. In addition, we analyzed the components of breast milk and examined the correlation with the infant gut microbiota. Analysis revealed that the gut microbiota of the infant contained high amount of Lactobacillales and its diversity was relatively low compared to that of the mother. We found several milk components, such as lactose, threonine and estradiol-17β, which showed a positive correlation with the change of Lactobacillales during the lactation period. In conclusion, the present study sheds light on the mechanism of gut microbiota formation during infancy in an Asian elephant and provides important insights into the health control of Asian elephants in zoos.

Kambe, J., et al. (2020). "Analysis of infant microbiota composition and the relationship with breast milk components in the asian elephant (Elephas maximus) at the zoo." <u>Journal of Veterinary Medical Science</u> **82**(7): 983-989.

> The prevention of diseases through health control is essential at zoos. Here, we investigated the gut microbiota formation during infancy in an Asian elephant and compared the composition between infant and mother. Besides, we analyzed the components of breast milk and examined the correlation with the infant gut microbiota. Analysis revealed the gut microbiota of the infant contained high amount of Lactobacillales and its diversity was relatively low compared to that of the mother. We found several milk components, showed a positive correlation with the change of Lactobacillales. The present study revealed the mechanism of gut microbiota formation during infancy in an Asian elephant and provides important insights into the health control of Asian elephants in zoos. © 2020 The Japanese Society of Veterinary Science.

Karanth, K. K. and A. Vanamamalai (2020). "Wild Seve: A Novel Conservation Intervention to Monitor and Address Human-Wildlife Conflict." <u>Frontiers in Ecology and Evolution</u> **8**.

> Human-wildlife interactions resulting in conflict remains a global conservation challenge, requiring innovative solutions to ensure the persistence of wildlife amidst people. Wild Seve was established in July 2015 as a conservation intervention program to assist people affected by conflict to file and monitor claims and receive ex-gratia payments from the Indian government. In 48 months of operation, Wild Seve filed and tracked 13,808 claims on behalf of those affected from 19 forest ranges around the Bandipur and Nagarahole National Parks in Karnataka, India. This included 10,082 incidents of crop loss, 1,176 property damage incidents, and 1,720 incidents where crop and property loss occurred together. Wild Seve also filed claims for 782 livestock predation incidents, and assisted in 45 human injury incidents and three human fatalities. Elephant related losses comprised 93.9%, and big cat losses comprised 5.5% of reported cases. Wild Seve provides an immediate response to human-wildlife conflict incidents and improves access to ex-gratia payment schemes. Wild Seve is a low cost intervention that uses open-source technology and leverages existing policies to facilitate ex-gratia payments. The Wild Seve model of monitoring and addressing human-wildlife conflict is adaptable and scalable to high conflict regions globally, to the benefit of people and wildlife. © Copyright © 2020 Karanth and Vanamamalai.

Kartzinel, T. R. and R. M. Pringle (2020). "Multiple dimensions of dietary diversity in large mammalian herbivores." <u>J Anim Ecol</u> **89**(6): 1482-1496.

> Theory predicts that trophic specialization (i.e. low dietary diversity) should make consumer populations sensitive to environmental disturbances. Yet diagnosing specialization is complicated both by the difficulty of precisely quantifying diet composition and by definitional ambiguity: what makes a diet 'diverse'? We sought to characterize the relationship between taxonomic dietary diversity (TDD) and phylogenetic dietary diversity (PDD) in a species-rich community of large mammalian herbivores in a semi-arid East African savanna. We hypothesized that TDD and PDD would be positively correlated within and among species, because taxonomically diverse diets are likely to include plants from many lineages. By using DNA metabarcoding to analyse 1,281 faecal samples collected across multiple seasons, we compiled high-resolution diet profiles for 25 sympatric large-herbivore species. For each of

these populations, we calculated TDD and PDD with reference to a DNA reference library for local plants. Contrary to our hypothesis, measures of TDD and PDD were either uncorrelated or negatively correlated with each other. Thus, these metrics reflect distinct dimensions of dietary specialization both within and among species. In general, grazers and ruminants exhibited greater TDD, but lower PDD, than did browsers and non-ruminants. We found significant seasonal variation in TDD and/or PDD for all but four species (Grevy's zebra, buffalo, elephant, Grant's gazelle); however, the relationship between TDD and PDD was consistent across seasons for all but one of the 12 best-sampled species (plains zebra). Our results show that taxonomic generalists can be phylogenetic specialists, and vice versa. These two dimensions of dietary diversity suggest contrasting implications for efforts to predict how consumers will respond to climate change and other environmental perturbations. For example, populations with low TDD may be sensitive to phylogenetically 'random' losses of food species, whereas populations with low PDD may be comparatively more sensitive to environmental changes that disadvantage entire plant lineages-and populations with low dietary diversity in both taxonomic and phylogenetic dimensions may be most vulnerable of all.

Karuppannan, K. V., et al. (2020). "SEX RATIO AND AGE STRUCTURE PATTERNS OF ASIAN ELEPHANTS FROM PENINSULAR MALAYSIA REVEALED BY NON-INVASIVE SURVEYS." Journal of Animal and Plant Sciences-Japs **30**(6): 1415-1423.

An effective conservation and management plan of Asian elephants in Peninsular Malaysia relies on understanding the population biology and ecology of the species. Since molecular genetic tools have been developed and widely used for elephant conservation, the Malaysian Department of Wildlife and National Parks (DWNP) aimed to obtain estimates of population size, individual identification and sex specific gene flow among elephant populations in Taman Negara National Parks (TNNP) in line with one of the long-term goals in the National Elephant Conservation Action Plan (NECAP). In this study, we apply non-invasive molecular techniques to sex Asian elephant faecal and we combine it with measurement of bolus dimensions to get reliable baseline information on sex ratio as well their age structure in TNNP. Peninsular Malaysia populations. Two Y chromosome specific fragments (SRY1 and AMEL Y2) and one X chromosome specific fragment (PLP1) were used to determine the sex of the elephants that were detected during our surveys in the TNNP study locations. A total of 217 fresh faecal samples from 31 sampling sites and measurements of each bolus circumference were analysed. Faecal samples from 10 elephant individuals of known sex from the National Elephant Conservation Centre (NECC), Kuala Gandah were included as controls. We identified 86 males and 131 females in TNNP via molecular sexing approach. In addition, to estimating the sex ratio in TNNP, we also categorized the different sexes into three different age classes by measuring mean of bolus circumference. Neonates/juveniles (Class 1) and sub-adults (Class 2) were composed of approximately an even number of males and females. However, our results of sexing, boli from adults (Class 3) revealed a lower number of males with 40 individuals compared to 84 females. This female biased sex ratio in adults could be due to poaching pressure on male adults around the study areas. Alternatively, we could have failed to detect more males because bulls are known to be more solitary and roam further in deeper forest areas away from their matriarchal herds and far from our sampling locations during our surveys. Despite these potential issues with detection of bulls, this study provided reliable information on the sex ratio pattern and age structure of free roaming elephant populations in TNNP. This information provides valuable scientific based management tools for DWNP as well policy makers in order to make decisions for future elephant conservation management plans in TNNP.

Kido, N., et al. (2020). "Emotion estimation using a wearable heart rate monitoring device in Asian elephants (Elephas maximus) during veterinary clinical procedures." J Vet Med Sci **82**(6): 856-860.

Fatal accidents in captive elephants occasionally occur because humans are unable to gauge elephants' emotions solely by their behavior. The intellectual capacity of elephants makes them capable of understanding circumstantial changes and associated emotions, allowing them to react accordingly. Physiological markers, such as heart rate variability, may be effective in determining an elephant's emotional state. In this study, a wearable heart rate monitor was used to determine the

emotional state of a female Indian captive elephant (Elephas maximus indicus). The average heart rate was higher when the elephant underwent painful treatment than when it underwent non-painful treatment. In addition, the heart rate increased both before and after the treatment, which included radiography and blood collection.

Kiffner, C., et al. (2020). "Community-based wildlife management area supports similar mammal species richness and densities compared to a national park." Ecol Evol **10**(1): 480-492.
Community-based conservation models have been widely implemented across Africa to improve wildlife conservation and livelihoods of rural communities. In Tanzania, communities can set aside land and formally register it as Wildlife Management Area (WMA), which allows them to generate revenue via consumptive or nonconsumptive utilization of wildlife. The key, yet often untested, assumption of this model is that economic benefits accrued from wildlife motivate sustainable management of wildlife. To test the ecological effectiveness (here defined as persistence of wildlife populations) of Burunge Wildlife Management Area (BWMA), we employed a participatory monitoring approach involving WMA personnel. At intermittent intervals between 2011 and 2018, we estimated mammal species richness and population densities of ten mammal species (African elephant, giraffe, buffalo, zebra, wildebeest, waterbuck, warthog, impala, Kirk's dik-dik, and vervet monkey) along line transects. We compared mammal species accumulation curves and density estimates with those of time-matched road transect surveys conducted in adjacent Tarangire National Park (TNP). Mammal species richness estimates were similar in both areas, yet observed species richness per transect was greater in TNP compared to BWMA. Species-specific density estimates of time-matched surveys were mostly not significantly different between BWMA and TNP, but elephants occasionally reached greater densities in TNP compared to BWMA. In BWMA, elephant, wildebeest, and impala populations showed significant increases from 2011 to 2018. These results suggest that community-based conservation models can support mammal communities and densities that are similar to national park baselines. In light of the ecological success of this case study, we emphasize the need for continued efforts to ensure that the BWMA is effective. This will require adaptive management to counteract potential negative repercussions of wildlife populations on peoples' livelihoods. This study can be used as a model to evaluate the effectiveness of wildlife management areas across Tanzania.

Killion, A. K., et al. (2020). "Human adaptation strategies are key to cobenefits in human-wildlife systems." Conservation Letters.
Sustainable development goals such as global food security and biodiversity conservation can conflict because these efforts create situations where humans and wildlife share landscapes, often leading to interactions that detrimentally affect both groups. Therefore, coexistence between humans and wildlife is more likely when adaptation strategies produce and sustain cobenefits, rather than benefitting one group only. However, we lack a good understanding of how different social and ecological factors contribute to cobenefit outcomes, which limits our opportunities to address local issues and scale up successful conservation actions. Here, we performed the first global review of the human-wildlife interaction literature to assess which human adaptation strategies generated cobenefits and how stakeholder involvement and other context-specific conditions mediated those outcomes. We found that active guarding, fencing, repellents, and socioeconomic mechanisms consistently led to cobenefits across species and contexts. Thus, these interventions might be the best candidates for scaling up coexistence from local to regional or national scales. Surprisingly, stakeholder involvement was less consequential than other variables, yet, overall, it played an important role in sustaining cobenefits regardless of adaptation strategy or social-ecological context. We highlight future research directions to help manage tradeoffs and achieve sustainable coexistence outcomes in shared landscapes.

King'ori, E., et al. (2020). "Patterns of helminth infection in Kenyan elephant populations." Parasit Vectors **13**(1): 145.
BACKGROUND: The dynamics of helminth infection in African elephant populations are poorly known. We examined the effects of age, sex, social structure and the normalized difference vegetation index

(NDVI) as primary drivers of infection patterns within and between elephant populations. METHODS: Coprological methods were used to identify helminths and determine infection patterns in distinct elephant populations in Maasai Mara National Reserve, Tsavo East National Park, Amboseli National Park and Laikipia-Samburu Ecosystem. Gaussian finite mixture cluster analyses of egg dimensions were used to classify helminth eggs according to genera. Generalized linear models (GLM) and Chi-square analyses were used to test for variation in helminth infection patterns and to identify drivers in elephant populations. RESULTS: Helminth prevalence varied significantly between the studied populations. Nematode prevalence (96.3%) was over twice as high as that of trematodes (39.1%) in elephants. Trematode prevalence but not nematode prevalence varied between populations. Although we found no associations between helminth infection and elephant social groups (male vs family groups), the median helminth egg output (eggs per gram, epg) did vary between social groups: family groups had significantly higher median epg than solitary males or males in bachelor groups. Young males in mixed sex family groups had lower epg than females when controlling for population and age; these differences, however, were not statistically significant. The average NDVI over a three-month period varied between study locations. Cluster analyses based on egg measurements revealed the presence of Protofasciola sp., Brumptia sp., Murshidia sp., Quilonia sp. and Mammomonogamus sp. GLM analyses showed that the mean epg was positively influenced by a three-month cumulative mean NDVI and by social group; female social groups had higher epg than male groups. GLM analyses also revealed that epg varied between elephant populations: Samburu-Laikipia elephants had a higher and Tsavo elephants a lower epg than Amboseli elephants. CONCLUSIONS: Elephants had infection patterns characterized by within- and between-population variation in prevalence and worm burden. Sociality and NDVI were the major drivers of epg but not of helminth prevalence. Gastrointestinal parasites can have a negative impact on the health of wild elephants, especially during resource scarcity. Thus, our results will be important when deciding intervention strategies.

Kobayashi, R., et al. (2020). "Comparison of the fecal microbiota of two monogastric herbivorous and five omnivorous mammals." Anim Sci J **91**(1): e13366.

Fecal microbiota in seven different monogastric animal species, elephant, horse, human, marmoset, mouse, pig and, rat were compared using the same analytical protocol of 16S rRNA metagenome. Fecal microbiota in herbivores showed higher alpha diversity than omnivores except for pigs. Additionally, principal coordinate analysis based on weighted UniFrac distance demonstrated that herbivores and pigs clustered together, whereas other animal species were separately aggregated. In view of butyrate- and lactate-producing bacteria, predominant genera were different depending on animal species. For example, the abundance of Faecalibacterium, a known butyrate producer, was 8.02% ± 3.22% in human while it was less than 1% in other animal species. Additionally, Bifidobacterium was a predominant lactate producer in human and marmoset, while it was rarely detected in other omnivores. The abundance of lactate-producing bacteria in herbivores was notably lower than omnivores. On the other hand, herbivores as well as pig possess Fibrobacter, a cellulolytic bacterium. This study demonstrated that fecal microbiota in herbivorous animals is similar, sharing some common features such as higher alpha diversity and higher abundance of cellulolytic bacterium. On the other hand, omnivorous animals seem to possess unique fecal microbiota. It is of interest that pigs, although omnivore, have fecal microbiota showing some common features with herbivores.

Kobeni, S., et al. (2020). "The Dynamic Changes of African Elephant Milk Composition over Lactation." Animals (Basel) **10**(6).

The combined data of milk composition of 14 African elephants over 25 months of lactation are presented. The milk density was constant during lactation. The total protein content increased with progressing lactation, with caseins as the predominant protein fraction. The total carbohydrates steadily decreased, with the oligosaccharides becoming the major fraction. Lactose and isoglobotriose reached equal levels at mid lactation. The milk fat content increased during lactation, as did the caprylic and capric acids, while the 12 carbon and longer fatty acids decreased. The fatty acid composition of the milk phospholipids fluctuated, and their total saturated fatty acid composition was low compared to the

triacylglycerides. The milk ash and content of the major minerals, Na, K, Mg, P, and Ca, increased. Vitamin content was low, Vitamin E occurred in quantifiable amounts, with traces of vitamins A, D3, and K. The energy levels of African elephant milk did not change much in the first ten months of lactation, but they increased thereafter due to the increase in protein and fat content. The overall changes in milk composition appeared to be in two stages: (a) strong changes up to approximately 12 months of lactation and (b) little or no changes thereafter.

Kosaruk, W., et al. (2020). "Effect of Tourist Activities on Fecal and Salivary Glucocorticoids and Immunoglobulin A in Female Captive Asian Elephants in Thailand." Animals : an open access journal from MDPI **10**(10).

Asian elephants have been an important part of wildlife ecotourism in Thailand for over two decades. Elephants in tourist camps are exposed to a variety of management styles and daily activities that can potentially affect health and welfare. This study investigated relationships between a novel welfare biomarker, immunoglobulin A (IgA), and daily camp activities, and compared results to glucocorticoid (GC) measures. Often no-riding camps are portrayed as providing better welfare than camps that offer riding. Therefore, we predicted that elephants at no-riding camps would have lower GC and higher IgA concentrations, and a low GC/IgA ratio. Forty-four female elephants from six elephant camps were divided into three groups based on riding activities: saddle-riding, bareback-riding, and no-riding. Fecal and salivary samples were collected monthly for 1 year along with evaluations of body condition, foot health, and wounding. Camp environment and management varied among camps, although the major difference was in riding activities. Concentrations of GCs and IgA varied among the working groups, but not always consistently between sample matrices. Overall fecal glucocorticoid metabolite concentrations were lowest in the saddle-riding group. Only in one bareback-riding camp did the elephants exhibit a potentially positive welfare response with a low GC/IgA ratio over time. Other results varied between the two biomarkers, with considerable variability across camps, suggesting there is more to good welfare than whether elephants participate in riding or not. Several other human-induced stressors, like chaining, ankus use, and limited social opportunities are likely to be impacting well-being and should be considered to ensure management practices meet physical and psychological welfare needs.

Kouakou, J. L., et al. (2020). "Ivory Coast without ivory: Massive extinction of African forest elephants in Côte d'Ivoire." PLoS ONE **15**(10): e0232993.

In pre-colonial and colonial times Côte d'Ivoire probably hosted one of the largest elephant populations in West Africa, resulting in the country's name Côte d'Ivoire (in English Ivory Coast) by French settlers. Numbers declined and by the early 90s it was estimated that the total number of both savannah and forest elephants had reached 63 to 360 elephants in the entire country. Here we present updated information on the distribution and conservation status of forest elephant in Côte d'Ivoire based on multiple sources-dung counts on line transects, records of human-elephant conflict, media reports, sign and interview surveys-obtained during the period 2011-2017. We used Pearson correlation to determine the correlation between the presence of forest elephant and site variables (size of the forest, percentage of area converted into plantation, size of the forest left, size of human population inside the PA, poaching index, distance to the nearest road, population density in the Department, level of protection of the PA). To examine the effect of ecological traits on elephant extirpation, we used Principal Components Analysis (PCA) to check for multicollinearity among variables. Based on dung count elephant presence was confirmed in only 4 of the 25 protected areas surveyed. PAs with higher level of protection have higher probability to be home of elephant population. The viability of these populations is uncertain, since they have a small size and are isolated. Aggressive conservation actions including law enforcement for the protection of their remaining habitat and ranger patrolling are needed to protect the remaining forest elephant populations.

Lasky, M., et al. (2020). "Increasing browse and social complexity can improve zoo elephant welfare." Zoo Biology.

While recent work has assessed how environmental and managerial changes influence elephant welfare across multiple zoos, few studies have addressed the effects of management changes within a single institution. In this paper, we examine how management changes related to social structure and diet affect the behavior of a group of zoo elephants over a 23-month period while also considering underlying factors, such as time of day, hormonal cycle, and individual differences. We recorded individual behaviors using 2-min scan samples during 60-min sessions. We analyzed behavioral changes across several study variables using generalized linear mixed models. We found that increasing browse can improve opportunities for foraging throughout the day but may not be sufficient to reduce repetitive behaviors. We observed that increasing group size and integration of bulls with cows can lead to increased social interaction in African elephants. Our results highlight the importance of using multiple management alterations to address elephant welfare, and considering environmental factors, when making management decisions.

Lefeuvre, M., et al. (2020). "Behavioural variability among captive African elephants in the use of the trunk while feeding." PeerJ **8**: e9678.

The Proboscideans, an order of mammals including elephants, are the largest of the Earth lands animals. One probable consequence of the rapid increase of their body size is the development of the trunk, a multitask highly sensitive organ used in a large repertoire of behaviours. The absence of bones in the trunk allows a substantial degree of freedom for movement in all directions, and this ability could underlie individual-level strategies. We hypothesised a stronger behavioural variability in simple tasks, and a correlation between the employed behaviours and the shape and size of the food. The observations of a captive group of African elephants allowed us to create a complete catalogue of trunk movements in feeding activities. We noted manipulative strategies and impact of food item properties on the performed behaviours. The results show that a given item is manipulated with a small panel of behaviours, and some behaviours are specific to a single shape of items. The study of the five main feeding behaviours emphasises a significant variability between the elephants. Each individual differed from every other individual in the proportion of at least one behaviour, and every behaviour was performed in different proportions by the elephants. Our findings suggest that during their lives elephants develop individual strategies adapted to the manipulated items, which increases their feeding efficiency.

Lohay, G. G., et al. (2020). "Genetic connectivity and population structure of African savanna elephants (Loxodonta africana) in Tanzania." Ecol Evol **10**(20): 11069-11089.

Increasing human population growth, exurban development, and associated habitat fragmentation is accelerating the isolation of many natural areas and wildlife populations across the planet. In Tanzania, rapid and ongoing habitat conversion to agriculture has severed many of the country's former wildlife corridors between protected areas. To identify historically linked protected areas, we investigated the genetic structure and gene flow of African savanna elephants in Tanzania using microsatellite and mitochondrial DNA markers in 688 individuals sampled in 2015 and 2017. Our results indicate distinct population genetic structure within and between ecosystems across Tanzania, and reveal important priority areas for connectivity conservation. In northern Tanzania, elephants sampled from the Tarangire-Manyara ecosystem appear marginally, yet significantly isolated from elephants sampled from the greater Serengeti ecosystem (mean F (ST) = 0.03), where two distinct subpopulations were identified.Unexpectedly, elephants in the Lake Manyara region appear to be more closely related to those across the East African Rift wall in the Ngorongoro Conservation Area than they are to the neighboring Tarangire subpopulations. We concluded that the Rift wall has had a negligible influence on genetic differentiation up to this point, but differentiation may accelerate in the future because of ongoing loss of corridors in the area. Interestingly, relatively high genetic similarity was found between elephants in Tarangire and Ruaha although they are separated by >400 km. In southern Tanzania, there was little evidence of female-mediated gene flow between Ruaha and Selous, probably due to the presence of the Udzungwa Mountains between them. Despite observing evidence of significant isolation, the populations of elephants we examined generally exhibited robust levels of allelic richness

(mean A (R) = 9.96), heterozygosity (mean μH (E) = 0.73), and effective population sizes (mean N (e) = 148). Our results may inform efforts to restore wildlife corridors between protected areas in Tanzania in order to facilitate gene flow for long-term survival of elephants and other species.

Lohay, G. G., et al. (2020). "Genetic connectivity and population structure of African savanna elephants (Loxodonta africana) in Tanzania." Ecol Evol **10**(20): 11069-11089.

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Lueders, I. and W. R. T. Allen (2020). "Managed wildlife breeding-an undervalued conservation tool?" Theriogenology **150**: 48-54.

Knowledge of and the technologies and resources applied to the ex situ care for wildlife have improved greatly in recent years. This has resulted in numerous successes bringing back populations from the brink of extinction by the reintroduction or restoration of animals from conservation breeding programmes. Controlled breeding of wildlife by humans is discussed controversially in society and in scientific circles and it faces a number of significant challenges. When natural breeding fails, Assisted Reproduction Technologies (ART) have been postulated to increase reproductive output and maintain genetic diversity. Furthermore, technical advances have improved the potential for successful collection and cryopreservation of gametes and embryos in many wildlife species. With the aim of creating a better understanding of why ex situ and in situ conservation of threatened species must complement each other, and under which circumstances ART provide additional tools in the rescue of a threatened population, we elucidate the current situation here by using as examples three different megavertebrate families: elephantidae, rhinoceridae and giraffidae. These mammal families consist of charismatic species, and most of their members are currently facing dramatic declines in population numbers. On the basis of these and other examples, we highlight the importance of captive zoo and other managed wildlife populations for species survival in a human dominated world. Without the possibility to study reproductive physiology in trained or habituated captive individuals, major advances made in wildlife ART during the past 20 years would not have been possible. This paper reviews the benefits and future challenges of large mammal conservation breeding and examines the role of assisted reproduction in such efforts. © 2020 Elsevier Inc.

Luther, I., et al. (2020). "Sperm motility, kinematics, morphometry and morphology over two seasons in free-ranging African elephants (Loxodonta africana)." Reprod Fertil Dev **32**(4): 425-438.
> This study aimed to address the lack of information on quantitative semen and sperm characteristics of free-ranging African elephants. Nineteen ejaculates were collected from 12 elephant bulls by means of electroejaculation in spring (Season 1, end of dry season, n=7) and in autumn (Season 2, end of rainy season, n=12). While most elephant cows are in oestrus in the rainy season, it is not evident whether sperm quality also improves during this period. Semen samples were assessed using computer-aided sperm analysis (CASA), brightfield microscopy and transmission electron microscopy. Seasonal differences and individual variation in sperm quality of bulls were apparent, with ejaculates collected during Season 2 revealing higher percentages for total motility, progressive motility, rapid-swimming spermatozoa and kinematic parameters compared with Season 1 (P<0.05). Although normal sperm morphology percentage was similar over the two seasons, more sperm tail defects were found in Season 2 (P<0.05). The baseline reference data and multivariate sperm parameter associations reported in this study can be used to predict elephant bull sperm quality and potential to fertilise. It is clear that CASA can detect subtle differences in sperm quality of African elephant ejaculates and should be the approach for future investigations.

Maicher, V., et al. (2020). "Effects of disturbances by forest elephants on diversity of trees and insects in tropical rainforests on Mount Cameroon." Sci Rep **10**(1): 21618.
> Natural disturbances are essential for tropical forests biodiversity. In the Afrotropics, megaherbivores have played a key role before their recent decline. Contrastingly to savanna elephants, forest elephants' impact on ecosystems remains poorly studied. Few decades ago, forests on Mount Cameroon were divided by lava flows, not being crossed by a local population of forest elephants until now. We assessed communities of trees, butterflies and two guilds of moths in the disturbed and undisturbed forests split by the longest lava flow. We surveyed 32 plots, recording 2025 trees of 97 species, and 7853 insects of 437 species. The disturbed forests differed in reduced tree density, height, and high canopy cover, and in increased DBH. Forest elephants' selective browsing and foraging also decreased tree species richness and altered their composition. The elephant disturbance increased butterfly species richness and had various effects on species richness and composition of the insect groups. These changes were likely caused by disturbance-driven alterations of habitats and species composition of trees. Moreover, the abandonment of forests by elephants led to local declines of range-restricted butterflies. The recent declines of forest elephants across the Afrotropics probably caused similar changes in forest biodiversity and should be reflected by conservation actions.

Manchip, K. E. L., et al. (2020). "Unilateral phacoemulsification in a captive African elephant (Loxodonta africana)." Open Vet J **9**(4): 294-300.
> BACKGROUND: The following case reports describe the clinical presentation, surgical protocol, post-operative care, and long-term follow-up of an African elephant (Loxodonta Africana) presenting with a unilateral cataract. CASE DESCRIPTION: A 42-year-old female African elephant presented for the assessment of ocular discomfort and visual deterioration in the left eye. Pre-surgical treatment included topical anti-inflammatory medication for 20 days prior to surgery. On the day of surgery, following anesthetic induction, a two-handed phacoemulsification technique was performed in the left eye. She was left aphakic post-operatively. Nine days post-operatively, the patient had an intact menace response, dazzle reflex, and direct pupillary light reflex. Fundoscopy at that stage was unremarkable. Follow-up information was available for 5 years, from the time of surgery to the present day. CONCLUSION: Despite remaining aphakic, this case presents a successful visual outcome. To the best of the authors' knowledge, there is no other published report of phacoemulsification in a captive elephant.

Manger, P. R. and J. M. Siegel (2020). "Do all mammals dream?" J Comp Neurol.
> The presence of dreams in human sleep, especially in REM sleep, and the detection of physiologically similar states in mammals has led many to ponder whether animals experience similar sleep mentation.

Recent advances in our understanding of the anatomical and physiological correlates of sleep stages, and thus dreaming, allow a better understanding of the possibility of dream mentation in nonhuman mammals. Here, we explore the potential for dream mentation, in both non-REM and REM sleep across mammals. If we take a hard-stance, that dream mentation only occurs during REM sleep, we conclude that it is unlikely that monotremes, cetaceans, and otariid seals while at sea, have the potential to experience dream mentation. Atypical REM sleep in other species, such as African elephants and Arabian oryx, may alter their potential to experience REM dream mentation. Alternatively, evidence that dream mentation occurs during both non-REM and REM sleep, indicates that all mammals have the potential to experience dream mentation. This non-REM dream mentation may be different in the species where non-REM is atypical, such as during unihemispheric sleep in aquatic mammals (cetaceans, sirens, and Otariid seals). In both scenarios, the cetaceans are the least likely mammalian group to experience vivid dream mentation due to the morphophysiological independence of their cerebral hemispheres. The application of techniques revealing dream mentation in humans to other mammals, specifically those that exhibit unusual sleep states, may lead to advances in our understanding of the neural underpinnings of dreams and conscious experiences.

Manthi, F. K., et al. (2020). "Late Middle Pleistocene Elephants from Natodomeri, Kenya and the Disappearance ofElephas(Proboscidea, Mammalia) in Africa." Journal of Mammalian Evolution **27**(3): 483-495.
Comparative morphometric study of recently recovered fossil elephant molars from Natodomeri, Kenya identifies them as belonging toElephas jolensisand confirms the presence of this species in Members I and II of the Kibish Formation. Improved datation of these geological units constrains them between 205 and 130 ka.Elephas jolensisis also reported from localities in northern, northwestern, eastern, and southern Africa. Thus, including its Natodomeri occurrence,E. jolensisappears to have been pan-African in distribution. Despite the wide geographic distribution of the species, molars ofE. jolensisare remarkably uniform morphometrically. They are characterized by their extreme hypsodonty, high amplitude of enamel folding, high lamellar frequency, and plates that are anteroposteriorly thick relative to transverse valley interval spacing. In addition, they exhibit only a modest number of plates (<20 in M3/m3).Elephas jolensiseither evolved from or represents the last stage ofElephas recki, the dominant elephant species in East Africa during the late Pliocene-Pleistocene. The dental morphology and isotopic composition ofE. jolensisindicates that, likeE. recki, it was a dedicated grazer. In the Kibish Formation,E. jolensisis succeeded byLoxodonta africanaat 130 ka, coincident with an intensely cool, dry interval marked by episodes of extreme drought. This marked the extirpation ofElephason the continent. The intensity and increased rate of climate fluctuation may have played an important role in the demise of the specialist, grazingE. recki-E. jolensislineage in favor of a generalist, mixed feeder such asL. africana.

Marston, C. G., et al. (2020). "'Remote' behavioural ecology: do megaherbivores consume vegetation in proportion to its presence in the landscape?" PeerJ **8**: e8622.
Examination of the feeding habits of mammalian species such as the African elephant (Loxodonta africana) that range over large seasonally dynamic areas is exceptionally challenging using field-based methods alone. Although much is known of their feeding preferences from field studies, conclusions, especially in relation to differing habits in wet and dry seasons, are often contradictory. Here, two remote approaches, stable carbon isotope analysis and remote sensing, were combined to investigate dietary changes in relation to tree and grass abundances to better understand elephant dietary choice in the Kruger National Park, South Africa. A composited pair of Landsat Enhanced Thematic Mapper satellite images characterising flushed and senescent vegetation states, typical of wet and dry seasons respectively, were used to generate land-cover maps focusing on the forest to grassland gradient. Stable carbon isotope analysis of elephant faecal samples identified the proportion of C(3) (typically browse)/C(4) (typically grass) in elephant diets in the 1-2 days prior to faecal deposition. The proportion of surrounding C(4) land-cover was extracted using concentric buffers centred on faecal sample locations, and related to the faecal %C(4) content. Results indicate that elephants consume C(4) vegetation in proportion to its availability in the surrounding area during the dry season, but during the

rainy season there was less of a relationship between C(4) intake and availability, as elephants targeted grasses in these periods. This study illustrates the utility of coupling isotope and cost-free remote sensing data to conduct complementary landscape analysis at highly-detailed, biologically meaningful resolutions, offering an improved ability to monitor animal behavioural patterns at broad geographical scales. This is increasingly important due to potential impacts of climate change and woody encroachment on broad-scale landscape habitat composition, allowing the tracking of shifts in species utilisation of these changing landscapes in a way impractical using field based methods alone.

McGowan, J., et al. (2020). "Conservation prioritization can resolve the flagship species conundrum." Nat Commun **11**(1): 994.

Conservation strategies based on charismatic flagship species, such as tigers, lions, and elephants, successfully attract funding from individuals and corporate donors. However, critics of this species-focused approach argue it wastes resources and often does not benefit broader biodiversity. If true, then the best way of raising conservation funds excludes the best way of spending it. Here we show that this conundrum can be resolved, and that the flagship species approach does not impede cost-effective conservation. Through a tailored prioritization approach, we identify places containing flagship species while also maximizing global biodiversity representation (based on 19,616 terrestrial and freshwater species). We then compare these results to scenarios that only maximized biodiversity representation, and demonstrate that our flagship-based approach achieves 79-89% of our objective. This provides strong evidence that prudently selected flagships can both raise funds for conservation and help target where these resources are best spent to conserve biodiversity.

Midgley, J. J., et al. (2020). "Mass sterilization of a common palm species by elephants in Kruger National Park, South Africa." Sci Rep **10**(1): 11719.

Chronic herbivory by elephants rarely eliminates any species of woody savanna plants because these plants are typically vigorous basal resprouters after damage by fire or herbivory. In some instances, resprouting after elephant herbivory even increases stem numbers per unit area compared to protected areas. It is thus difficult to know whether an area has been severely degraded by elephant herbivory or not because although trees may be severely reduced in size, they will still be present and may even be relatively dense. By using an elephant exclosure in the Kruger National Park, South Africa, we demonstrate that this resprouting ability masks the fact that entire populations of a widespread African palm, Hyphaene petersiana, are prevented from reaching sexual maturity by chronic elephant herbivory. Besides sterilizing these palms and thus preventing their evolution and seed dispersal, the absence of the palm fruits, flowers and tall stems has other negative biodiversity impacts on their associated fauna. We suggest that to determine sustainable elephant impacts on savanna plants, conservation managers also use the reproductive condition of savanna plants rather than their presence, height or stem density.

Moehlman, P. D., et al. (2020). "Long-term historical and projected herbivore population dynamics in Ngorongoro crater, Tanzania." PLoS ONE **15**(3): e0212530.

The Ngorongoro Crater is an intact caldera with an area of approximately 310 km2 located within the Ngorongoro Conservation Area (NCA) in northern Tanzania. It is known for the abundance and diversity of its wildlife and is a UNESCO World Heritage Site and an International Biosphere Reserve. Long term records (1963-2012) on herbivore populations, vegetation and rainfall made it possible to analyze historic and project future herbivore population dynamics. NCA was established as a multiple use area in 1959. In 1974 there was a perturbation in that resident Maasai and their livestock were removed from the Ngorongoro Crater. Thus, their pasture management that was a combination of livestock grazing and fire was also removed and 'burning' stopped being a regular occurrence until it was resumed in 2001 by NCA management. The Maasai pasture management would have selected for shorter grasses and more palatable species. Vegetation mapping in 1966-1967 recorded predominately short grasslands. Subsequent vegetation mapping in the crater in 1995 determined that the grassland structure had changed such that mid and tall grasses were dominant. After removal of the Maasai

pastoralists from the Ngorongoro Crater in 1974, there were significant changes in population trends for some herbivore species. Buffalo, elephant and ostrich numbers increased significantly during 1974-2012. The zebra population was stable from 1963 to 2012 whereas population numbers of five species declined substantially between 1974 and 2012 relative to their peak numbers during 1974-1976. Grant's and Thomson's gazelles, eland, kongoni, and waterbuck (wet season only) declined significantly in the Crater in both seasons after 1974. In addition, some herbivore species were consistently more abundant inside the Crater during the wet than the dry season. This pattern was most evident for the large herbivore species requiring bulk forage, i.e., buffalo, eland, and elephant. Even with a change in grassland structure, total herbivore biomass remained relatively stable from 1963 to 2012, implying that the crater has a stable carrying capacity. Analyses of rainfall indicated that there was a persistent cycle of 4.83 years for the annual component. Herbivore population size was correlated with rainfall in both the wet and dry seasons. The relationships established between the time series of historic animal counts in the wet and dry seasons and lagged wet and dry season rainfall series were used to forecast the likely future trajectories of the wet and dry season population size for each species under three alternative climate change scenarios.

Molenaar, F. and W. Schaftenaar (2020). "Should we treat elephants with EEHV?" <u>Vet Rec</u> **186**(7): 222.

Muir, Y. S. S., et al. (2020). "Retrospective anti-tetanus antibody responses of zoo-based Asian elephants (Elephas maximus) and rhinoceros (Rhinocerotidae)." <u>Dev Comp Immunol</u> **114**: 103841.
    Tetanus toxoids (TT) commercially available for use in horses and livestock are commonly used to vaccinate elephants and rhinoceros that are in human care. Although recommendations for booster intervals have changed in human and horse protocols to reduce the risks associated with hyper-immunity (i.e. B-cell anergy and hypersensitivity reactions) these have generally not been adopted in zoo protocols. Additionally, there is no evidence to demonstrate commercial TT immunogenicity in rhinoceros. In this study, a preliminary analysis of rhinoceros antibody responses to TT was conducted, in addition to an exploration of the impact of various booster frequencies on antibody responses in elephant. Retrospective analysis of archived serum samples was conducted for 9 Asian elephants (Elephas maximus), 7 southern black (Diceros bicornis minor), one southern white (Ceratotherium simum simum), and two greater one-horned (Rhinoceros unicornis) rhinoceros. Pre-vaccination (baseline) samples and those following priming vaccination (rhinoceros only), annual and non-annual boosters were targeted. A commercially available competitive ELISA kit was used to quantify serum anti-TT antibodies. Average baseline and post-vaccination anti-tetanus antibody concentrations were greater in elephant (92 mg/L ± 42, n = 3, N = 3; 125 ± 76, n = 82, N = 9) than in rhinoceros (47 mg/L ± 39, n = 8, N = 8; 44 mg/L ± 37, n = 16, N = 7). Rhinoceros antibody concentrations did not differ markedly following vaccinations from their naturally acquired high pre-vaccination concentrations. Eight elephants demonstrated antibody maintenance for 3-5 years without a tetanus booster. Additionally, although five out of nine elephants developed local reactions consistent with delayed type IV hypersensitivity following some boosters, there was no association between high antibody concentrations and increased incidence of adverse reactions. In addition, no decrease in antibody concentrations was detected as a result of annual vaccination in elephants, though this does not entirely rule out potential for B-cell anergy.

Musiwa, A. R. and W. Mhlanga (2020). "Human-wildlife conflict in Mhokwe Ward, Mbire District, North-East Zimbabwe." <u>African Journal of Ecology</u>.
    This research investigates the economic and social aspects of human-wildlife conflict (HWC) in Mhokwe, Mbire district, Zimbabwe. Data were collected through key informant interviews and a questionnaire survey. Most households in Mhokwe rely on crop and livestock production, and hence, HWC is an important factor affecting livelihoods. More than 60% of respondents experienced problems with lions (Panthera leoLinnaeus), spotted hyaenas (Crocuta crocutaErxleben), armoured bush crickets (Acanthoplus speiseriBrancsik) and quelea birds (Quelea queleaReichenbach). Other problem animals included elephant (Loxodonta africanaBlumenbach), vervet monkey (Chlorocebus pygerythrusCuvier),

kudu (Tragelaphus strepsicerosPallas), chacma baboon (Papio ursinusKerr), bushpig (Potamochoerus porcusLinnaeus) and common duiker (Sylvicapra grimmiaLinnaeus). Few incidences of conflicts were reported for hippopotamus (Hippopotamus amphibiusLinnaeus), side-striped jackal (Canis adustusSundevall), porcupine (Hystrix africaeaustralisPeters), nile crocodile (Crocodylus niloticusLaurenti), African wild cat (Felis lybicaForster), African python (Python sebaeGmelin) and guinea fowl (Numida meleagrisLinnaeus). Livestock and crop losses were US$45,285 and US$57,541 in 2013 and 2014, respectively. Despite the losses, most respondents had positive attitudes towards wildlife. Construction of strong kraals and implementation of integrated pest management (IPM) can contribute to conflict reduction.

Naha, D., et al. (2020). "Elephants in the neighborhood: patterns of crop-raiding by Asian elephants within a fragmented landscape of Eastern India." PeerJ **8**: e9399.
> Loss of forest cover, rise in human populations and fragmentation of habitats leads to decline in biodiversity and extinction of large mammals globally. Elephants, being the largest of terrestrial mammals, symbolize global conservation programs and co-occur with humans within multiple-use landscapes of Asia and Africa. Within such shared landscapes, poaching, habitat loss and extent of human-elephant conflicts (HEC) affect survival and conservation of elephants. HEC are severe in South Asia with increasing attacks on humans, crop depredation and property damage. Such incidents reduce societal tolerance towards elephants and increase the risk of retaliation by local communities. We analyzed a 2-year dataset on crop depredation by Asian elephants (N = 380) events in North Bengal (eastern India). We also explored the effect of landscape, anthropogenic factors (area of forest, agriculture, distance to protected area, area of human settlements, riverine patches and human density) on the spatial occurrence of such incidents.Crop depredation showed a distinct nocturnal pattern (22.00-06:00) and majority of the incidents were recorded in the monsoon and post-monsoon seasons. Results of our spatial analysis suggest that crop depredation increased with an increase in the area of forest patches, agriculture, presence of riverine patches and human density. Probability of crop depredation further increased with decreasing distance from protected areas. Villages within 1.5 km of a forest patch were most affected. Crop raiding incidents suggest a deviation from the "high-risk high-gain male biased" foraging behavior and involved proportionately more mixed groups (57%) than lone bulls (43%). Demographic data suggest that mixed groups comprised an average of 23 individuals with adult and sub adult females, bulls and calves. Crop depredation and fatal elephant attacks on humans were spatially clustered with eastern, central and western parts of North Bengal identified as hotspots of HEC. Our results will help to prioritize mitigation measures such as prohibition of alcohol production within villages, improving condition of riverine patches, changing crop composition, fencing agriculture fields, implement early warning systems around protected areas and training local people on how to prevent conflicts.

Naidoo, R., et al. (2020). "Mapping and assessing the impact of small-scale ephemeral water sources on wildlife in an African seasonal savannah." Ecol Appl.
> In many savannah regions of Africa, pronounced seasonal variability in rainfall results in wildlife being restricted to floodplains and other habitats adjacent to permanent surface water in the dry season. During the wet season, rainfall fills small-scale, ephemeral water sources that allows wildlife to exploit forage and other resources far from permanent surface water. These water sources remain difficult to quantify, however, due to their small and ephemeral nature, and as a result are rarely included in quantitative studies of wildlife distribution, abundance, and movement. Our goal was to map ephemeral water in Bwabwata National Park in Namibia using two different approaches, and to relate measures of ephemeral water to the abundance, distribution, and movement of two large wildlife species. We used high-resolution Google Earth and ESRI World imagery to visually identify waterholes. Additionally, we used Sentinel-2 satellite imagery to map ephemeral water across the study area using the Normalized Difference Water Index. With these mapped waterhole layers and data from GPS-collared individuals of African elephant (Loxodonta africana) and African buffalo (Syncerus caffer), we evaluated the importance of ephemeral water in conditioning abundance and movement of these two species. The

two approaches to mapping ephemeral water resulted in the visual identification of nearly 10,000 waterholes, and a predicted ephemeral water layer of ~76% accuracy. The inclusion of ephemeral water into models of abundance and movement resulted in improved goodness of fit relative to those without water, and water impacts on abundance and movement were among the strongest of all variables considered. The potential importance of ephemeral water in conditioning the movements and distributions of large herbivores in African savannahs has been difficult to quantify relative to vegetation drivers. Our results suggest research into ephemeral water impacts deserves more attention.

Nevo, O., et al. (2020). "Sweet tooth: Elephants detect fruit sugar levels based on scent alone." Ecol Evol. The ability to assess food quality is crucial to all organisms. Fleshy fruits are a major source of nutrients to various animals, and unlike most food sources, have evolved to be attractive and to be consumed by animals to promote seed dispersal. It has recently been established that fruit scent-the bouquet of volatile chemicals emitted by ripe fruit-is an evolved communication system between plants and animals. Further, it has been argued that chemicals that are synthesized from sugar and its products may be an honest signal for sugar content and fruit quality. Elephants are important seed dispersers for numerous species and possess an olfactory system that is likely to outperform most other animals. We tested the hypothesis that fruit scent signifies sugar content and that elephants are capable of assessing fruit sugar levels based on scent alone. Using a paired-choice test of marula fruits (Sclerocarya birrea) by semitame African elephants, we show that elephants are capable of identifying more sugar-rich fruits based on scent alone and that this is likely based on two chemical compounds: ethanol and ethyl acetate, both downstream products of sugar fermentation. These results shed light on the mechanisms driving elephant feeding ecology, plant signaling, and the coevolutionary process between angiosperms and animal seed dispersers.

Ngamkala, S., et al. (2020). "Serological study on brucellosis in captive elephants (Elephas maximus) and stray dogs in North Thailand." Veterinary world **13**(9): 1992-1997.
Background and Aim: Brucellosis is considered as an important zoonotic disease caused by various strains of Brucella in numerous host species. Although brucellosis has been reported in almost animal species, the relevance of brucellosis infection and diagnostic technique in Asian elephant (Elephas maximus) has been limited. The present serological investigation aimed to investigate the antibody response to Brucella abortus in captive Asian elephants in North Thailand. Moreover, further serological survey was also conducted to detect the antibody response to Brucella canis in stray dogs cohabiting the same area as the elephant herd. Materials and Methods: Serum samples were collected from 40 captive Asian elephants and submitted for serological analysis based on B. abortus antigen using Rose Bengal plate test (RBPT) in combination with ethylenediaminetetraacetic acid-tube agglutination test (EDTA-TAT) as a supplementary test and by commercial indirect enzyme-linked immunosorbent assay (iELISA). In addition, serum samples were also obtained from 16 stray dogs that live nearby the elephant-raising area and were tested using commercial Dot-ELISA based on B. canis antigen. Results: Serological analysis in captive Asian elephants showed 100% seronegative (40/40) from all serological tests response to B. abortus. For stray dogs, 12.5% (2/16) had a low positive reaction response to B. canis. Conclusion: The serological survey for brucellosis in Asian elephant was adapted and applied using RBPT, EDTA-TAT, and iELISA in the present study. For future evaluation, we recommended the use of a combination of serological tests with validation together with comparing by direct detection such as bacterial isolation to provide an appropriate brucellosis surveillance program in Asian elephants. In addition, the surveillance of stray dogs or multispecies habitation should be kept into considerations.

Ngorima, A., et al. (2020). "Local community benefits from elephants: Can willingness to support anti-poaching efforts be strengthened?" Conservation Science and Practice.
Poaching of Africa's elephants has led to substantial population declines over the last decade. Local communities coexisting with elephants can play an important role in strengthening protection measures against poaching. Our paper empirically examined how the spread of costs and benefits associated

with elephants, and associated ownership rights, influenced community attitudes to support anti-poaching activities. Based on surveys of 90 community members in the Zimbabwean part of the Kavango Zambezi Transfrontier Conservation Area, our results show that 92% of the respondents were unwilling to engage in conservation activities due to lack of financial gain from elephants. Local communities identified numerous benefits and costs associated with elephants. The majority (54%) of community members identified meat from the elephant as an essential benefit to their livelihoods. The most significant cost identified by the majority (60%) of respondents was crop destruction. The reported costs influenced villagers' perceptions of elephants with 71% of respondents stating that continued incurred costs has reduced their willingness to participate in conservation activities. More so, the majority (88%) of respondents indicated that these costs have led to locals supporting actions to reduce elephant numbers. Furthermore, 82% of respondents indicated a lack of remorse when an elephant was killed after destroying their crops, and 95% of community members identified that feelings of bitterness toward elephants increased as they encountered costs. Our results suggest that gaining local support for elephant conservation to be more sustainable in low income regions, the overall benefits from elephants should outweigh the costs they impose.

Nunney, L. (2020). "Resolving Peto's paradox: Modeling the potential effects of size-related metabolic changes, and of the evolution of immune policing and cancer suppression." Evol Appl **13**(7): 1581-1592.
> The intrinsic risk of cancer increases with body size and longevity; however, big long-lived species do not exhibit this increase, a contradiction named Peto's paradox. Five hypotheses potentially resolving this paradox were modeled using the multistage model of carcinogenesis. The five hypotheses were based on (1) intrinsic changes in metabolic rate with body size; adaptive increase in immune policing of (2) cancer cells or (3) cells with driver mutations; or adaptive increase in cancer suppression via (4) decreased somatic mutation rate, or (5) increased genetic control. Parameter changes needed to stabilize cancer risk in three types of cancer were estimated for tissues scaled from mouse size and longevity to human and blue whale levels. The metabolic rate hypothesis alone was rejected due to a conflict between the required interspecific effect with the observed intraspecific effect of size on cancer risk, but some metabolic change was optionally incorporated in the other models. Necessary parameter changes in immune policing and somatic mutation rate far exceeded values observed; however, natural selection increasing the genetic suppression of cancer was generally consistent with data. Such adaptive increases in genetic control of cancers in large and/or long-lived animals raise the possibility that nonmodel animals will reveal novel anticancer mechanisms.

Nyumba, T. O., et al. (2020). "Assessing impacts of human-elephant conflict on human wellbeing: An empirical analysis of communities living with elephants around Maasai Mara National Reserve in Kenya." PLoS ONE **15**(9): e0239545.
> Human-elephant conflict is an often intractable problem that threatens the contribution of conservation interventions to human wellbeing and securing livelihoods in Africa and Asia. Local human populations living in key elephant ranges are among the world's most poor and vulnerable people. In efforts to address this problem, previous studies have mainly focused on the direct impacts of conflict and applied standard regression models based on the assumption of individual-level homogeneity. More recently, human-elephant conflict has been seen to extend well beyond the physical, to the psychological and social sides of wellbeing. However, the impacts on human wellbeing have not been robustly explored, especially for local communities co-existing with elephants. We evaluated the impacts of conflicts on the wellbeing of local communities around the world-famous Masai Mara National Reserve in Kenya. We conducted 18 focus group discussions with 120 community members in different locations and administered a questionnaire survey to 367 sampled households from 26 sub-locations in Trans Mara. We used descriptive statistics with appropriate statistical tests, including propensity score matching, to evaluate the impacts of conflict on human wellbeing. Before matching, the results of the descriptive statistics showed differences between households experiencing conflicts and those without in terms of gender, age, education level, household size, benefiting from elephant conservation, main occupation and number of income sources. Our matching results indicate the

existence of a significant negative and positive impacts on four and one of our eight wellbeing indicators for households that experienced conflicts, respectively. Better conflict mitigation approaches and conservation policies need to be adopted to realize the harmonious and concurrent development of ecological and wellbeing objectives.

Oduor, S., et al. (2020). "Differing physiological and behavioral responses to anthropogenic factors between resident and non-resident African elephants at Mpala Ranch, Laikipia County, Kenya." PeerJ **8**.
Background: Heterogeneous landscapes like those of Laikipia County, Kenya consist of a mosaic of land-use types, which may exert differential physiological effects on elephants that occupy and traverse them. Understanding behavioral and physiological states of wild African elephants in response to the challenges of living in human-dominated landscapes is therefore important for conservation managers to evaluate risks imposed by elephants to humans and vice versa. Several conservation physiology tools have been developed to assess how animals respond to both natural and anthropogenic changes, and determine biological impacts. This study investigated how migratory and avoidance behavioral to vehicle presence, and vegetation quality affected fecal glucocorticoid (GC) metabolite (FGM) concentrations in African elephants at Mpala Ranch, Laikipia County, Kenya. Methods: The study compared adrenal glucocorticoid activity of resident elephants that live within Mpala (n = 57) and non-resident elephants whose space use patterns overlap several ranches (n = 99) in Laikipia County, Kenya. Fecal samples were collected for a 4-month period between April and August for analysis of FGM concentrations. Behavioral reactions to research vehicles and body condition also were assessed. Satellite images from Terra Moderate Resolution Imaging (MODIS MOD13Q1) were downloaded and processed using Google Earth Engine to calculate a Normalized Difference Vegetation Index (NDVI) as a measure of vegetation quality. Results: As expected, there was a positive correlation between avoidance behavior to vehicle presence and FGM concentrations in both resident and non-resident elephants, whereas there was an inverse relationship between FGM concentrations and NDVI values. Our study also found a positive influence of age on the FGM concentrations, but there were no relationships between FGM and sex, social group type, herd size, and body condition. However, contrary to our expectations, resident elephants had higher FGM concentrations than non-residents. Discussion: Findings reveal elephants with stronger avoidance responses to research vehicles and resident elephants with relatively smaller home ranges exhibited higher FGM concentrations within the Mpala Ranch, Kenya and surrounding areas. Higher vegetative quality within the ranges occupied by non-resident elephants in Laikipia may be one reason for lower FGM, and an indication that the non-residents are tracking better forage quality to improve energy balance and reduce overall GC output. Additionally, our study found a positive influence of age, but no other demographic variables on FGM concentrations. Finally, adrenal glucocorticoid activity was inversely related to vegetative quality. Our findings can help conservation managers better understand how behavior and environment influences the physiological states of African elephants, and how management intervention might mitigate negative human-elephant interactions.

Oo, Z. M., et al. (2020). "Elephant Endotheliotropic Herpesvirus Hemorrhagic Disease in Asian Elephant Calves in Logging Camps, Myanmar." Emerg Infect Dis **26**(1): 63-69.
In recent years, an alarming number of cases of lethal acute hemorrhagic disease have occurred in Asian elephant calves raised in logging camps in Myanmar. To determine whether these deaths were associated with infection by elephant endotheliotropic herpesvirus (EEHV), we conducted diagnostic PCR subtype DNA sequencing analysis on necropsy tissue samples collected from 3 locations. We found that EEHV DNA from 7 PCR loci was present at high levels in all 3 calves and was the same EEHV1A virus type that has been described in North America, Europe, and other parts of Asia. However, when analyzed over 5,610 bp, the strains showed major differences from each other and from all previously characterized EEHV1A strains. We conclude that these 3 elephant calves in Myanmar died from the same herpesvirus disease that has afflicted young Asian elephants in other countries over the past 20 years.

Ouso, D. O., et al. (2020). "Three-gene PCR and high-resolution melting analysis for differentiating vertebrate species mitochondrial DNA for biodiversity research and complementing forensic surveillance." Sci Rep **10**(1): 4741.

> Reliable molecular identification of vertebrate species from morphologically unidentifiable tissue is critical for the prosecution of illegally-traded wildlife products, conservation-based biodiversity research, and identification of blood-meal hosts of hematophagous invertebrates. However, forensic identification of vertebrate tissue relies on sequencing of the mitochondrial cytochrome oxidase I (COI) 'barcode' gene, which remains costly for purposes of screening large numbers of unknown samples during routine surveillance. Here, we adapted a rapid, low-cost approach to differentiate 10 domestic and 24 wildlife species that are common in the East African illegal wildlife products trade based on their unique high-resolution melting profiles from COI, cytochrome b, and 16S ribosomal RNA gene PCR products. Using the approach, we identified (i) giraffe among covertly sampled meat from Kenyan butcheries, and (ii) forest elephant mitochondrial sequences among savannah elephant reference samples. This approach is being adopted for high-throughput pre-screening of potential bushmeat samples in East African forensic science pipelines.

Padalia, H., et al. (2020). "Assessment of historical forest cover loss and fragmentation in Asian elephant ranges in India." Environ Monit Assess **191**(Suppl 3): 802.

> India is home of the largest remaining population of the Asian elephant (Elephas maximus L.) in the South and Southeast Asia. The forest loss and fragmentation is the main threat to the long-term survival of Asian elephants. In the present study, we assessed forest loss and fragmentation in the major elephant ranging provinces in India, viz., north-eastern, north-western, central, and southern since the 1930s. We quantified forest cover changes by generating and analyzing forest cover maps of 1930, 1975, and 2013, whereas fragmentation of contiguous forest areas was quantified by applying landscape metrics on the temporal forest cover maps. A total of 21.49% of the original forest cover was lost from 1930 to 1975, while another 3.19% forest cover was lost from 1975 to 2013 in the elephant ranges in India. The maximum forest loss occurred in the southern range (13,084 km(2)) followed by north-eastern (10,188 km(2)), central (5614 km(2)), and north-western (4030 km(2)) elephant ranges in the past eight decades. The forests in the central range were the most fragmented followed by southern, north-eastern, and north-western elephant ranges. The forest fragmentation in the southern range occurred at the fastest rate than central, north-eastern, and north-western ranges. The core forest areas shrunk by 39.6% from 1930 to 2013. The causative factors of forest change and situation of elephant-human conflict have been discussed. Study outcomes would be helpful in planning effective conservation strategies for Asian elephants in India.

Parker, J. M., et al. (2020). "Strongylid infection varies with age, sex, movement and social factors in wild African elephants." Parasitology **147**(3): 348-359.

> Comparing parasitic infection among individuals of wildlife populations can provide insight into factors that influence wildlife disease ecology. Strongylids are parasitic worms that infect the intestinal tract of vertebrates, and infection with strongylids can be approximated by counting strongylid eggs in dung samples. Here we tested for correlations between strongylid egg counts and 18 different individual characteristics, environmental and social factors in individually known wild African elephants. We counted more eggs in the dung samples of younger elephants and females relative to mature elephants and males. We also found that elephants spending more time outside reserves shed more strongylid eggs than elephants that were more often within reserves. Elephants that were less socially integrated, as measured by how much aggression they received from other elephants, shed fewer strongylid eggs; relatedly, socially isolated orphan elephants that had left their family shed fewer strongylid eggs than elephants that remained with their family. Our results suggest that landscapes altered by livestock grazing and social disruption caused by humans may impact parasitic infection in wildlife.

Paudel, S. and S. Sreevatsan (2020). "Tuberculosis in elephants: Origins and evidence of interspecies transmission." Tuberculosis **123**.

Tuberculosis (TB) is a devastating disease in elephants caused by either Mycobacterium tuberculosis or M. bovis. It is an ancient disease, and TB in elephants was first reported over two millennia ago in Sri Lanka. Outbreaks of TB worldwide, in captive and free-ranging elephant populations, have been recorded. Interspecies transmission of TB among elephants and humans has been confirmed in several geographic localities using spoligotyping, MIRU-VNTR analysis, and/or comparative genomics. Active surveillance of TB in wild and captive elephants and their handlers is necessary to prevent TB transmission at the elephant-human interface and to aid in the conservation of Asian and African elephants. In this review, we present an overview of diagnosis, reports of TB outbreaks in the past 25 years, TB in wild elephants, its transmission, and possible prevention and control strategies that can be applied at the elephant-human interface. © 2020

Perrin, K. L., et al. (2020). "BIOLOGICAL VARIATION of HEMATOLOGY and BIOCHEMISTRY PARAMETERS for the ASIAN ELEPHANT (ELEPHAS MAXIMUS), and APPLICABILITY of POPULATION-DERIVED REFERENCE INTERVALS." Journal of Zoo and Wildlife Medicine **51**(3): 643-651.
　　The aim of this study was to objectively evaluate the biological variation of healthy Asian elephant (Elephas maximus) hematology and biochemistry parameters, therefore enabling evidence-based clinical decision-making to improve patient management. Ten clinically healthy elephants had blood samples collected weekly for 5 wk under standardized conditions. The analytical, between-and within-individual variation, index of individuality, and reference change values were calculated using previously reported methods. Large between-individual variation and small within-individual variation for almost all parameters indicated that individual normal values should be used for interpreting blood results from Asian elephants. © Copyright 2020 by American Association of Zoo Veterinarians.

Peters, H., et al. (2020). "Risks from disease caused by Mycobacterium orygis as a consequence of Greater one-horned Rhinoceros (Rhinoceros unicornis) translocation in Nepal." Transboundary and Emerging Diseases **67**(2): 711-723.
　　The greater one-horned rhinoceros (Rhinoceros unicornis) is listed as vulnerable by the IUCN Red List. Mycobacterium orygis-associated disease was identified in a single greater one-horned rhino in Chitwan National Park in February 2015 prior to a planned translocation of five greater one-horned rhinoceros from Chitwan National Park to Bardia National Park for conservation purposes. This paper describes a qualitative disease risk analysis conducted retrospectively post-translocation for Mycobacterium orygis and this translocation, with the aim to improve the understanding of disease threats to the conservation of greater one-horned rhino. The disease risk analysis method used was devised by Sainsbury & Vaughan-Higgins (Conservation Biology, 26, 2017, 442) with modifications by Bobadilla Suarez et al (EcoHealth, 14, 2017, 1) and Rideout et al (EcoHealth, 14, 2017, 42) and included the use of a scenario tree and an analysis of uncertainty as recommended by Murray et al. (Handbook on import risk analysis for animals and animal products. Volume 1. Introduction and qualitative risk analysis, 2004), and the first time this combination of methods has been used to assess the risk from disease in a conservation translocation. The scenario tree and analysis of uncertainty increased the clarity and transparency of the analysis. Rideout et al.'s (EcoHealth, 14, 2017, 42) criteria were used to assess the source hazard and may be useful in comparative assessment of source hazards for future conservation translocations. The likelihood of release into the destination site of Mycobacterium orygis as a source hazard was estimated as of low risk, the risk of exposure of populations at the destination was of high risk and the likelihood of biological and environmental consequences was low. Overall, the risk from disease associated with Mycobacterium orygis as a result of this translocation was found to be low. Recommendations on disease risk management strategies could be improved with a better understanding of the epidemiology including the presence/absence of Mycobacterium orygis in greater one-horned rhino to develop effective disease risk management strategies.

Photichai, K., et al. (2020). "Attempt to Isolate Elephant Endotheliotropic Herpesvirus (EEHV) Using a Continuous Cell Culture System." Animals (Basel) **10**(12).

Elephant endotheliotropic herpesvirus (EEHV) infection is known to cause acute fatal hemorrhagic disease, which has killed many young Asian elephants (Elephas maximus). Until recently, in vitro isolation and propagation of the virus have not been successful. This study aimed to isolate and propagate EEHV using continuous cell lines derived from human and/or animal origins. Human cell lines, including EA. hy926, A549, U937, RKO, SW620, HCT-116 and HT-29, and animal cell lines, including CT26.CL25 and sp2/0-Ag14, were investigated in this study. Mixed frozen tissue samples of the heart, lung, liver, spleen and kidney obtained from fatal EEHV1A- or EEHV4-infected cases were homogenized and used for cell inoculation. At 6, 24, 48 and 72 h post infection (hpi), EEHV-inoculated cells were observed for cytopathic effects (CPEs) or were assessed for EEHV infection by immunoperoxidase monolayer assay (IPMA) or quantitative PCR. The results were then compared to those of the mock-infected controls. Replication of EEHV in the tested cells was further determined by immunohistochemistry of cell pellets using anti-EEHV DNA polymerase antibodies or re-inoculated cells with supernatants obtained from passages 2 or 3 of the culture medium. The results reveal that no CPEs were observed in the tested cells, while immunolabeling for EEHV gB was observed in only U937 human myeloid leukemia cells. However, quantitation values of the EEHV terminase gene, as well as those of the EEHV gB or EEHV DNA polymerase proteins in U937 cells, gradually declined from passage 1 to passage 3. The findings of this study indicate that despite poor adaptation in U937 cells, this cell line displays promise and potential to be used for the isolation of EEHV1 and EEHV4 in vitro.

Plangsangmas, T., et al. (2020). "Circadian Rhythm of Salivary Immunoglobulin A and Associations with Cortisol as A Stress Biomarker in Captive Asian Elephants (Elephas maximus)." Animals (Basel) **10**(1).
Salivary immunoglobulin A (sIgA) has been proposed as a potential indicator of welfare for various species, including Asian elephants, and may be related to adrenal cortisol responses. This study aimed to distinguish circadian rhythm effects on sIgA in male and female Asian elephants and compare patterns to those of salivary cortisol, information that could potentially have welfare implications. Subjects were captive elephants at an elephant camp in Chiang Mai province, Thailand (n = 5 males, 5 females). Salivette(®) kits were used to collect saliva from each elephant every 4 h from 06:00 to 22:00 h for 3 consecutive days (n = 15 samples/elephant). Enzyme immunoassays were used to quantify concentrations of IgA and cortisol in unextracted saliva. Circadian rhythm patterns were determined using a generalized least-squares method. Both sIgA and cortisol followed a circadian rhythm, although the patterns differed. sIgA displayed a daily quartic trend, whereas cortisol concentrations demonstrated a decreasing linear trend in concentrations throughout the day. There was no clear relationship between patterns of sIgA and salivary cortisol, implying that mechanisms of control and secretion differ. Results demonstrate for the first time that circadian rhythms affect sIgA, and concentrations follow a daily quartic pattern in Asian elephants, so standardizing time of collection is necessary.

Pontzer, H., et al. (2020). "Air temperature and diet influence body composition and water turnover in zoo-living African elephants (Loxodonta africana)." R Soc Open Sci **7**(11): 201155.
African elephants, the largest land animal, face particular physiological challenges in captivity and the wild. Captive elephants can become over- or under-conditioned with inadequate exercise and diet management. Few studies have quantified body composition or water turnover in elephants, and none to date have examined longitudinal responses to changes in diet or air temperature. Using the stable isotope deuterium oxide ((2)H(2)O), we investigated changes in body mass, estimated fat-free mass (FFM, including fat-free gut content) and body fat in response to a multi-year intervention that reduced dietary energy density for adult African elephants housed at the North Carolina Zoo. We also examined the relationship between air temperature and water turnover. Deuterium dilution and depletion rates were assayed via blood samples and used to calculate body composition and water turnover in two male and three female African elephants at six intervals over a 3-year period. Within the first year after the dietary intervention, there was an increase in overall body mass, a reduction in body fat percentage and an increase in FFM. However, final values of both body fat percentage and FFM were similar to initial values. Water turnover (males: 359 ± 9 l d(-1); females: 241 ± 28 l d(-1)) was consistent with the

allometric scaling of water use in other terrestrial mammals. Water turnover increased with outdoor air temperature. Our study highlights the physiological water dependence of elephants and shows that individuals have to drink every 2-3 days to avoid critical water loss of approximately 10% body mass in hot conditions.

Pontzer, H., et al. (2020). "Air temperature and diet influence body composition and water turnover in zoo-living African elephants (Loxodonta africana): Water turnover in African elephants." <u>Royal Society Open Science</u> **7**(11).

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Potoczniak, M. J., et al. (2020). "Development of a multiplex, PCR-based genotyping assay for African and Asian elephants for forensic purposes." <u>Int J Legal Med</u> **134**(1): 55-62.

Wildlife crimes and the threats they present to elephant populations raise the need to develop and implement DNA-based methodology as an aid for wildlife forensic investigations and conservation efforts. This study describes the development of a tetra-nucleotide repeat STR multiplex, genotyping assay that will identify Asian elephant (Elephas maximus) and African elephant (Loxodonta africana) DNA. The assay targets six tetra-nucleotide STRs and two sex-typing markers simultaneously in both genera of elephants, a first for elephant genotyping assays. The developed assay has potential application in wildlife investigations to associate a biological sample to a particular individual elephant and additionally in conservation science for population management.

Prado, N. A., et al. (2020). "Ovarian cyclicity and prolactin status of African elephants (Loxodonta africana) in North American zoos may be influenced by life experience and individual temperament." <u>Horm Behav</u> **125**: 104804.

Hyperprolactinemia is an endocrine disorder associated with infertility in many species, including elephants. In a recent survey of zoos accredited by the Association of Zoos and Aquariums (AZA), over half of African elephant females (N = 101) were not cycling normally, 30% of which exhibited hyperprolactinemia. We examined whether life experience and temperament predict ovarian cyclicity and circulating prolactin status in individual African elephant females. We hypothesized that, similar to humans, acyclicity and hyperprolactinemia in elephants will be associated with an apprehensive or fearful, anxious temperament, and an increased number of potentially challenging life events (transfers, deaths and births). Ninety-five adult African elephant females housed at 37 AZA institutions were included in this study. Blood samples were collected twice a month for 1 year to determine ovarian cycle (cycling, n = 44; irregular, n = 13; non-cycling, n = 38) and prolactin (normal, n = 44; low; n = 23; high; n = 28) status. Keeper ratings on a 6-point scale were obtained on 32 temperament traits in 85 of these elephants. We determined that giving birth and being exposed to herd mates entering the facility

were positively associated with normal ovarian cycle and prolactin profiles. By contrast, age, serum cortisol, and an increased number of herd mates leaving a facility were negatively associated with both. Contrary to our hypothesis, hyperprolactinemia was associated with a popular and caring temperament rating, whereas consistently low prolactin was associated with a fearful, apprehensive temperament. These findings indicate that pituitary-ovarian function may be impacted by life history (cyclicity) and temperament (prolactin), which should be taken into consideration when making management decisions.

Prakash, T. G. S. L., et al. (2020). "Illegal capture and internal trade of wild Asian elephants (Elephas maximus) in Sri Lanka." Nature Conservation **42**: 51-69.
> The illegal wildlife trade is considered one of the major threats to global biodiversity. Asian elephants (Elephas maximus) have been highly valued by various cultures for use in religious and spiritual contexts, as a draft animal, and more recently, as a tourist attraction. Thus, the demand for captive elephants is high. Wild Asian elephants are taken from the wild, often illegally, to maintain these captive populations due to the unviability of captive breeding programs. For the first time, we documented the extent to which wild elephants are being illegally captured and traded in Sri Lanka between January 2008 and December 2018. We collected data from case records maintained by the Sri Lanka court system where the suspects of illegal elephant trade were prosecuted in addition to information gathered by archives and interviews with various stakeholders. We documented 55 cases where elephants were illegally traded. This is probably an underestimate due to the mortality rate of elephants during capture operations, and challenges in collecting data on this highly organized illicit trade. Nearly equal numbers of male and female elephants were traded and more than 50% of them were juveniles, aged ≤5 years. Significantly more elephants were found to be seized in 2014-2015 than in the other time periods combined. We found evidence of the illegal capture of wild elephants from wildlife protected areas and state forests. More importantly, we identified evidence of corruption of wildlife officers, involvement of politicians and other high-ranking personnel in the illegal wildlife trade, and lack of active enforcement of wildlife law as major challenges to overcome if the illegal capture and domestic trade of wild elephants in Sri Lanka are to be halted. Based on our study, we make a series of recommendations that should result in implementing policy to reduce the trafficking of Asian elephants in Sri Lanka and improve the conservation management of the species. © 2020 Pensoft Publishers. All rights reserved.

Psonis, N., et al. (2020). "Molecular identification and geographic origin of a post-Medieval elephant finding from southwestern Portugal using high-throughput sequencing." Sci Rep **10**(1): 19252.
> Molecular species identification plays a crucial role in archaeology and palaeontology, especially when diagnostic morphological characters are unavailable. Molecular markers have been used in forensic science to trace the geographic origin of wildlife products, such as ivory. So far, only a few studies have applied genetic methods to both identify the species and circumscribe the provenance of historic wildlife trade material. Here, by combining ancient DNA methods and genome skimming on a historical elephantid tooth found in southwestern Portugal, we aimed to identify its species, infer its placement in the elephantid phylogenetic tree, and triangulate its geographic origin. According to our results the specimen dates back to the eighteenth century CE and belongs to a female African forest elephant (non-hybrid Loxodonta cyclotis individual) geographically originated from west-west-central Africa, from areas where one of the four major mitochondrial clades of L. cyclotis is distributed. Historical evidence supports our inference, pointing out that the tooth should be considered as post-Medieval raw ivory trade material between West Africa and Portugal. Our study provides a comprehensive approach to study historical products and artefacts using archaeogenetics and contributes towards enlightening cultural and biological historical aspects of ivory trade in western Europe.

Rajapakse, R., et al. (2020). "Characterization and phylogenetic properties of the complete mitochondrial genome of Fascioloides jacksoni (syn. Fasciola jacksoni) support the suggested intergeneric change from Fasciola to Fascioloides (Platyhelminthes: Trematoda: Plagiorchiida)." Infect Genet Evol **82**: 104281.
> Fascioloides jacksoni (syn. Fasciola jacksoni, Cobbold, 1869) (Platyhelminthes: Echinostomatoidea), is

a liver fluke that causes severe morbidity and mortality of Asian elephants (Elephas maximus maximus). Understandings on molecular diagnosis, epidemiology, genetics and evolution of this flatworm are limited. In this study, we present the complete mitochondrial DNA (mt) sequence of 14,952 bp obtained from an individual fluke and comparative characterization of mitogenomic features with fasciolids, primarily, Fascioloides magna and other taxa in the superfamily Echinostomatoidea. Taxonomic relationship within and between Echinostomatoidea, Opisthorchioidea and Paramphistomoidea in the order Plagiorchiida, are also taxonomically considered. The complete circular mt molecule of Fas. jacksoni contained 12 protein-coding, two ribosomal RNA, 22 transfer RNA genes, and a non-coding region (NCR) rich in tandem repeat units. As common in digenean trematodes, Fas. jacksoni has the usual gene order, the absence of atp8 and the overlapped region by 40 bp between nad4L and nad4 genes. The NCR located between tRNA(Glu) (trnE) and cox3 contained nine nearly identical tandem repeat units (TRs of 113 bp each). Special DHU-arm missing tRNAs for Serine were found for both, tRNA(S1(AGN)) and tRNA(S2(UCN)). Base composition indicated that cox1 of Fas. jacksoni showed the lowest (11.8% to Fas. magna, 12.9 - 13.6% to Fasciola spp. and 18.1% to Fasciolopsis buski) and nad6 the highest divergence rate (19.2%, 23.8-26.5% and 27.2% to each fasciolid group), respectively. A clear bias in nucleotide composition, as of 61.68%, 62.88% and 61.54%, with a negative AT-skew of the corresponding values (-0.523, -0.225 and - 0.426) for PCGs, MRGs and mtDNA for Fas. jacksoni and likewise data for the fasciolids. Phylogenetic analysis confirmed the sister branch of Fas. jacksoni and Fas. magna with the nodal support of 100%, clearly separated from the taxonomically recognized Fasciola spp. With the previous studies, mitogenomic data presented in this study are strongly supportive for Fasciola jacksoni reappraisal as Fascioloides jacksoni in the Fascioloides genus.

Remis, M. J. and C. A. J. Robinson (2020). "Elephants Hunters and Others. Integrating Biological Anthropology and Multispecies Ethnography in a Conservation Zone." American Anthropologist **122**(3): 459-472.

Popular and scholarly accounts lament the demise of African forest elephants (Loxodonta cyclotis) and the loss of biodiversity across the Congo Basin, but there has been less appreciation of the consequences of restricted forest access for human communities in conservation contexts. We demonstrate the usefulness of biological anthropology in combination with multispecies ethnography for anchoring the futures of BaAka foragers and African forest elephants.Tumaelephant hunters have long negotiated their communities' relationships with elephants and others who have relied on the BaAka to navigate the forest. Tracing multispecies interactions along a transnational network of elephant trails (bembo) helps us understand the ways that elephants have shaped forest structure and the fabric of existence fortumaand others.Bembofacilitate movement across watersheds and may prove a critical tool in the development of culturally relevant conservation practices. [foragers, elephants, multispecies, BaAka, Congo Basin]

Revathe, T., et al. (2020). "Development of motor control and behaviour in Asian elephants in the Kabini elephant population, southern India." Int J Dev Biol **64**(4-5-6): 367-382.

Although neonates of precocial mammals are capable of locomotory, sensory, nutritional, and thermoregulatory independence to some extent soon after birth, they attain their adult body mass more slowly than altricial mammals, allowing for an extended period of learning or perfecting skills to an adult-like degree. Asian elephants are precocial but are nutritionally dependent on the mother for at least two years and are long-lived and social. We wanted to examine the ontogeny of trunk motor control and various behaviours in Asian elephant calves and see whether the former develops faster than the latter since limb motor control is achieved soon after birth. We collected field data on trunk use, lateralisation, and behaviours from individually identified, free-ranging elephants in southern India and examined how they were affected by age and other factors. Unlike limb motor control, we found trunk motor skills and behaviours to develop gradually with age. Trunk lateralisation occurred very early on, was not highly dependent on trunk motor skills, and is probably not a developmental marker in Asian elephants. Adult-like behaviours that required low trunk usage emerged within 3 months, while

some feeding behaviours emerged later. Calves spent less time resting and more time feeding as they grew, and their activity budgets resembled those of adults only after a year; hence, mother-offspring behavioural synchrony was low for young calves and increased with age. Behavioural development and trunk motor control in Asian elephants are both gradual processes, taking about a year to mature.

Revathe, T., et al. (2020). "Development of motor control and behaviour in asian elephants in the kabini elephant population, southern India." International Journal of Developmental Biology **64**(1-3): 377-392.
> Although neonates of precocial mammals are capable of locomotory, sensory, nutritional, and thermoregulatory independence to some extent soon after birth, they attain their adult body mass more slowly than altricial mammals, allowing for an extended period of learning or perfecting skills to an adult-like degree. Asian elephants are precocial but are nutritionally dependent on the mother for at least two years and are long-lived and social. We wanted to examine the ontogeny of trunk motor control and various behaviours in Asian elephant calves and see whether the former develops faster than the latter since limb motor control is achieved soon after birth. We collected field data on trunk use, lateralisation, and behaviours from individually identified, free-ranging elephants in southern India and examined how they were affected by age and other factors. Unlike limb motor control, we found trunk motor skills and behaviours to develop gradually with age. Trunk lateralisation occurred very early on, was not highly dependent on trunk motor skills, and is probably not a developmental marker in Asian elephants. Adult-like behaviours that required low trunk usage emerged within 3 months, while some feeding behaviours emerged later. Calves spent less time resting and more time feeding as they grew, and their activity budgets resembled those of adults only after a year; hence, mother-offspring behavioural synchrony was low for young calves and increased with age. Behavioural development and trunk motor control in Asian elephants are both gradual processes, taking about a year to mature. © 2020 UPV/EHU Press.

Rija, A. A., et al. (2020). "Global extent and drivers of mammal population declines in protected areas under illegal hunting pressure." PLoS ONE **15**(8 August 2020).
> Illegal hunting is a persistent problem in many protected areas, but an overview of the extent of this problem and its impact on wildlife is lacking. We reviewed 40 years (1980–2020) of global research to examine the spatial distribution of research and socio-ecological factors influencing population decline within protected areas under illegal hunting pressure. From 81 papers reporting 988 species/site combinations, 294 mammal species were reported to have been illegally hunted from 155 protected areas across 48 countries. Research in illegal hunting has increased substantially during the review period and showed biases towards strictly protected areas and the African continent. Population declines were most frequent in countries with a low human development index, particularly in strict protected areas and for species with a body mass over 100 kg. Our results provide evidence that illegal hunting is most likely to cause declines of large-bodied species in protected areas of resource-poor countries regardless of protected area conservation status. Given the growing pressures of illegal hunting, increased investments in people's development and additional conservation efforts such as improving anti-poaching strategies and conservation resources in terms of improving funding and personnel directed at this problem are a growing priority. © 2020 Rija et al. This is an open access article distributed under the terms of the Creative Commons Attribution License, which permits unrestricted use, distribution, and reproduction in any medium, provided the original author and source are credited.

Rodríguez-Habibe, I., et al. (2020). "A Comprehensive Review of the Immunological Response against Foot-and-Mouth Disease Virus Infection and Its Evasion Mechanisms." Vaccines (Basel) **8**(4).
> Foot-and-mouth disease (FMD) is a highly contagious viral disease, which has been reported for over 100 years, and against which the struggle has lasted for the same amount of time. It affects individuals from the order Artiodactyla, such as cattle, swine, sheep, wild animals from this order, and a few non-cloven hoofed species, such as mice and elephants. FMD causes large-scale economic losses for agricultural production systems; morbidity is almost 100% in an affected population, accompanied by a

high mortality rate in young animals due to myocarditis or an inability to suckle if a mother is ill. The aetiological agent is an Aphthovirus from the family Picornaviridae, having seven serotypes: A, O, C, SAT1, SAT2, SAT3, and Asia 1. Serotype variability means that an immune response is serospecific and vaccines are thus designed to protect against each serotype independently. A host's adaptive immune response is key in defence against pathogens; however, this virus uses successful strategies (along with most microorganisms) enabling it to evade a host's immune system to rapidly and efficiently establish itself within such host, and thus remain there. This review has been aimed at an in-depth analysis of the immune response in cattle and swine regarding FMD virus, the possible evasion mechanisms used by the virus and describing some immunological differences regarding these species. Such aspects can provide pertinent knowledge for developing new FMD control and prevention strategies.

Romey, A., et al. (2020). "Molecular characterization of encephalomyocarditis virus strains isolated from an African elephant and rats in a French zoo." J Vet Diagn Invest: 1040638720978389.
In November 2013, a fatal encephalomyocarditis virus (EMCV) case in a captive African elephant (Loxodonta africana) occurred at the Réserve Africaine de Sigean, a zoo in the south of France. Here we report the molecular characterization of the EMCV strains isolated from samples collected from the dead elephant and from 3 rats (Rattus rattus) captured in the zoo at the same time. The EMCV infection was confirmed by reverse-transcription real-time PCR (RT-rtPCR) and genome sequencing. Complete genome sequencing and sequence alignment indicated that the elephant's EMCV strain was 98.1-99.9% identical to the rat EMCV isolates at the nucleotide sequence level. Phylogenetic analysis of the ORF, P1, VP1, and 3D sequences revealed that the elephant and rat strains clustered into lineage A of the EMCV 1 group. To our knowledge, molecular characterization of EMCV in France and Europe has not been reported previously in a captive elephant. The full genome analyses of EMCV isolated from an elephant and rats in the same outbreak emphasizes the role of rodents in EMCV introduction and circulation in zoos.

Rossman, Z. T., et al. (2020). "Contagious Yawning in African Elephants (Loxodonta africana): Responses to Other Elephants and Familiar Humans." Front Vet Sci 7: 252.
While spontaneous yawning is common across all vertebrate classes, contagious yawning is less common and has been observed only in a few species of social animals. Interspecific contagious yawning in response to yawning by humans has been observed only by chimpanzees and dogs. After confirming additional occurrences of intraspecific contagious yawning in a group of captive African elephants previously studied, we further investigated the potential for the same group of elephants to engage in interspecific contagious yawning with familiar human handlers. Ten captive African elephants, most of whom had been previously studied, were observed over 13 nights for evidence of intraspecific contagious yawning. Seven of these elephants were also involved in trials where familiar handlers performed staged yawns, as well as trials with staged non-yawning gapes, or trials with no yawns or gapes. Incorporating previously collected contagious yawning data, we describe nine instances of intraspecific contagious yawning in the elephants. Three of the seven elephants yawned contagiously in response to humans during the interspecific yawning trials. This is the first report of interspecific contagious yawning by elephants in response to yawns by familiar humans.

Ruda, A., et al. (2020). "Spatial Concentrations of Wildlife Attacks on Humans in Chitwan National Park, Nepal." Animals (Basel) 10(1).
The study was conducted within and adjacent to Chitwan National Park in Nepal (CNP), where several wildlife species are involved in conflicts with humans. We assessed the spatial relationships between the number of victims/km(2) (=victim density or VD) of attack by wildlife (elephant, rhino, wild boar, sloth bear, leopard or tiger) versus landscape features, including both natural habitat type and land use by humans (e.g., nursery, orchard or cultivated). We identified four levels of VD, ranging from <1 V (victim)/4 km(2) to >1 V/2 km(2) for each land use zone, then tested for correlations at one or more of those VD between each pair of wildlife species across different land use types. Our results high

correlation for sloth bear and leopard (r ≈ 0.8), for all species except elephant and wild boar at VD > 1 V/4 km(2) (r > 0.9) and for leopard vs. rhinoceros (r = 0.99) across land use types at 1 V/4 km(2)) indicate some risk-reduction measures. One of them would be division of each buffer zone into three concentric rings, for instance ranging from high-risk adjacent areas to areas of high use by humans, to low-risk where human use is low. This revision would facilitate giving local people more voice in implementing conservation measures and reducing risks.

Ruetten, M., et al. (2020). "Iron Regulation in Elderly Asian Elephants (Elephas maximus) Chronically Infected With Mycobacterium tuberculosis." Front Vet Sci **7**: 596379.

Restriction of nutrients to pathogens (nutritional immunity) is a critical innate immune response mechanism that operates when pathogens such as Mycobacterium tuberculosis have the potential to evade humoral immunity. Tuberculosis is of growing concern for zoological collections worldwide and is well-illustrated by infections of Asian and African elephants, where tuberculosis is difficult to diagnose. Here, we investigated hematological parameters and iron deposition in liver, lung, and spleen of three Asian elephants (Elephas maximus) infected with Mycobacterium tuberculosis. For reference purposes, we analyzed tissue samples from control M. tuberculosis-negative elephants with and without evidence of inflammation and/or chronic disease. Molecular analyses of bacterial lesions of post mortally collected tissues confirmed M. tuberculosis infection in three elephants. DNA sequencing of the bacterial cultures demonstrated a single source of infection, most likely of human origin. In these elephants, we observed moderate microcytic anemia as well as liver (mild), lung (moderate) and spleen (severe) iron accumulation, the latter mainly occurring in macrophages. Macrophage iron sequestration in response to infection and inflammation is caused by inhibition of iron export via hepcidin-dependent and independent mechanisms. The hepatic mRNA levels of the iron-regulating hormone hepcidin were increased in only one control elephant suffering from chronic inflammation without mycobacterial infection. By contrast, all three tuberculosis-infected elephants showed low hepcidin mRNA levels in the liver and low serum hepcidin concentrations. In addition, hepatic ferroportin mRNA expression was high. This suggests that the hepcidin/ferroportin regulatory system aims to counteract iron restriction in splenic macrophages in M. tuberculosis infected elephants to provide iron for erythropoiesis and to limit iron availability for a pathogen that predominantly proliferates in macrophages. Tuberculosis infections appear to have lingered for more than 30 years in the three infected elephants, and decreased iron availability for mycobacterial proliferation may have forced the bacteria into a persistent, non-proliferative state. As a result, therapeutic iron substitution may not have been beneficial in these elephants, as this therapy may have enhanced progression of the infection.

Rutherford, L. and L. E. Murray (2020). "Personality and behavioral changes in Asian elephants (Elephas maximus) following the death of herd members." Integr Zool.

Elephants are highly social beings with complex individual personalities. We know that elephants have a general interest in death, investigating carcasses, not just limited to kin; however, research does not explore in depth whether individuals change their behavior or personality following traumatic events, such as the death of a conspecific. Within a captive herd of Asian elephants (Elephas maximus) housed at Chester Zoo, UK, we measured social behavior and proximity and personality using the Ten-Item Personality Inventory, and found age-related and relationship-related changes in both behavior and personality following the deaths of herd members. Overall, the herd spent less time socializing and engaging in affiliative behaviors following the death of the adult female when compared to baseline data, yet spent more time engaging in these behaviors after the death of two calves. The death of the central female had a dramatic impact on her infant calf, resulting in increasingly withdrawn behavior, yet had the opposite effect on her adult daughter, who subsequently established a more integrated role within the herd. Emotional Stability fell in the motherless calf but rose in an adult female, who had lost her adult daughter, but had a new calf to care for. We suggest that the greater impact on the behavior and personality of surviving herd members following the deaths of calves, compared to an adult member, attests to the significance of the unifying role played by calves within an elephant herd.

Saaban, S., et al. (2020). "Viability and management of the Asian elephant (Elephas maximus) population in the Endau Rompin landscape, Peninsular Malaysia." PeerJ **8**: e8209.

> The need for conservation scientists to produce research of greater relevance to practitioners is now increasingly recognized. This study provides an example of scientists working alongside practitioners and policy makers to address a question of immediate relevance to elephant conservation in Malaysia and using the results to inform wildlife management policy and practice including the National Elephant Conservation Action Plan for Peninsular Malaysia. Since ensuring effective conservation of elephants in the Endau Rompin Landscape (ERL) in Peninsular Malaysia is difficult without data on population parameters we (1) conducted a survey to assess the size of the elephant population, (2) used that information to assess the viability of the population under different management scenarios including translocation of elephants out of the ERL (a technique long used in Malaysia to mitigate human-elephant conflict (HEC)), and (3) assessed a number of options for managing the elephant population and HEC in the future. Our dung-count based survey in the ERL produced an estimate of 135 (95% CI [80-225]) elephants in the 2,500 km(2) area. The population is thus of national significance, containing possibly the second largest elephant population in Peninsular Malaysia, and with effective management elephant numbers could probably double. We used the data from our survey plus other sources to conduct a population viability analysis to assess relative extinction risk under different management scenarios. Our results demonstrate that the population cannot sustain even very low levels of removal for translocation or anything other than occasional poaching. We describe, therefore, an alternative approach, informed by this analysis, which focuses on in situ management and non-translocation-based methods for preventing or mitigating HEC. The recommended approach includes an increase in law enforcement to protect the elephants and their habitat, maintenance of habitat connectivity between the ERL and other elephant habitat, and a new focus on adaptive management.

Sach, F., et al. (2020). "Potential bio-indicators for assessment of mineral status in elephants." Sci Rep **10**(1): 8032.

> The aim of this study was two-fold: (1) identify suitable bio-indicators to assess elemental status in elephants using captive elephant samples, and (2) understand how geochemistry influences mineral intake. Tail hair, toenail, faeces, plasma and urine were collected quarterly from 21 elephants at five UK zoos. All elephant food, soil from enclosure(s), and drinking water were also sampled. Elemental analysis was conducted on all samples, using inductively coupled plasma mass spectrometry, focusing on biologically functional minerals (Ca, Cu, Fe, K, Mg, Mn, Na, P, Se and Zn) and trace metals (As, Cd, Pb, U and V). Linear mixed modelling was used to identify how keeper-fed diet, water and soil were reflected in sample bio-indicators. No sample matrix reflected the status of all assessed elements. Toenail was the best bio-indicator of intake for the most elements reviewed in this study, with keeper-fed diet being the strongest predictor. Calcium status was reflected in faeces, (p 0.019, R(2) between elephant within zoo - 0.608). In this study urine was of no value in determining mineral status here and plasma was of limited value. Results aimed to define the most suitable bio-indicators to assess captive animal health and encourage onward application to wildlife management.

Sach, F., et al. (2020). "Spatial geochemistry influences the home range of elephants." Sci Total Environ **729**: 139066.

> The unique geochemistry surrounding the Palabora Mining Company (PMC) land may act as a micronutrient hotspot, attracting elephants to the area. The PMC produces refined copper and extracts phosphates and other minerals. Understanding the spatial influence of geochemistry on the home range size of African elephants is important for elephant population management and conservation. The home ranges of collared elephants surrounding the PMC were significantly smaller (P = 0.001) than conspecifics in surrounding reserves, suggesting that their resource needs were met within these smaller areas. Environmental samples (soil, water and plants) were analysed from the mine area and along six transects radiating from the mine centre. Tail hair and faecal samples from elephants at the PMC, and conspecifics within the surrounding area were analysed. All samples were analysed for minerals essential to health and potentially toxic elements (PTEs; As, Ca, Cd, Cu, Fe, K, Mg, Mn, Na,

P, Pb, Se, U, V and Zn). Results show that the geochemistry at the PMC is different compared to surrounding areas, with significant elevations seen in all analysed minerals and PTEs in soil closer to the mine, thereby drawing the elephants to the area. Additionally significant elevations were seen in elements analysed in water and vegetation samples. Elephant tail hair from elephants at the mine was significantly greater in Cd, whilst Mg, P, Cu, As, Cd, Pb and U concentrations were significantly greater in elephant faecal samples at the mine compared to the non-mine samples. When micronutrient hotspots overlap with human activity (such as mining), this can lead to poor human-elephant coexistence and thus conflict. When managing elephant populations, the influence of mineral provision on elephant movement must be considered. Such detailed resource information can inform conservation efforts for coordinated programmes (UN SDGs 15 and 17) and underpin sustainable economic activity (UN SDG 8, 11 and 12).

Saif, O., et al. (2020). "Costs of coexistence: understanding the drivers of tolerance towards Asian elephantsElephas maximusin rural Bangladesh." Oryx **54**(5): 603-611.
Habitat degradation and fragmentation have heightened the importance of understanding human tolerance towards wildlife, as the fate of wildlife in multi-use landscapes depends on people's capacity for coexistence. We applied the wildlife tolerance model to examine drivers of tolerance towards Asian elephantsElephas maximusin rural Bangladesh, interviewing local people in 17 villages. We used structural equation modelling to identify causal pathways in which elephant-related exposure, positive and negative interactions, costs and benefits (tangible and intangible) contributed to tolerance. Contrary to expectations, monetary costs were non-significant in shaping tolerance despite major impacts on livelihoods. Instead, intangible costs and intangible benefits were significant factors determining tolerance. Furthermore, reducing people's exposure to elephants would not necessarily affect tolerance, nor would increasing positive interactions. We discuss how the socio-economic and bio-cultural dynamics of local communities can explain these results, and demonstrate how our model can be used to incorporate such complexities into conservation decision-making. For instance, compensation schemes aim to recompense monetary losses and direct damages, to improve tolerance, whereas our results suggest a more effective approach would be to enhance resilience to non-monetary costs and improve perceived benefits. We conclude that future studies should pay increased attention to intangible costs and consider the less direct drivers of tolerance. Through repeated testing of universal models such as that presented here, broad trends may emerge that will facilitate the application of policies across contexts and landscapes.

Salerno, J., et al. (2020). "Wildlife impacts and vulnerable livelihoods in a transfrontier conservation landscape." Conserv Biol.
Interactions between humans and wildlife resulting in negative impacts are among the most pressing conservation challenges globally. In regions of smallholder livestock and crop production, interactions with wildlife can compromise human well-being and motivate negative sentiment and retaliation toward wildlife, undermining conservation goals. Although impacts may be unavoidable when human and wildlife land use overlap, scant large-scale human data exist quantifying the direct costs of wildlife to livelihoods. In a landscape of global importance for wildlife conservation in southern Africa, we quantified costs for people living with wildlife through a fundamental measure of human well-being, food security, and we tested whether existing livelihood strategies buffer certain households against crop depredation by wildlife, predominantly elephants. To do this, we estimated Bayesian multilevel statistical models based on multicounty household data (n = 711) and interpreted model results in the context of spatial data from participatory land-use mapping. Reported crop depredation by wildlife was widespread. Over half of the sample households were affected and household food security was reduced significantly (odds ratio 0.37 [0.22, 0.63]). The most food insecure households relied on gathered food sources and welfare programs. In the event of crop depredation by wildlife, these 2 livelihood sources buffered or reduced harmful effects of depredation. The presence of buffering strategies suggests a targeted compensation strategy could benefit the region's most vulnerable people. Such strategies should be combined with dynamic and spatially explicit land-use planning that

may reduce the frequency of negative human-wildlife impacts. Quantifying and mitigating the human costs from wildlife are necessary steps in working toward human-wildlife coexistence.

Sanders, W. J. (2020). "Proboscidea from Kanapoi, Kenya." <u>J Hum Evol</u> **140**: 102547.
   The early Pliocene site of Kanapoi (Turkana Basin, Kenya) has a large, diverse vertebrate sample that contains the earliest representatives of the hominin genus Australopithecus. Included in this sample is an impressive assemblage of fossil proboscideans, comprised of deinotheres (Deinotherium bozasi), anancine gomphotheres (Anancus ultimus), and at least three species of elephant (Loxodonta adaurora, a primitive morph of Loxodonta exoptata, and Elephas ekorensis). A single specimen from high in the sequence could plausibly belong to a primitive stage of Elephas recki. A review of dental carbon isotope analyses indicates a range of dietary habits for these taxa, from dedicated browsing (deinotheres) to mixed feeding/grazing (elephants and gomphotheres), which in early Pliocene elephants corresponds to molars with greater crown height and more plates than in late Miocene confamilials, bringing their morphology more in phase with feeding behavior than was the case in their earlier relatives. Variation in feeding preferences among Kanapoi proboscideans corresponds to evidence for habitat heterogeny, including inferred substantial presence of grasses; the occurrence of multiple megaherbivores may have contributed to the fragmentation of ecosystems, positively affecting early hominin success and aiding diversification of other ungulate groups.

Schaftenaar, W. (2020). "The challenge of obtaining reference values for use in captive animals like elephants." <u>Vet Q</u> **40**(1): 115-117.

Schiffmann, C., et al. (2020). "Soft and persistent-The influence of sand-flooring and calves on the resting behavior of a zoo-kept African elephant (Loxodonta africana) group." <u>Zoo Biol</u> **39**(1): 56-62.
   Caring for all aspects of zoo elephants' well-being is considered a major challenge. Providing an appropriate flooring substrate to facilitate lying rest presents a meaningful part of a holistic management concept. Investigating the impact of a new sand flooring on the nocturnal resting behavior of a breeding group of seven African elephants living at one zoo revealed more total lying rest, longer bouts of lying rest and a reduced side preference in the adult females. With an average total daily lying rest of about 1.5-2.0 hrs, the investigated zoo elephants expressed longer lying rest compared to recently reported data from free-ranging individuals in Botswana. In addition, the presence of nursing calves in the observed elephant group seemed to impact the resting pattern of all group members, with around 60% of all lying bouts being discontinued after interruption by the youngsters. With respect to observed nursing during leaning rest, we encourage the installation of appropriate horizontal structures in breeding facilities to support leaning rest behavior of their female elephants. In doing so, zoos may improve rest quality of nursing females, and, in general, the welfare aspect of sleep for their elephants.

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Schlossberg, S., et al. (2020). "Understanding the drivers of mortality in African savannah elephants." <u>Ecol Appl</u>.

> Populations of African savannah elephants (Loxodonta africana) have been declining due to poaching, human-elephant conflict, and habitat loss. Understanding the causes of these declines could aid in stabilizing elephant populations. We used data from the Great Elephant Census, a 19-country aerial survey of savannah elephants conducted in 2014 and 2015, to examine effects of a suite of variables on elephant mortality. Independent variables included spatially explicit measures of natural processes and human presence as well as country-level socioeconomic measures. Our dependent variable was the carcass ratio, the ratio of dead elephants to live plus dead elephants, which is an index of recent elephant mortality. Carcass ratios are inversely proportional to population growth rates of elephants over the 4 yr prior to a survey. At the scale of survey strata (n = 275, median area = 1,222 km(2)), we found strong negative associations for carcass ratios with vegetation greenness at the time of the survey, overseas development aid to the country, and distance to the nearest international border. At the scale of ecosystems (n = 42, median area = 12,085 km(2)), carcass ratios increased with drought frequency and decreased with human density and overseas development aid to the country. Both stratum- and ecosystem-scale models explained well under one-half of the variance in carcass ratios. The differences in results between scales suggest that the drivers of mortality may be scale-specific and that the corresponding solutions may vary by scale as well.

Sein, C. (2020). "A New Stegolophodon (Proboscidea, Mammalia) from the Irrawaddy Formation of Myanmar." <u>Open Journal of Geology</u> **10**(8): 863-873.

> The new fossil teeth of Stegolophodon (Proboscidea, Mammalia) were discovered from the terrestrial sediments of the Irrawaddy Formation, in Kyauksaungsan and Tebingan areas, Magway Region, central Myanmar. A new Stegolophodon species is established in this paper. Stegolophodon iravaticus shares the characters of the advanced Stegolophodon and the primitive Stegodon. The M3 of S. iravaticus is related to that of the molar of Sand Pit in Tha Chang, Thailand and that of from Dhedari, Pakistan which is included in the Stegolophodon group 6 of Saegusa et al (2005).

Seltmann, M. W., et al. (2020). "Faecal Glucocorticoid Metabolites and H/L Ratio are Related Markers of Stress in Semi-Captive Asian Timber Elephants." <u>Animals (Basel)</u> **10**(1).

> Animals are kept in captivity for various reasons, but species with a slower pace of life may adapt to captive environments less easily, leading to welfare concerns and the need to assess stress reliably in order to develop effective interventions. Our aim was to assess welfare of semi-captive timber elephants from Myanmar by investigating the relationship between two physiological markers of stress commonly used as proxies for welfare, faecal glucocorticoid metabolite concentrations (FGM) and heterophil/lymphocyte ratios (H/L), and link these measures to changes in body condition (determined by body weight). We further assessed how robustly these two markers of stress performed in animals of different age or sex, or in different ecological contexts. We measured FGM concentrations and H/L ratios between 2016 and 2018 from 316 samples of 75 females and 49 males ranging in age from 4 to 68. We found a positive and consistent link between FGMs and H/L ratios in Asian elephants, irrespective of their sex, age, or ecological context. Our results will help to inform managers of (semi-) captive elephants about using heterophil/lymphocyte ratio data from blood smears on site as a potentially cheaper and faster alternative to determining stress than measuring faecal glucocorticoid metabolite concentrations in the laboratory.

Sharma, P., et al. (2020). "Suitable habitat of wild Asian elephant in Western Terai of Nepal." <u>Ecol Evol</u> **10**(12): 6112-6119.

> BACKGROUND: There is currently very little available research on the habitat suitability, the influence of infrastructure on distribution, and the extent and connectivity of habitat available to the wild Asian elephant (Elephas maximus). Information related to the habitat is crucial for conservation of this species. METHODS: In this study, we identified suitable habitat for wild Asian elephants in the Western

Terai region of Nepal using Maximum Entropy (MaxEnt) software. RESULTS: Of 9,207 km(2), we identified 3194.82 km(2) as suitable habitat for wild Asian elephants in the study area. Approximately 40% of identified habitat occurs in existing protected areas. Most of these habitat patches are smaller than previous estimations of the species home range, and this may reduce the probability of the species continued survival in the study area. Proximity to roads was identified as the most important factor defining habitat suitability, with elephants preferring habitats far from roads. CONCLUSIONS: We conclude that further habitat fragmentation in the study area can be reduced by avoiding the construction of new roads and connectivity between areas of existing suitable habitat can be increased through the identification and management of wildlife corridors between habitat patches.

Sharma, P., et al. (2020). "Suitable habitat of wild Asian elephant in Western Terai of Nepal." Ecol Evol **10**(12): 6112-6119.

> Background: There is currently very little available research on the habitat suitability, the influence of infrastructure on distribution, and the extent and connectivity of habitat available to the wild Asian elephant (Elephas maximus). Information related to the habitat is crucial for conservation of this species. Methods: In this study, we identified suitable habitat for wild Asian elephants in the Western Terai region of Nepal using Maximum Entropy (MaxEnt) software. Results: Of 9,207 km2, we identified 3194.82 km2 as suitable habitat for wild Asian elephants in the study area. Approximately 40% of identified habitat occurs in existing protected areas. Most of these habitat patches are smaller than previous estimations of the species home range, and this may reduce the probability of the species continued survival in the study area. Proximity to roads was identified as the most important factor defining habitat suitability, with elephants preferring habitats far from roads. Conclusions: We conclude that further habitat fragmentation in the study area can be reduced by avoiding the construction of new roads and connectivity between areas of existing suitable habitat can be increased through the identification and management of wildlife corridors between habitat patches. © 2020 The Authors. Ecology and Evolution published by John Wiley & Sons Ltd.

Sivasubramanian, G. and B. Ramakrishnan (2020). "New range extension by Asian Elephant Elephas maximus L. - a case study of Oddanchatram Forest Range in Dindigul Forest Division, Tamil Nadu, southern India." Zoos' Print **35**(7): 4-12.

Smet, A. F. and R. W. Byrne (2020). "African elephants interpret a trunk gesture as a clue to direction of interest." Current Biology **30**(16): R926-R927.

Songthammanuphap, S., et al. (2020). "Detection of Mycobacterium tuberculosis complex infection in Asian elephants (Elephas maximus) using an interferon gamma release assay in a captive elephant herd." Sci Rep **10**(1): 14551.

> Tuberculosis is highly contagious disease that can be transmitted between humans and animals. Asian elephants (Elephas maximus) in captivity live in close contact with humans in many Asian countries. In this study, we developed an interferon gamma release assay (IGRA) for elephant TB detection using antigens from the MTB complex (MTBC) and nontuberculous mycobacteria (NTM) as stimulating antigens (PPD, ESAT6, CFP10) to elicit a cell-mediated immune response (CMIR). The developed assay was applied to an elephant herd of more than 60 animals in Thailand, and the results were compared with those obtained through serological detection. IGRA has sufficient sensitivity for detecting elephant interferon gamma (eIFNγ) from specific antigen-stimulated PBMCs. Among 60 animals tested, 20 samples (33.3%) showed negative results for both MTBC and NTM infection. Eighteen samples (30%) showed positive responses against PPD from M. bovis and/or ESAT6 and CFP10, indicating MTBC infection. In contrast, only 15.6% showed seropositivity in a commercial serological test kit for elephant TB. The discrepancies between serological and CMIR highlight that the two methods may detect different stages of elephant TB. Therefore, employing both tests may enable them to complement each other in correctly identifying elephants that have been exposed to MTBC.

Sookaromdee, P. and V. Wiwanitkit (2020). "Zoonotic possibility of tuberculosis from domestic elephants: a case assessment from Thailand." Egyptian Journal of Chest Diseases and Tuberculosis **69**(3): 447-448.
> Background Tuberculosis is an important medical problem which is at present a public health problem around the world. Zoonotic tuberculosis is a new emerging problem and has become an important issue today. The elephant tuberculosis is the specific kind of animal tuberculosis. Zoonotic tuberculosis from elephants is an interesting situation that becomes the new concern in the community where domestic elephants are common. Methods In this article, the authors specifically perform a mathematical model study to assess zoonotic possibility of tuberculosis from domestic elephants based on the available data in Thailand. Results According to this study, the prediction on the transmission rate is equal to 54.5% focusing on zoonotic transmission from domestic elephants to humans. Conclusion In this article, the authors assessed the possibility of zoonotic tuberculosis from the domestic elephant. It can be seen that there is a high chance.

Spagopoulou, F. (2020). "Transgenerational maternal age effects in nature: Lessons learnt from Asian elephants." J Anim Ecol **89**(4): 936-939.
> Reichert, S., Berger, V., Jackson, J., Chapman, S. N., Htut, W., Mar, K. U., & Lummaa, V. (2019). Maternal age at birth shapes offspring life-history trajectory across generations in long-lived Asian elephants. Journal of Animal Ecology, 89, 996-1007. Parental age can have strong effects on offspring life history, but the prevalence and magnitude of such effects in natural populations remain poorly understood. Using a multigenerational dataset of semi-captive Asian elephants, Reichert et al. (2019) studied the effects of maternal and grandmaternal age on offspring performance and found that offspring from old mothers have lower survival, but higher body condition and reproductive success than offspring from younger mothers. Importantly the observed consequences on survival are long-lasting and span more than one generation, with grand-offspring of old grandmothers also showing reduced survival. These findings suggest that persistent transgenerational effects of maternal age on fitness can shape the individual variation in ageing patterns in nature and ultimately the evolution of life histories.

Sripiboon, S., et al. (2020). "Subclinical infection of captive Asian elephants (Elephas maximus) in Thailand with elephant endotheliotropic herpesvirus." Arch Virol **165**(2): 397-401.
> Elephant endotheliotropic herpesvirus (EEHV) infection is a conservation threat to the endangered Asian elephant (Elephas maximus), causing fatal hemorrhagic disease in juvenile elephants throughout the world, including Thailand. This study revealed a subclinical EEHV1 infection rate of 5.5% in healthy captive Asian elephants in Thailand (n=362). The virus was detected in all age classes above one year old, in both sexes, and across the country - even in facilities with no history of hemorrhagic disease (EEHV HD). Subclinical EEHV infection in Thailand urgently requires proper health management.

Stephan, C., et al. (2020). "Responses to a poached conspecific in wild forest elephants (Loxodonta africana cyclotis)." Behaviour **157**(8-9): 823-833.
> The, increased attention towards deceased conspecifics in various social animal species is one of the most intriguing conundrums in animal behaviour. The factors that might explain the observed behavioural variation amongst individuals remain nebulous. Here we analyse forest elephants' (Loxodonta africana cyclotis) responses to a poached adult male conspecific, using remote camera trapping during a period of eight months. After completely avoiding the carcass site for over a week, females and males substantially differed in behavioural responses. Males consistently stayed longer around the remains, showed signs of increased arousal, interacted with the dead body, and twisted trunks with each other. Females, in contrast, were more passively explorative and preferred to visit the site without their dependent offspring. Findings show a previously unknown sexual-dimorphism in forest elephant behaviour towards a poached conspecific and raise the possibility that individuals might be able to infer further context-specific information about the event.

Su, K., et al. (2020). "Human-Elephant Conflicts and Villagers' Attitudes and Knowledge in the Xishuangbanna

Nature Reserve, China." <u>Int J Environ Res Public Health</u> **17**(23).

> In this study, we analyzed the accidents associated with the Asian elephant (Elephas maximus Linnaeus) and issues pertaining to compensation in Xishuangbanna Nature Reserve from 2011 to 2018. We conducted interviews and a questionnaire survey with 217 villagers. The results show that: (1) the main Asian elephants damage is crop loss (more than 95% of the total damage), and the villagers suffer economic losses; (2) through the influence of traditional culture and natural education, the majority of local villagers still have a favorable impression of Asian elephants; (3) female respondents, those engaged in agricultural production, those who had experienced crop loss and those who had never seen Asian elephants had more negative attitudes toward Asian elephants; (4) most villagers believe that the Asian elephant population has increased in the past decade; and (5) the villagers are quite passive in the human-elephant conflict, and most of them do not take action. Finally, based on the research results, this paper discusses the causes of human elephant conflict and proposes targeted mitigation measures.

Suter, I. (2020). "Rewilding or reviewing:Conservation and the elephant-based tourism industry Commentary on Baker & Winkler on Elephant Rewilding." <u>Animal Sentience</u> **304**: 1-4.

> Baker & Winkler (2020) provide a detailed examination of elephants in captivity, from an historical perspective to modern-day concerns. Concerns include the poor level of mahout skills and subsequent captive elephant welfare issues in the Thai elephant tourism industry. Rewilding is proposed as a method of rehabilitation and a way to include mahouts in the conservation process. This commentary argues that the tourism industry is making positive changes and mahout skills can be utilised successfully without the arduous task of rewilding. Animal rights groups and the transfer of misinformation surrounding captive elephant welfare are also examined, as these typically fail to acknowledge the socio-economic and geopolitical complexities of elephant conservation in the least developed and developing nations.

Suwanchatree, N., et al. (2020). "Discrimination of highly degraded, aged Asian and African elephant ivory using denaturing gradient gel electrophoresis (DGGE)." <u>Int J Legal Med</u>.

> BACKGROUND: Elephant populations have greatly reduced mainly due to illegal poaching for their ivory. The trade in elephant products is protected by national laws and CITES agreements to prevent them from further decline. For instance, in Thailand, it is illegal to trade ivory from African elephants; however, the law allows possession of ivory from Asian elephants if permission has been obtained from the authorities. As such, means of enforcement of legislation are needed to classify the legal status of seized ivory products. Many DNA-based techniques have been previously reported for this purpose, although all have a limit of detection not suitable for extremely degraded samples. AIM: We report an assay based on nested PCR followed by DGGE to confirm the legal or illegal status of seized ivory samples where it is assumed that the DNA will be highly degraded. METHOD AND RESULTS: The assay was tested on aged ivory from which the assay was tested for reproducibility, specificity, and, importantly, sensitivity. Blind testing showed 100% identification accuracy. Correct assignment in all 304 samples tested was achieved including confirmation of the legal status of 227 highly degraded, aged ivories, thus underlining the high sensitivity of the assay. CONCLUSION AND RECOMMENDATION: The research output will be beneficial to analyze ivory casework samples in wildlife forensic laboratories.

Szott, I. D., et al. (2020). "Normalized difference vegetation index, temperature and age affect faecal thyroid hormone concentrations in free-ranging African elephants." <u>Conserv Physiol</u> **8**(1): coaa010.

> Conservation biologists can use hormone measurements to assess animals' welfare, reproductive state, susceptibility to stressors, as well as energy expenditure. Quantifying hormone concentrations from faecal samples is particularly advantageous as samples can be collected without disturbing animals' behaviour. In order for an endocrine marker to be useful for wildlife managers, we need to understand how extrinsic and intrinsic factors affect hormone concentrations in free-ranging animal populations. Thyroid hormones are linked to basal metabolic rate and energy expenditure. Previous

research demonstrated that triiodothyronine (T3) can be measured successfully in faecal matter of African elephants, Loxodonta africana. However, to our knowledge, research into factors affecting changes in elephant T3 levels has only been carried out in captive elephants so far. Thus, we present the first study of faecal T3 metabolite (mT3) concentrations of a large population of free-ranging African elephants. Over 15 months, we collected faecal samples from identified (n = 43 samples) and unidentified (n = 145 samples) individuals in Madikwe Game Reserve, South Africa. We investigated whether vegetative productivity [normalized difference vegetation index (NDVI)] in interaction with mean monthly temperature, age and sex affected mT3 concentrations. We found a significant negative interaction effect of NDVI and temperature. Increasing NDVI was related to higher concentrations of mT3, but increasing temperature was related to a decrease in mT3 concentrations in individually identified and unidentified elephants. In unidentified individuals, juvenile elephants had significantly higher mT3 concentrations compared to adult elephants. Faecal T3 can successfully be quantified in samples from free-ranging elephant populations and thus provides insight into energy expenditure in large herbivores.

Takehana, K., et al. (2020). "Anthropometric and blood data on a hand-reared captive Asian elephant (Elephas maximus) calf: A retrospective case report." J Vet Med Sci **82**(7): 943-947.
> The anthropometric and blood data of an unsuccessfully hand-reared Asian elephant (Elephas maximus) calf were retrospectively compared with the data for calves raised by their real mothers or allomothers, to identify potential reasons for poor outcomes in the hand-reared case. The hand-reared calf grew normally in terms of body weight and withers height. However, blood biochemical data suggested reduced bone metabolism, low immune status, and malnutrition during its life. Blood bone markers were measured to determine whether a skeletal disorder was present in the Asian elephant calf, which was not clear from the anthropometric data. Monitoring these parameters in hand-reared Asian elephant calves, with the aim of keeping them within the normal range, may increase the success rate of hand-rearing of Asian elephant calves.

Talukdar, N. R., et al. (2020). "Mapping and Assessing the Transboundary Elephant Corridor in the Patharia Hills Reserve Forest of Assam, India." Rangeland Ecology & Management **73**(5): 694-702.
> Asiatic elephants are facing numerous direct and indirect anthropogenic threats throughout their geographical distributional range. Consequent to the land use and land cover change, habitat loss, fragmentation, and deterioration of the corridor status are the prime threats for the species. The current study aimed to delineate the routes and migratory corridors of elephants in the Indo-Bangla forest along the Patharia Hills Reserve Forest and characterizing existing threats on the corridor for long-term conservation of the elephants using field survey and geospatial techniques. The study identified and mapped the elephant corridor for the first time in the area and named it the "Juri-Patharia-Tilbhum elephant corridor." Land use and land cover changes in the corridor were markedly observed for over 4 decades (between 1972 and 2018). Forest-covered areas in the corridor were 32.06% in 1972, which has been reduced to only 2.98% in 2018, whereas human development types have all increased, grasslands by 127.18%, plantations by 146.56%, agriculture by 279.63%, and settlements by 147.17% between 1972 and 2018. The study concluded that the corridor area is at risk because of the lack of sustainable development in the area, which deliberately undermines conservation. Human settlement, road construction, and electrification in and around habitats and the corridor are vital threats faced by elephants in the Patharia Hills Reserve Forest. Conservation of habitat and corridor through both adoption of legal measures and community participation might be a better proposition for their long-term conservation in the habitat. The study appeals to the government to take conservation initiative in the area and suggest legal protection of the corridor and provide subsidies to the local private landowner to restrict the land-use change on the corridor. (C) 2020 The Society for Range Management. Published by Elsevier Inc. All rights reserved.

Tang, R., et al. (2020). "Raging elephants: effects of human disturbance on physiological stress and reproductive potential in wild Asian elephants." Conserv Physiol **8**(1): coz106.

Human disturbance has become a widespread threat to wildlife viability. The Asian elephant (Elephas maximus), an endangered and disturbance-prone species, is under severe threat from habitat loss and fragmentation, human-elephant conflict and poaching. Establishing connections between human disturbance, stress responses and reproduction is crucial for assessing the long-term survivability of a species and will provide critical information for conservation management. The current study investigated the effects of human disturbance on population-level stress responses and stress-related effects on reproductive potential of wild Asian elephants in Xishuangbanna Dai Autonomous Prefecture, China. We used a radioimmunoassay to measure the concentration of fecal cortisol and estradiol in 257 samples collected from five local populations at 15 sites over 4 years. Human disturbance in Xishuangbanna was quantified based on the Ecological-Niche Factor Analysis model. We found that fecal cortisol concentrations were strongly positively correlated with the degree of human disturbance and increased markedly with the expansion of tea plantations. Percentage of non-stressed individuals in a population was higher depending on the extend of undisturbed area in their home ranges. Fecal estradiol concentrations decreased significantly with increasing stress levels. Our results suggest that human disturbance poses environmental challenges to wild Asian elephant populations, and chronic exposure to human disturbance could lead to population decline. The study demonstrates the efficacy of non-invasive endocrine monitoring for further informing management decisions and developing conservation strategies.

Taylor, L. A., et al. (2020). "Movement reveals reproductive tactics in male elephants." J Anim Ecol **89**(1): 57-67.

Long-term bio-logging has the potential to reveal how movements, and hence life-history trade-offs, vary over a lifetime. Reproductive tactics in particular may vary as individuals' trade-off current investment versus lifetime fitness. Male African savanna elephants (Loxodona africana) provide a telling example of balancing body growth with reproductive fitness due to the combination of indeterminate growth and strongly delineated periods of sexual activity (musth), which results in reproductive tactics that alter with age. Our study aims to quantify the extent to which male elephants alter their movement patterns, and hence energetic allocation, in relation to (a) reproductive state and (b) age, and (c) to determine whether musth periods can be detected directly from GPS tracking data. We used a combination of GPS tracking data and visual observations of 25 male elephants ranging in age from 20 to 52 years to examine the influence of reproductive state and age on movement. We then used a three-state hidden Markov model (HMM) to detect musth behaviour in a subset of sequential tracking data. Our results demonstrate that male elephants increased their daily mean speed and range size with age and in musth. Furthermore, non-musth speed decreased with age, presumably reflecting a shift towards energy acquisition during non-musth. Thus, despite similar speeds and marginally larger ranges between reproductive states at age 20, by age 50, males were travelling 2.0 times faster in a 3.5 times larger area in musth relative to non-musth. The distinctiveness of musth periods over age 35 meant the three-state HMM could automatically detect musth movement with high sensitivity and specificity, but could not for the younger age class. We show that male elephants increased their energetic allocation into reproduction with age as the probability of reproductive success increases. Given that older male elephants tend to be both the target of legal trophy hunting and illegal poaching, man-made interference could drive fundamental changes in elephant reproductive tactics. Bio-logging, as our study reveals, has the potential both to quantify mature elephant reproductive tactics remotely and to be used to institute proactive management strategies around the reproductive behaviour of this charismatic keystone species.

Thewarage, L. D., et al. (2020). "Morphology and Molecular Characterization of Parabronema smithii (Cobbold, 1882) (Nematoda: Habronematidae) from Wild Asian Elephant (Elephas maximus maximus) of Sri Lanka." Acta Parasitol **65**(2): 504-517.

PURPOSE: The aim of the present study was to carry out a detailed study of morphological features and to determine the phylogenetic position of Parabronema smithii (Cobbold, 1882) found in wild elephants in Sri Lanka. METHODS: Adult worms were collected from stomach ulcers at postmortem

examination of wild elephants in the Udawalawe National Park, Sri Lanka. The detailed morphology of P. smithii was studied using light microscopy and, for the first time, scanning electron microscopy. Fifteen morphological characteristics were investigated. The phylogenetic analysis was conducted using the second internal transcribed spacer region (ITS2), and portions of the large subunit ribosomal DNA (28S) and cytochrome c oxidase subunit 1 (cox1). Furthermore, the present study provides a comparison of morphology and morphometrics of Parabronema species that occur in different hosts. CONCLUSION: Parabronema smithii isolated from wild elephants exhibited the key morphological features. Phylogenetic analysis of selected genes revealed that P. smithii is closely associated with P. skrjabini and Habronema spp. Findings of the present study enhance our understanding of the biology and taxonomy of P. smithii in wild elephant in Sri Lanka and will contribute to future phylogeographic studies.

Toin, P., et al. (2020). "Reproductive performance of captive Asian elephants (Elephas maximus) in large tourist camps in Thailand." <u>Anim Reprod Sci</u> **222**: 106606.

In Thailand, many elephants are used in tourism, with populations sustained by breeding of animals that are in captive habitats. Even though there are programs to promote breeding, there is not success in all camps. In this study, there was summarization of reproductive performance data of 407 elephants (150 males, 257 females) at seven tourist camps based on 4-21 years of breeding records. Age pyramid structures for elephants varied among camps. Reproductive rates averaged 21.6 ± 6.17% and varied among camps (2.8-45.0%). Based on parity, 77.4% of elephants were nulliparous, 8.2% produced one calf, and 14.3% were multiparous, with there being camp differences. There were 1.10 ± 0.46 (range, 0.03-3.55) births per year, with a total of 19.6 ± 9.3 (1-71) calves per camp. Age at first calving was 19.2 ± 1.1 years (range, 8-40 years), mean inter-birth interval was 4.4 ± 0.2 years (range, 1.8-7.9 years), and average gestation length was 653.9 ± 6.9 days (range, 578-743 days). Rates of abortions/stillbirths averaged 12.4% and ranged from 3.5%-66.7%. There were no obvious differences in management (e.g., number of males, estrous detection methods, work activities) that when evaluated explained the range in breeding success, although lack of male interest in females was a common problem. While informative and useful for designing future studies, results of this study indicate there is a lack of precise breeding records that makes it difficult to evaluate effects of management practices on reproductive performance of captive elephants in Thailand.

Uno, K. T., et al. (2020). "High-resolution stable isotope profiles of modern elephant (Loxodonta africana) tusk dentin and tail hair from Kenya: Implications for identifying seasonal variability in climate, ecology, and diet in ancient proboscideans." <u>Palaeogeography, Palaeoclimatology, Palaeoecology</u> **559**.

Stable isotope ratios in tissues of large mammalian herbivores record diet and climate information integrated over large spatial areas and can be used to study modern and fossil ecosystems. Sound interpretation of data requires that tissue growth rates be determined accurately and that ecological and behavioral variables that influence stable isotope ratios of tissues be measured and related to experienced environmental conditions assessed through field observations, remote sensing data, and meteorological records. If well-understood in modern herbivores, stable isotopes from closely-related extinct taxa have tremendous potential for resolving paleodiet, paleoenvironment, and paleoclimate of terrestrial ecosystems. We present multiyear, high-resolution (i.e., weekly) stable isotope records from bioapatite in tusk dentin ($\delta^{13}C_{dentin}$ and $\delta^{18}O_{dentin}$) and tail hair ($\delta^{13}C_{hair}$ and $\delta^{15}N_{hair}$) of an African elephant (Loxodonta africana) from Kenya that was fitted with a GPS collar intermittently over a five year period and observed for nearly a decade. GPS and observational data provide behavioral, life history, and location information. Normalized Difference Vegetation Index (NDVI), precipitation, and isotopic data from plants and water provide further constraints for interpreting isotope profiles. We determine tusk and hair growth rates using a combination of histological and geochemical approaches, including bomb-curve radiocarbon, that confirm approximately weekly resolution in the stable isotope profiles. Tusk dentin isotope profiles spanning the periods 1982 to 1987 and 2000 to 2006 record weekly variability in $\delta^{13}C_{dentin}$, where increases of up to 4.5‰ from baseline values due to diet switches from predominantly C3 browsing to mixed C3 browsing and C4 grazing occur during the twice-

yearly (biannual) rainy seasons. The δ13Chair values show a similar trend. The δ13C profiles served as a proxy for seasonal changes in rainfall, vegetation, and diet. The δ18O of tusk bioapatite varied approximately biannually up to 5‰, likely reflecting increases in the proportion of plant water ingested during the wet season. Using a least squares inverse filter, we show that NDVI can be used to predict δ13C of dentin and vice versa, offering the possibility to reconstruct seasonal changes in vegetation and rainfall in the geologic past. Our results demonstrate that high-resolution tusk isotope profiles serve as a proxy for seasonality of diet and precipitation, and thus can be used to reconstruct aspects of elephant life history, vegetation, and climate at unprecedented resolution from modern and fossil proboscidean samples. © 2020 Elsevier B.V.

Uno, K. T., et al. (2020). "Forward and inverse methods for extracting climate and diet information from stable isotope profiles in proboscidean molars." Quaternary International **557**: 92-109.

Intratooth stable isotope profiles in enamel provide time series of dietary and environmental information that if correctly interpreted, serve as archives of seasonal variability in past environments. A major challenge in interpreting these profiles arises from time averaging imparted by enamel mineralization and developmental geometry, whereby the primary (δ13C or δ18O) input signal is attenuated and shifted, which can potentially lead to incorrect interpretations of the magnitude or frequency of seasonal variability. Several forward and inverse models have been developed to reconstruct the primary input signal from intratooth profiles in continuously growing teeth. Here the models developed by Passey and Cerling (2002) and Passey et al. (2005) are extended to molars of Elephantinae, which grow over a long but finite interval of time. Proboscidean molars are particularly attractive for intratooth profiles because they may contain a decade or more of information and they are often well preserved in the fossil record because of their thick enamel and large size. Forward model parameters are established using histological analysis of molar thin sections of extant African elephants (Loxodonta africana) and a mammoth (Mammuthus columbi) and by micro-CT analysis of L. africana molar plates. The density of immature enamel is about 65% of the final density of mature enamel. The appositional length varies from approximately 35 to 55 mm, and the maturation length is about 70 mm. Histological methods are used to determine crown formation time (CFT) in elephant and mammoth molar plates. CFT for the elephant and mammoth molar plates studied in thin section are about 5–6 years and 11 years, which translate to mean growth rates of about 21 mm/year and 16 mm/year, respectively. Coeval molar and tusk profiles from a zoo elephant are compared. The tusk isotope profile serves as a proxy for the primary input signal, and thus provides an opportunity to evaluate the forward and inverse models. The results from the zoo elephant profiles demonstrate that the inverse model accurately reconstructs the amplitude and overall structure of the primary input signal. Inverse model results of mammoth molar profiles show double the range of δ13C in measured enamel profiles. Inversion model results illustrate that improved reconstruction of the primary input signal can lead to more accurate interpretations of the seasonal variability of diet and body water and by extension, vegetation and precipitation in past environments. © 2020 Elsevier Ltd and INQUA

Unuma, K., et al. (2020). "Autopsy Identification of Viable Mycobacterium Tuberculosis in the Lungs of a Markedly Decomposed Body." Journal of Forensic Sciences.

Various infectious diseases, including COVID-19, MERS, and tuberculosis, are global public health issues. Tuberculosis, which is caused by Mycobacterium tuberculosis (MTB), is highly contagious and can be transmitted through inhalation of the bacteria. However, it has been assumed that the infectiousness of bacteria and viruses in dead bodies weakens as the time from death increases. In particular, there is little awareness of infection control measures concerning decomposed bodies or even the need for such measures. The deceased, in whom we discovered MTB 3 months following her death, was a woman in her 80s who died at home. We performed judicial autopsy, because police suspected homicide when her husband hanged himself. Obtained organs were used for microscopic examination by hematoxylin–eosin staining and Ziehl–Neelsen staining. In addition, real-time PCR and mycobacterial culture testing using Ogawa's medium were performed for the detection of MTB. We found that the MTB in the decomposed body remained viable and potentially infectious. To identify the

bacterial strain further, we performed DNA-DNA hybridization and identified the strain as MTB complex. Potentially infectious live MTB survived in the dead body far longer than had been previously reported. Pathologists should consider microbial culture tests for all autopsied cases in which the decedent's medical history or macro-examination suggests possible infection, even when a long duration of time has passed since death. Pathologists and specialists who perform autopsies should recognize that all dead bodies are potentially infectious, including those in which long periods have elapsed since death. © 2020 American Academy of Forensic Sciences

van de Water, A., et al. (2020). "Beehive fences as a sustainable local solution to human-elephant conflict in Thailand." Conservation Science and Practice **2**(10).
> As human-elephant conflict (HEC) increases, a better understanding of the human dimensions of these conflicts and non-violent mitigation methods are needed to foster long-term coexistence. In this study, we conducted household questionnaires (n= 296) to assess the prevalence of HEC and attitudes towards elephants in four rural villages in Thailand. In addition, we evaluated a pilot beehive fence as a sustainable solution for HEC. The majority of the households reported seeing or hearing elephants near their property at least once a week (84.9%) and experienced negative impacts from elephants in the last 5 years, (81.0%). The beehive fence deterred 88.4% of individual elephants (n= 155) and 64.3% of elephant groups (n= 28) that approached the fence. Most elephants (70.7%) exhibited behaviors suggesting heightened attentiveness or alarm. The farm owner reported economic and social benefits of the beehive fence. By contributing to farmer income and reducing crop damage caused by wild elephants, beehive fencing may provide an important locally-managed complement to regional HEC mitigation methods.

Venturini, S. and D. L. Roberts (2020). "Disguising Elephant Ivory as Other Materials in the Online Trade." Tropical Conservation Science **13**.
> Despite efforts of law enforcement, tech companies and other stakeholders, the illegal online trade in wildlife products continues to increase. A particular problem in tackling this online illicit trade is the misdescription of item materials, making the search for internationally CITES regulated materials, such as elephant ivory, challenging. We investigated the issue of misrepresentation of materials in item descriptions by studying the trade in netsuke, carved objects, attached to the cord of the kimono, originally from 17th century Japan, that are often made of elephant ivory. The study, conducted on the online marketplace, eBay, in the United Kingdom, shows that elephant ivory is still sold in spite of eBay's policy on ivory. While the netsuke trade is small, elephant ivory was most frequently described as cow bone. Our results also indicated that, among the items identified as elephant ivory, only a small fraction were actually detected and removed by eBay. To discourage the sale of ivory items, eBay should increase its efforts to implement its policy banning the trade in ivory. Further, eBay could consider additional restrictions on the range of words that can be used by the vendors in all of the item listing fields. © The Author(s) 2020.

Vogel, S. M., et al. (2020). "Timing of dietary switching by savannah elephants in relation to crop consumption." Biological Conservation **249**.
> Tree and grass quality on the African savannah shows seasonal variation, driving mixed-feeding herbivores to switch between browsing and grazing. During this switch, crop consumption could be an attractive alternative to browsing. We analysed elephant diet variability in the Okavango Delta, Botswana, using faecal stable isotope ratios of carbon (delta<^>13C) and frequencies of elephant crop consumption, to determine the extent to which crop consumption relates to this potential switch. Although elephants did increase their relative grass consumption in the wet season, browse dominated the annual diet. After February, the proportion of grass in the diet dropped considerably, and continued decreasing through April when farmers reported most crop consumption. Generalized Linear Models revealed that the occurrence of elephant crop consumption increased with the proportion of grass consumed and with decreasing grass quality. The proportion of grass in elephant faeces increased with increasing crop consumption intensity. As crop consumption could also be related to nutrient

deficiencies in elephant diet, we calculated the total dietary input of nutrients to reveal potential deficiencies. Elephant diet contained insufficient levels of sodium year-round, and insufficient phosphorus from February to July. As the latter coincides with the timing of crop consumption, we consider our results an indication that phosphorus -and potentially sodium deficiencies, could play a role in elephant dietary choices, including crop consuming behaviour. Further experimental research is required to show whether supplying elephants with supplementary phosphorus and sodium sources could reduce this micro-nutrient deficiency, and could play a role in reducing elephant crop consumption.

Vogel, S. M., et al. (2020). "Exploring movement decisions: Can Bayesian movement-state models explain crop consumption behaviour in elephants (Loxodonta africana)?" J Anim Ecol **89**(4): 1055-1068.
  Animal movements towards goals or targets are based upon either maximization of resource acquisition or risk avoidance, and the way animals move can reveal information about their motivation. We use hidden Markov models (HMMs) fitted in a Bayesian framework and hourly Global Positioning System fixes to distinguish animal movements into distinct states and analyse the influence of environmental variables on being in, and switching to, a particular state. Specifically, we apply our models to understand elephant movement decisions around agricultural fields, and crop consumption. As it is unclear what the role of habitat features are on this complex process, we analyse whether elephants target agricultural crops for consumption, or simply pass through them in search of water. Our HMMs separate elephant movements into two states: exploratory movements that are fast and directional, and encamped movements that are slow and meandering. For each elephant, we ran 16 models with each possible combination of selected habitat features (river, elephant corridor, agricultural field, trees), and repeated these analyses including interaction effects with both season and time of day. We used cross-validation to select the best model. In corridors, exploratory movements are dominant. Elephants mainly showed encamped movements at the river during the dry season, when temporary water sources have dried out and elephants relied on this permanent water source. In fields, males most often exhibited exploratory movements to and from the river, while females showed an increase in the frequency of encamped behaviour during the dry season and at night-the times when most crop consumption and movements through fields occur. Adaptation to risk could explain this behaviour, since foraging in fields is likely less risky under the cover of darkness and during the dry season when farmers are absent. This sex segregation in elephant movement decisions highlights the importance of predation risk in shaping movement patterns, which can result in sex segregation in responses to mitigation methods. The increase in encamped movements in the dry season suggests the importance of agricultural timing, and shows the potential for early ploughing and early-harvest crop types in order to reduce elephant crop consumption. Taking this into account could increase efficiency of elephant crop consumption mitigation.

Wang, Z., et al. (2020). "China's dams isolate Asian elephants." Science **367**(6476): 373-374.

Webb, J. L., et al. (2020). "Evaluating the Reliability of Non-Specialist Observers in the Behavioural Assessment of Semi-Captive Asian Elephant Welfare." Animals (Basel) **10**(1).
  Recognising stress is an important component in maintaining the welfare of captive animal populations, and behavioural observation provides a rapid and non-invasive method to do this. Despite substantial testing in zoo elephants, there has been relatively little interest in the application of behavioural assessments to the much larger working populations of Asian elephants across Southeast Asia, which are managed by workers possessing a broad range of behavioural knowledge. Here, we developed a new ethogram of potential stress- and work-related behaviour for a semi-captive population of Asian elephants. We then used this to collect observations from video footage of over 100 elephants and evaluated the reliability of behavioural welfare assessments carried out by non-specialist observers. From observations carried out by different raters with no prior experience of elephant research or management, we tested the reliability of observations between-observers, to assess the general inter-observer agreement, and within-observers, to assess the consistency in behaviour identification. The

majority of ethogram behaviours were highly reliable both between- and within-observers, suggesting that overall, behaviour was highly objective and could represent easily recognisable markers for behavioural assessments. Finally, we analysed the repeatability of individual elephant behaviour across behavioural contexts, demonstrating the importance of incorporating a personality element in welfare assessments. Our findings highlight the potential of non-expert observers to contribute to the reliable monitoring of Asian elephant welfare across large captive working populations, which may help to both improve elephant wellbeing and safeguard human workers.

Webber, C. E. and P. C. Lee (2020). "Play in Elephants: Wellbeing, Welfare or Distraction?" <u>Animals (Basel)</u> **10**(2).

We explore elephant play behaviour since (a) play has been proposed to represent a potential welfare indicator; and (b) play has been associated with long-term survival in the wild. We categorised play into four types, and investigate both social (gentle, escalated-contact) and non-social (lone-locomotor, exploratory-object) play from observations made on wild (Asian N = 101; African N = 130) and captive (Asian N = 8; African N = 7) elephant calves ranging in age from birth to five years. Social play was the most frequent type of play among immature elephants, accounting for an average of 3%-9% of active time. Non-social play accounted for an additional 1%-11% of time. The most time spent in play was seen in captive Asian calves, particularly at the ages of 1-6 months, while wild African calves spent the least time in play overall, even though they had the greatest number and most diverse range of play partners available. We assessed calf energetics using time spent suckling, resting, moving and independent feeding. Time spent playing was unrelated to time spent suckling but negatively associated with time spent independently feeding. There were no associations with time spent moving or resting. Maternal energy via lactation was unrelated to play early in life, but energy acquired independently may constrain or enable play. Play, while a potential indicator of compromised welfare for many species when absent, can act as a highly stimulating activity for captive elephants in the absence of other forms of arousal.

Wendler, P., et al. (2020). "Influencing factors on the foot health of captive Asian elephants (Elephas maximus) in European zoos." <u>Zoo Biology</u> **39**(2): 109-120.

Pathological lesions of feet occur frequently in captive elephant populations. To improve foot health, it is important to identify risk factors associated with such pathologies. Several previous studies have analyzed potentially influencing factors but were limited, for example, by small sample sizes. This study analyzed the relationship between 87 independent variables and the foot health score of 204 Asian elephants (Elephas maximus) in European zoos using bivariate correlation, multivariable regression models, and principal component analysis (PCA). Correlation and regression tests revealed significant results for 30 different variables, mainly with small effect sizes. Only three variables were significant in more than one test: sex, time spent indoors, and time spent on hard ground, with lower scores (i.e. less or less severe pathological lesions) in females, and when less time is spent indoors or on hard ground. Due to small effect sizes and differing results of the statistical tests, it is difficult to determine which risk factors are most important. Instead, a holistic consideration appears more appropriate. A biplot of the PCA shows that factors representing more advanced husbandry conditions (e.g. large areas, high proportions of sand flooring) were associated with each other and with decreased foot scores, whereas indicators of more limited conditions (e.g. high proportions of hard ground, much time spent indoors) were also associated with each other but increased the foot score. In conclusion, instead of resulting from just one or two factors, reduced foot health might be an indicator of a generally poorer husbandry system. © 2019 Wiley Periodicals, Inc.

Williams, E., et al. (2020). "Understanding Temporal Social Dynamics in Zoo Animal Management: An Elephant Case Study." <u>Animals (Basel)</u> **10**(5).

Zoo animal management procedures which lead to changes to social groups can cause disruption in social hierarchies and the temporary breakdown of social relationships. Animals have different roles in social networks. Understanding individual positions in social networks is important for effective

management and ensuring positive welfare for all animals. Using elephants as a case study, the aim of this research was to investigate temporal social dynamics in zoo animals. Behavioural data were collected between January 2016 and February 2017 from 10 African and 22 Asian elephants housed at seven zoos and safari parks in the UK and Ireland. Social interactions were defined as positive physical, positive non-physical, negative physical or negative non-physical. Social network analysis explored social relationships including the fluidity of networks over time and dyadic reciprocity. Social interaction networks were found to be fluid but did not follow a seasonal pattern. Positive interaction networks tended to include the entire social group whereas negative interactions were restricted to specific individuals. Unbalanced ties were observed within dyads, suggesting potential inequalities in relationships. This could impact on individual experiences and welfare. This research highlights subtle temporal dynamics in zoo elephants with the potential for species-level differences. Similar temporal dynamics may also be present in other socially housed zoo species. This research thus provides evidence for the importance of understanding the social networks of zoo animals over longer periods of time. Understanding social networks enables pro-active and evidence-based management approaches. Further research should seek to identify the minimum sampling efforts for social networks in a range of species, to enable the implementation of regular monitoring of social networks and thus improve the welfare of social species under human care.

Wilson, G., et al. (2020). "Identifying the variation in utilization density estimators and home ranges of elephant clans in Aceh, Sumatra, Indonesia." European Journal of Wildlife Research **66**(6).
    Movement ecology is fundamental to understanding animal home ranges or utilization distribution (UD), and is an important aspect in conservation management strategies. Over the years, there have been several new developments and some contention on which methods are best in determining animal movement and UD. Using data from Global Positioning System (GPS)-tracked Sumatran elephants, minimum convex polygon values (MCP), various Kernel Density Estimator bandwidths (KDE), and dynamic Brownian Bridge Movement Models (dBBMM) were compared to identify the most suitable estimators of space-use. Models were analyzed for variability of home range, goodness of fit, isopleth contour complexity, and precision in representing habitat features. dBBMM was shown to be the most efficient in their representation of elephant home range estimations when compared to other methods in terms of trade-off between type I and type II errors and their ability to classify high- and low-use areas, along with insight into variation of movement. We further discuss the implications of variability in home range estimation regarding conservation and provide recommendations for future studies using similar data.

Wood, J., et al. (2020). "Circulating nutrients and hematological parameters in managed African elephants (Loxodonta Africana) over a 1-year period." Zoo Biol.
    African elephants (Loxodonta Africana) are currently considered a vulnerable species. One key to improving methods of species management is to better monitor and understand elephant nutrition. Analyzing circulating nutrients is one of the best and least invasive methods of monitoring managed elephant nutrition, but limited reference values are available. This study examined the circulating basic hematology concentrations, minerals, vitamins A, D, and E, and fatty acids of six African elephants (two males and four females) at the North Carolina Zoo collected monthly from March 2016 to April 2017 and compared levels among seasons. Creatinine (CRE) and albumin had seasonal differences ($p \leq .05$). Calcium, magnesium, phosphorus, potassium, selenium, zinc, cobalt, manganese, and molybdenum displayed seasonal differences ($p \leq .05$). Retinol and 25-hydroxyvitamin D(2) had seasonal differences ($p \leq .05$). Linoleic acid, α-linolenic acid, arachidonic acid, total omega-3 fatty acids, total omega-6 fatty acids, and the omega-6 to omega-3 ratio showed seasonal differences ($p \leq .05$). Findings suggest that exogenous vitamin E supplements may not be necessary with a mixed feedstuff diet (hay, fortified concentrate pellet, browse, and produce) based on circulating values. This data offer updated information on circulating reference values and novel circulating concentrations of nutrients for Southeastern US managed African elephants that can be used to inform nutritional and health management in all similar habitats.

Wood, J., et al. (2020). "Analyses of African elephant (Loxodonta africana) diet with various browse and pellet inclusion levels." <u>Zoo Biol</u> **39**(1): 37-50.

> To more closely simulate the diet of free-ranging elephants, the diet of six (2.4) African elephants (Loxodonta africana) was altered to include more browse and less pelleted complete feed (5% total diet). Dietary proximate compounds, minerals, vitamins A (and carotenoids), D and E, and fatty acids were analyzed on pelleted diet items and forages including hay, grass, and browse. A total of 42 browse species were offered over 1 year with an average total diet inclusion of 5.2% (dry matter basis) per day. Dietary Na and Se were low while Fe and Mn were high compared to published intake levels for elephants. Analyzed nutrients within browse varied widely among seasons and species. Ingredient analyses were used to create predicted elephant nutrient intake for (a) the current diet, (b) a diet excluding pellets, and (c) a diet excluding pellets and providing browse at doubled levels. Formulated diets excluding pellets had lower mineral levels than the current diet and doubled browse did not alter mineral inclusions of concern. This study provides seasonal data on the nutrient levels of Southeastern browse species important for various pachyderm and herbivorous species. Predicted nutrient intake with new diet scenarios does not support the exclusion of pellets in the diets of African elephants without greater browse quantity availability, strict diet management, or additional supplements.

Xie, Y. (2020). "Ecological labeling and wildlife conservation: Citizens' perceptions of the elephant ivory-labeling system in China." <u>Sci Total Environ</u> **702**: 134709.

> Eco-labeling of products such as ivory contributes to conservation of wildlife species and is most effective when potential consumers of such products are made aware of the threats to wildlife and protections associated with the labels. This paper investigates factors affecting citizens' perceptions of China's eco-labeling system for elephant ivory, which was established in 2004, using unique datasets collected in 2015 and 2017. The results indicate that citizens in China have little understanding of the ivory-labeling system. <10% of the participants were aware of the three accreditation subsystems for ivory products regulating manufacturers, retailers, and the products and only about 20% were familiar with one subsystem. The results of Bayesian logit models show that citizens' demographic and other characteristics are significantly correlated with their knowledge of the labeling system for elephant ivory, and the effects varied for the 2015 and 2017 samples. The one consistent influence was income level, which had similar significant and positive impacts in all of the models. The temporal coefficients reflecting changes in awareness between 2015 and 2017 were not significant, indicating that knowledge of the ivory-labeling system did not increase overall during that period. Our results indicate that significantly greater outreach is needed for China's ivory-labeling system so citizens can consistently play a role in ridding the market of illegal ivory products and regulating noncommercial ivory trading. Special attention should be given to groups of citizens who have relatively little education, income, and awareness of wildlife conservation efforts.

Yang, S., et al. (2020). "A paradigm of thermal adaptation in penguins and elephants by tuning cold activation in TRPM8." <u>Proc Natl Acad Sci U S A</u> **117**(15): 8633-8638.

> To adapt to habitat temperature, vertebrates have developed sophisticated physiological and ecological mechanisms through evolution. Transient receptor potential melastatin 8 (TRPM8) serves as the primary sensor for cold. However, how cold activates TRPM8 and how this sensor is tuned for thermal adaptation remain largely unknown. Here we established a molecular framework of how cold is sensed in TRPM8 with a combination of patch-clamp recording, unnatural amino acid imaging, and structural modeling. We first observed that the maximum cold activation of TRPM8 in eight different vertebrates (i.e., African elephant and emperor penguin) with distinct side-chain hydrophobicity (SCH) in the pore domain (PD) is tuned to match their habitat temperature. We further showed that altering SCH for residues in the PD with solvent-accessibility changes leads to specific tuning of the cold response in TRPM8. We also observed that knockin mice expressing the penguin's TRPM8 exhibited remarkable tolerance to cold. Together, our findings suggest a paradigm of thermal adaptation in vertebrates, where the evolutionary tuning of the cold activation in the TRPM8 ion channel through altering SCH and

solvent accessibility in its PD largely contributes to the setting of the cold-sensitive/tolerant phenotype.