

ELEPHANT PUBLICATIONS 2019
Elephant Care International Database
www.elephantcare.org

Alamgir, M., et al. (2019). "High-risk infrastructure projects pose imminent threats to forests in Indonesian Borneo." *Sci Rep* **9**(1): 140.

Indonesian Borneo (Kalimantan) sustains ~37 million hectares of native tropical forest. Numerous large-scale infrastructure projects aimed at promoting land-development activities are planned or ongoing in the region. However, little is known of the potential impacts of this new infrastructure on Bornean forests or biodiversity. We found that planned and ongoing road and rail-line developments will have many detrimental ecological impacts, including fragmenting large expanses of intact forest. Assuming conservatively that new road and rail projects will influence only a 1 km buffer on either side, landscape connectivity across the region will decline sharply (from 89% to 55%) if all imminently planned projects proceed. This will have particularly large impacts on wide-ranging, rare species such as rhinoceros, orangutans, and elephants. Planned developments will impact 42 protected areas, undermining Indonesian efforts to achieve key targets under the Convention on Biological Diversity. New infrastructure will accelerate expansion in intact or frontier regions of legal and illegal logging and land colonization as well as illicit mining and wildlife poaching. The net environmental, social, financial, and economic risks of several imminent projects—such as parallel border roads in West, East, and North Kalimantan, new Trans-Kalimantan road developments in Central Kalimantan and North Kalimantan, and freeways and rail lines in East Kalimantan—could markedly outstrip their overall benefits. Such projects should be reconsidered in light of rigorous cost-benefit frameworks.

Angkawanish, T., et al. (2019). "Evidence of high EEHV antibody seroprevalence and spatial variation among captive Asian elephants (*Elephas maximus*) in Thailand." *Virology* **16**(1): 33.

BACKGROUND: Elephant endotheliotropic herpesviruses (EEHV) can cause an acute highly fatal hemorrhagic disease in young Asian elephants (*Elephas maximus*), both ex situ and in situ. Amongst eight EEHV types described so far, type 1 (subtype 1A and 1B) is the predominant disease-associated type. Little is known about routes of infection and pathogenesis of EEHV, and knowledge of disease prevalence, especially in range countries, is limited. **METHODS:** A large cross-sectional serological survey was conducted in captive elephants (n = 994) throughout Thailand using an EEHV-1A glycoprotein B protein antigen specific antibody ELISA. **RESULTS:** Antibody seroprevalence was 42.3%, with 420 of 994 elephants testing positive. Associations between seropositivity and potential risk factors for EEHV infection were assessed and included: elephant age, sex, camp cluster size, management type (extensive versus intensive), sampling period (wet vs. dry season) and location of camp (region). Univariable regression analysis identified management system and region as risk factors for the presence of EEHV antibodies in elephants, with region being significant in the final multivariable regression model. Prevalence was highest in the North region of the country (49.4%). **CONCLUSIONS:** This study produced baseline serological data for captive elephants throughout Thailand, and showed a significant EEHV burden likely to be maintained in the captive population.

Athapattu, T. P. J., et al. (2019). "Detection of pathogenic leptospires in the urine of domesticated elephants in Sri Lanka." *Acta Trop* **195**: 78-82.

Leptospirosis is a globally common zoonotic infectious disease in humans and animals. This disease is caused by pathogenic spirochetes belonging to the genus *Leptospira*. The pathogen is able to survive in mammalian kidneys after infection and is excreted in urine intermittently. Pathogenic leptospires infect humans either by direct contact with infected animal urine or through contaminated soil or water. In Sri Lanka, some studies have demonstrated the involvement of animals, such as livestock species and peridomestic rats, in the transmission of leptospirosis to humans. However,

none of the previous studies focused on domesticated elephants, which are in close contact with humans during cultural and religious events and bathe in rivers together with humans. If domesticated elephants act as carriers of pathogenic leptospires, it could be a major public health issue in the country. In this study, 13 healthy domesticated elephants were subjected to leptospiral DNA detection from urine samples collected on three consecutive days. Four elephants (31%) were confirmed to shed pathogenic leptospires in their urine. DNA sequencing followed by phylogenetic distance measurements revealed that all positive elephants were infected with *L. interrogans*. This study reveals the possibility that elephants act as a source of infection of leptospires to humans and recommends the screening of all domesticated elephants that are in close contact with humans for the shedding of pathogenic leptospires.

Backues, K. A. and E. B. Wiedner (2019). "Recommendations for the diagnosis, treatment and management of tuberculosis, *Mycobacterium tuberculosis*, in elephants in human care." International Zoo Yearbook **53**(1): 116-127.

African elephants *Loxodonta africana* and Asian elephants *Elephas maximus* are both susceptible to infection by *Mycobacterium tuberculosis* (Mtb). The Asian elephant has lived in close association with humans in Asian range countries for thousands of years and this close partnership is likely responsible for the exposure of the Asian elephant to this human disease. The confirmation by modern veterinary medicine of the existence of Mtb infection in elephants has only occurred recently after a testing programme was initiated in 1996 in elephant-holding facilities in the United States. At the time of writing, Mtb is recognized as a disease primarily of Asian elephants in zoos. However, recent identification of tuberculosis in several free-ranging elephants, both Asian and African, indicates that the disease may be emerging in the threatened wild populations of these species, which may further hinder the survival of wild elephants in some free-ranging populations. Ante-mortem diagnosis of the disease in elephants is improving but remains challenging. Protecting both human and elephant health via prevention of Mtb exposure must be part of a preventative-medicine strategy wherever humans and elephants closely interact. Treatment of Mtb-infected elephants has been accomplished by many facilities with some promising results. However, many challenges remain, including the side effects of drug therapies and poor compliance to medication administration by the elephant. Inconsistent treatment may potentially result in the bacterium developing resistance to the antibiotics. A brief overview of the diagnosis, treatment and management of Mtb in elephants in human care is provided.

Backues, K. A. and E. B. Wiedner (2019). "Recommendations for the diagnosis, treatment and management of tuberculosis, *Mycobacterium tuberculosis*, in elephants in human care." International Zoo Yearbook **53**(1): 116-127.

African elephants *Loxodonta africana* and Asian elephants *Elephas maximus* are both susceptible to infection by *Mycobacterium tuberculosis* (Mtb). The Asian elephant has lived in close association with humans in Asian range countries for thousands of years and this close partnership is likely responsible for the exposure of the Asian elephant to this human disease. The confirmation by modern veterinary medicine of the existence of Mtb infection in elephants has only occurred recently after a testing programme was initiated in 1996 in elephant-holding facilities in the United States. At the time of writing, Mtb is recognized as a disease primarily of Asian elephants in zoos. However, recent identification of tuberculosis in several free-ranging elephants, both Asian and African, indicates that the disease may be emerging in the threatened wild populations of these species, which may further hinder the survival of wild elephants in some free-ranging populations. Ante-mortem diagnosis of the disease in elephants is improving but remains challenging. Protecting both human and elephant health via prevention of Mtb exposure must be part of a preventative-medicine strategy wherever humans and elephants closely interact. Treatment of Mtb-infected elephants has been accomplished by many facilities with some promising results. However, many challenges remain, including the side effects of drug therapies and poor compliance to medication administration by the elephant. Inconsistent treatment may potentially result in the bacterium developing resistance to the antibiotics. A brief overview of the diagnosis, treatment and management of Mtb in elephants in human care is provided.

Bansiddhi, P., et al. (2019). "Management factors affecting adrenal glucocorticoid activity of tourist camp elephants in Thailand and implications for elephant welfare." *PLoS ONE* **14**(10): e0221537.

Elephant camps are among the most popular destinations in Thailand for tourists from many countries. A wide range of management strategies are used by these camps, which can have varied impacts on health and welfare of elephants. The objectives of this study were to examine relationships between FGM (fecal glucocorticoid metabolite) concentrations and camp management factors (work routine, walking, restraint, rest area, foraging), and to other welfare indicators (stereotypic behaviors, body condition, foot health, and skin wounds). Data were obtained on 84 elephants (18 males and 66 females) from 15 elephant camps over a 1-year period. Elephants were examined every 3 months and assigned a body condition score, foot score, and wound score. Fecal samples were collected twice monthly for FGM analysis. Contrary to some beliefs, elephants in the observation only program where mahouts did not carry an ankus for protection had higher FGM concentrations compared to those at camps that offered riding with a saddle and shows. Elephants that were tethered in the forest at night had lower FGM concentrations compared to elephants that were kept in open areas inside the camps. There was an inverse relationship between FGM concentrations and occurrence of stereotypy, which was not anticipated. Thus, assessing adrenal activity via monitoring of FGM concentrations can provide important information on factors affecting the well-being of elephants. Results suggest that more naturalistic housing conditions and providing opportunities to exercise may be good for elephants under human care in Thailand, and that a no riding, no hook policy does not necessarily guarantee good welfare.

Bansiddhi, P., et al. (2019). "Elephant Tourism in Thailand: A Review of Animal Welfare Practices and Needs." *Journal of Applied Animal Welfare Science*.

Elephant tourism in Thailand has developed into an important socio-economic factor after a logging ban initiated in 1989 resulted in thousands of out-of-work elephants. However, the welfare of captive elephants has been a topic of intense debate among tourists, scientists and stakeholders because of the range of working conditions and management practices to which they are exposed. The aim of this paper is to summarize the current state of knowledge on captive elephant welfare, with an emphasis on tourist elephants in Thailand, and highlight information gaps and recommendations for future directions. Tourist-oriented elephant camps could improve the welfare of elephants through better management practices that take into account physiological and psychological needs of individual animals, including meeting social and nutritional requirements, providing good health care, and maintaining adequate facilities. Our goal is to develop science-based guidelines that government agencies can use to develop an enforceable set of practical regulations to ensure good management of tourist elephants in Thailand. © 2019, © 2019 Informa UK Limited, trading as Taylor & Francis Group.

Bansiddhi, P., et al. (2019). "Management factors affecting physical health and welfare of tourist camp elephants in Thailand." *PeerJ* **7**: e6756.

Background: Variation in management across elephant camps likely has differential effects on the well-being of elephants. Methods: This study calculated body condition, foot health and skin wound scores (WSs) for 122 elephants from 15 elephant camps in Chiang Mai province, and examined relationships to management factors using a multi-variable modeling approach. Results: The majority of elephants had high body condition scores (BCS) indicative of being overweight or obese, mild foot problems, but few visible wounds. Females had higher BCSs than males, as did elephants provided a water source at night. Increasing age was associated with higher foot and WSs. Higher WSs were observed in about a quarter of the cases where mahouts carried a hook. Wounds related to saddle riding were rare. Elephants that rested on sand floors at night had a decreased risk of high WSs compared to elephants that rested on compact dirt floors. Discussion: Findings emphasize the need for elephant camps to adjust management activities that negatively affect body condition (e.g., feeding too many sweet treats), foot health (e.g., hard substrates) and wounding (e.g., misuse of equipment) to

improve health and welfare of this population.

Bennitt, E., et al. (2019). "Terrestrial mammalian wildlife responses to Unmanned Aerial Systems approaches." Sci Rep **9**(1): 2142.

Unmanned Aerial Systems (UAS) are increasingly being used recreationally, commercially and for wildlife research, but very few studies have quantified terrestrial mammalian reactions to UAS approaches. We used two Vertical Take-off and Landing (VTOL) UAS to approach seven herbivore species in the Moremi Game Reserve, Botswana, after securing the relevant permissions. We recorded responses to 103 vertical and 120 horizontal approaches, the latter from three altitudes above ground level (AGL). We ran mixed logistic regressions to identify factors triggering (i) any response and (ii) an evasive response. We included effects of activity, altitude, direction of approach, distance, habitat, herd type, herd size, other species, target species, time, VTOL type and wind strength. Response triggers were linked to altitude, distance, habitat and target species. Elephant (*Loxodonta africana*), giraffe (*Giraffa camelopardalis*), wildebeest (*Connochaetes taurinus*) and zebra (*Equus quagga*) were most affected by VTOL approach, impala (*Aepyceros melampus*) and lechwe (*Kobus leche*) were least responsive, and tsessebe (*Damaliscus lunatus*) displayed intermediate sensitivity. VTOLs flown lower than 60 m AGL and closer than 100 m horizontal distance from target animals triggered behavioural responses in most species. Enforced regulations on recreational UAS use in wildlife areas are necessary to minimise disturbance to terrestrial mammals.

Bennitt, E., et al. (2019). "Terrestrial mammalian wildlife responses to Unmanned Aerial Systems approaches." Sci Rep **9**(1): 2142.

Unmanned Aerial Systems (UAS) are increasingly being used recreationally, commercially and for wildlife research, but very few studies have quantified terrestrial mammalian reactions to UAS approaches. We used two Vertical Take-off and Landing (VTOL) UAS to approach seven herbivore species in the Moremi Game Reserve, Botswana, after securing the relevant permissions. We recorded responses to 103 vertical and 120 horizontal approaches, the latter from three altitudes above ground level (AGL). We ran mixed logistic regressions to identify factors triggering (i) any response and (ii) an evasive response. We included effects of activity, altitude, direction of approach, distance, habitat, herd type, herd size, other species, target species, time, VTOL type and wind strength. Response triggers were linked to altitude, distance, habitat and target species. Elephant (*Loxodonta africana*), giraffe (*Giraffa camelopardalis*), wildebeest (*Connochaetes taurinus*) and zebra (*Equus quagga*) were most affected by VTOL approach, impala (*Aepyceros melampus*) and lechwe (*Kobus leche*) were least responsive, and tsessebe (*Damaliscus lunatus*) displayed intermediate sensitivity. VTOLs flown lower than 60m AGL and closer than 100m horizontal distance from target animals triggered behavioural responses in most species. Enforced regulations on recreational UAS use in wildlife areas are necessary to minimise disturbance to terrestrial mammals.

Benoit, J., et al. (2019). "Brain evolution in Proboscidea (Mammalia, Afrotheria) across the Cenozoic." Sci Rep **9**(1): 9323.

As the largest and among the most behaviourally complex extant terrestrial mammals, proboscideans (elephants and their extinct relatives) are iconic representatives of the modern megafauna. The timing of the evolution of large brain size and above average encephalization quotient remains poorly understood due to the paucity of described endocranial casts. Here we created the most complete dataset on proboscidean endocranial capacity and analysed it using phylogenetic comparative methods and ancestral character states reconstruction using maximum likelihood. Our analyses support that, in general, brain size and body mass co-evolved in proboscideans across the Cenozoic; however, this pattern appears disrupted by two instances of specific increases in relative brain size in the late Oligocene and early Miocene. These increases in encephalization quotients seem to correspond to intervals of important climatic, environmental and faunal changes in Africa that may have positively selected for larger brain size or body mass.

Benoit, J., et al. (2019). "Brain evolution in Proboscidea (Mammalia, Afrotheria) across the Cenozoic." *Sci Rep* **9**(1): 9323.

As the largest and among the most behaviourally complex extant terrestrial mammals, proboscideans (elephants and their extinct relatives) are iconic representatives of the modern megafauna. The timing of the evolution of large brain size and above average encephalization quotient remains poorly understood due to the paucity of described endocranial casts. Here we created the most complete dataset on proboscidean endocranial capacity and analysed it using phylogenetic comparative methods and ancestral character states reconstruction using maximum likelihood. Our analyses support that, in general, brain size and body mass co-evolved in proboscideans across the Cenozoic; however, this pattern appears disrupted by two instances of specific increases in relative brain size in the late Oligocene and early Miocene. These increases in encephalization quotients seem to correspond to intervals of important climatic, environmental and faunal changes in Africa that may have positively selected for larger brain size or body mass.

Bercovitch, F. B. (2019). "A comparative perspective on the evolution of mammalian reactions to dead conspecifics." *Primates*.

In a variety of mammalian species, mothers and others care for and/or carry deceased newborns, and sometimes other conspecifics. The rationale for such behavior remains elusive. Based upon field observations of olive baboon (*Papio anubis*), African elephant (*Loxodonta africana*), and Thornicroft's giraffe (*Giraffa camelopardalis*) responses to recently dead conspecifics, combined with reports in the literature, a hypothesis is proposed to account for this activity. Among female mammals, lifetime reproductive success is more dependent upon rearing, than production, of offspring. The successful nurturing of progeny is associated with a strong maternal-offspring bond. One of the most important chemicals involved in both lactation and mother-infant bonding is oxytocin, a tiny molecule that has a lengthy evolutionary history and is implicated in the formation of social bonds across mammals. Evolution has extended the impact of oxytocin by adopting it beyond the original mother-infant bond to the establishment of social bonds that are required among group-living animals. Hence, sociality is a consequence of the same fundamental biological mediator of mother-offspring bonding, and this intricate connection between physiology and behavior has produced a situation where sometimes animals will care for or carry dead companions. Ways to test this hypothesis, as well as a potential way to refute it, are proposed.

Black, C. E., et al. (2019). "Mining morphometrics and age from past survey photographs." *Front Zool* **16**: 14. Background: Researchers often document wildlife surveys using images. These images contain data that can be used to understand alternative research objectives, even years after they were originally captured. We have developed a method to measure age and morphology (body size measurements and tusk size) from survey image databases and future surveys, without the availability of a known subject distance or a scale in each image. African savanna elephants (*Loxodonta africana*) serve as an ideal model species to develop a non-invasive, image-based morphometric methodology: as handling these animals is particularly invasive and expensive, involving anaesthesia and because of their IUCN 'vulnerable' status. We compare in situ measurements, taken during collaring events, to tusk-to-body-size ratios, measured from the images. Results: We provide evidence that relative morphological measurements, musth timing, and age of male African savanna elephants can accurately be obtained from a survey image database of over 30,000 images, taken over an 18-year period. Of the 11 tusk to body size ratios calculated, we recommend the use of two in particular for future measurement in African elephants to determine size and age: 1) tusk length to tusk diameter and 2) tusk length to body height. Conclusions: We present a practical, non-invasive measure to estimate morphometrics, including both age and tusk size from photographs, which has conservation applications to the protection of elephants and is relevant to a range of other taxa.

Boonprasert, K., et al. (2019). "Survival analysis of confirmed elephant endotheliotropic herpes virus cases in Thailand from 2006 - 2018." *PLoS ONE* **14**(7): e0219288.

The elephant endotheliotropic herpesvirus (EEHV) has been a known cause of death of young elephants in Thailand for over a decade. In this study, we report on the demography, disease characteristics and mortality of 58 elephants with confirmed EEHV hemorrhagic disease between January 2006 and August 2018 using retrospective data subjected to survival analysis. Median age of EEHV presentation was 29 months, and the mortality rate was 68.97% with a median survival time of 36 h. Most EEHV cases occurred in the north of Thailand, the region where most of the country's captive elephants reside. The hazard ratio analysis identified application of medical procedures and antiviral medications as being significant factors correlated to the risk of death. Our results indicate a need to focus EEHV monitoring efforts on young elephants and to follow current protocols that advise starting treatments before clinical signs appear.

Bourgeois, S., et al. (2019). "Improving cost-efficiency of faecal genotyping: New tools for elephant species." PLoS ONE **14**(1): e0210811.

Despite the critical need for non-invasive tools to improve monitoring of wildlife populations, especially for endangered and elusive species, faecal genetic sampling has not been adopted as regular practice, largely because of the associated technical challenges and cost. Substantial work needs to be undertaken to refine sample collection and preparation methods in order to improve sample set quality and provide cost-efficient tools that can effectively support wildlife management. In this study, we collected an extensive set of forest elephant (*Loxodonta cyclotis*) faecal samples throughout Gabon, Central Africa, and prepared them for genotyping using 107 single-nucleotide polymorphism assays. We developed a new quantitative polymerase chain reaction (PCR) assay targeting a 130-bp nuclear DNA fragment and demonstrated its suitability for degraded samples in all three elephant species. Using this assay to compare the efficacy of two sampling methods for faecal DNA recovery, we found that sampling the whole surface of a dung pile with a swab stored in a small tube of lysis buffer was a convenient method producing high extraction success and DNA yield. We modelled the influence of faecal quality and storage time on DNA concentration in order to provide recommendations for optimized collection and storage. The maximum storage time to ensure 75% success was two months for samples collected within 24 hours after defecation and extended to four months for samples collected within one hour. Lastly, the real-time quantitative PCR assay allowed us to predict genotyping success and pre-screen DNA samples, thus further increasing the cost-efficiency of our approach. We recommend combining the validation of an efficient sampling method, the build of in-country DNA extraction capacity for reduced storage time and the development of species-specific quantitative PCR assays in order to increase the cost-efficiency of routine non-invasive DNA analyses and expand the use of next-generation markers to non-invasive samples.

Bourgeois, S., et al. (2019). "Improving cost-efficiency of faecal genotyping: New tools for elephant species." PLoS ONE **14**(1): e0210811.

Despite the critical need for non-invasive tools to improve monitoring of wildlife populations, especially for endangered and elusive species, faecal genetic sampling has not been adopted as regular practice, largely because of the associated technical challenges and cost. Substantial work needs to be undertaken to refine sample collection and preparation methods in order to improve sample set quality and provide cost-efficient tools that can effectively support wildlife management. In this study, we collected an extensive set of forest elephant (*Loxodonta cyclotis*) faecal samples throughout Gabon, Central Africa, and prepared them for genotyping using 107 single-nucleotide polymorphism assays. We developed a new quantitative polymerase chain reaction (PCR) assay targeting a 130-bp nuclear DNA fragment and demonstrated its suitability for degraded samples in all three elephant species. Using this assay to compare the efficacy of two sampling methods for faecal DNA recovery, we found that sampling the whole surface of a dung pile with a swab stored in a small tube of lysis buffer was a convenient method producing high extraction success and DNA yield. We modelled the influence of faecal quality and storage time on DNA concentration in order to provide recommendations for optimized collection and storage. The maximum storage time to ensure 75% success was two months for samples collected within 24 hours after defecation and extended to four

months for samples collected within one hour. Lastly, the real-time quantitative PCR assay allowed us to predict genotyping success and pre-screen DNA samples, thus further increasing the cost-efficiency of our approach. We recommend combining the validation of an efficient sampling method, the build of in-country DNA extraction capacity for reduced storage time and the development of species-specific quantitative PCR assays in order to increase the cost-efficiency of routine non-invasive DNA analyses and expand the use of next-generation markers to non-invasive samples.

Branco, P. S., et al. (2019). "Determinants of elephant foraging behaviour in a coupled human-natural system: Is brown the new green?" *J Anim Ecol* **88**(5): 780-792.

Crop raiding by wildlife poses major threats to both wildlife conservation and human well-being in agroecosystems worldwide. These threats are particularly acute in many parts of Africa, where crop raiders include globally threatened megafauna such as elephants, and where smallholder agriculture is a primary source of human livelihood. One framework for understanding herbivore feeding behaviour, the forage-maturation hypothesis, predicts that herbivores should align their movements with intermediate forage biomass (i.e., peak green-up); this phenomenon is known as "surfing the green wave." Crop-raiding elephants, however, often consume not just foliage, but also fruits and tubers (e.g., maize and potatoes), which generally mature after seasonal peaks in photosynthetic activity. Thus, although elephants have been reported to surf the green wave in natural habitats, they may utilize a different strategy in cultivated landscapes by selecting crops that are "browning down." We sought to understand the factors that underpin movement of elephants into agricultural landscapes. In Mozambique's Gorongosa National Park, we used movement data from GPS-collared elephants, together with precipitation records, remotely sensed estimates of landscape greenness (NDVI), DNA-based diet analysis, measurements of plant nutritional quality and survey-based metrics of crop availability to understand spatiotemporal variation in elephant crop-raiding behaviour. Elephants tracked peak NDVI while foraging inside the Park. During the dry season, however, when NDVI within the Park declined and availability of mature crops was high, crop raiding increased dramatically, and elephants consistently selected crop plants that were browning down while foraging in cultivated landscapes. Crops contained significantly higher digestible energy than wild food plants, but comparable (and sometimes lower) levels of digestible protein, suggesting that this foraging strategy maximized energy rather than protein intake. Our study is the first to combine GPS tracking data with high-resolution diet analysis and community-based reporting of crop availability to reveal fine-scale plasticity in foraging behaviour of elephants at the human-wildlife interface. Our results extend the forage-maturation hypothesis by showing that elephants surf waves of plant brown-down in cultivated landscapes. These findings can aid efforts to reduce human-elephant conflict by enabling wildlife managers to prioritize mitigation actions in time and space with limited resources.

Brown, J. L. (2019). "Update on Comparative Biology of Elephants: Factors Affecting Reproduction, Health and Welfare." *Adv Exp Med Biol* **1200**: 243-273.

Asian (*Elephas maximus*) and African (*Loxodonta africana*) elephants serve as important keystone, umbrella and flagship species. Despite that, population numbers are declining, due mainly to poaching and habitat destruction. Understanding reproductive mechanisms is vital to effective management, particularly insurance populations in captivity, and to that end, long-term biological databases are key to understanding how intrinsic and extrinsic factors affect reproductive function at individual and population levels. Through decades of hormonal and ultrasonographic monitoring, many unique aspects of zoo elephant reproduction have been identified, including differences in luteal steroidogenic activity, follicular maturation, pituitary gonadotropin secretion, fetal development and reproductive tract anatomy. Reproductive problems also hamper captive propagation efforts, particularly those related to abnormal or lack of ovarian cyclicity. Recent large-scale, multi-institutional studies and use of epidemiological approaches have identified factors important for good welfare and reproduction, which include enrichment, feeding diversity, good elephant-keeper relations, social compatibility, exercise, and not being obese. There are notable differences in reproductive mechanisms between Asian and African elephants, as well as the factors that influence reproduction

and welfare, suggesting species-targeted management approaches are needed to maximize fitness. In the first edition, we discussed reproductive function in male and female elephants. Since then, a number of significant advances have been made primarily in female elephants, which will be the focus of this updated review.

Brown, J. L., et al. (2019). "Individual and environmental risk factors associated with fecal glucocorticoid metabolite concentrations in zoo-housed Asian and African elephants." PLoS ONE **14**(9): e0217326.

A recent large-scale welfare study in North America involving 106 Asian (*Elephas maximus*) and 131 African (*Loxodonta africana*) elephants at 64 accredited facilities identified links (i.e., risk factors) between zoo environmental factors and a number of welfare outcomes (stereotypic behavior, ovarian acyclicity, hyperprolactinemia, walking and recumbence, body condition, health status, serum cortisol). For this population of elephants, we used the same epidemiological methods to examine associations between those risk factors and two additional welfare outcomes, mean concentration and individual variability (CV) of fecal glucocorticoid metabolite concentrations (FGM) as indicators of stress. Results indicate that African elephants are more responsive to social stressors than Asians, and that poor joint health is a stress-related welfare problem for Asian, but not African elephants in the North American population. For both species, higher FGM concentrations were associated with zoos located at more northern latitudes, whereas lower FGM concentrations were associated with having free access to indoor/outdoor spaces, and spending more time in managed interactions with staff. Also important for captive management, elephants having diverse enrichment options and belonging to compatible social groups exhibited reduced intra-individual variability in FGM concentrations. Our findings show that aspects of the zoo environment can be potential sources of stress for captive elephants, and that there are management activities that may facilitate coping with zoo conditions. Given species differences in factors that affected FGM, targeted, species-specific management approaches likely are needed to ensure good welfare for all elephants.

Carpenter, S. (2019). "A cross-national comparison of the efficacy of community-based and national governance approaches on the protection of the African elephant." J Environ Manage **231**: 336-344.

This study uses a longitudinal cross-national carcass database to analyze the relative effectiveness of community-based and national governance approaches at conserving elephant populations. Controlling for variables previously identified as impacting poaching levels, an increase in land area under either community or national governance is found to be correlated with an increased likelihood of illegal elephant deaths, with community-based governance being associated with an increase roughly twice that of national governance. This finding suggests that community-based governance may be less effective than national governance at protecting commercially valuable wildlife such as elephants, but neither approach has been able to demonstrate sustained success. Consequently, rather than declaring either conservation approach as clearly preferable, policymakers should instead focus on ensuring that selected conservation approaches are tailored to site-specific natural, institutional, and socio-economic characteristics.

Cerreta, A. J., et al. (2019). "Bilateral Phacoemulsification in an African Elephant (*Loxodonta africana*)."
Case Rep Vet Med **2019**: 2506263.

A 37-year-old bull African elephant (*Loxodonta africana*) at the North Carolina Zoo (NCZ) was diagnosed with bilateral cataracts leading to behavioral changes and significant weight loss secondary to functional blindness. On initial examination, a weight loss of 234 kg, a mature cataract in the right eye, and a focal cataract in the left eye were diagnosed. Ultrasound and electroretinography (ERG) indicated normal retinal attachment and both eyes were viable candidates for surgery. After careful planning and behavioral training, the left cataract was surgically removed via phacoemulsification and irrigation/aspiration. The right eye subsequently developed a ventral lens subluxation, and phacoemulsification and irrigation/aspiration were performed six months after the first procedure. Four years after surgery, menace response, palpebral reflex, dazzle reflex, and pupillary light reflexes were present in both eyes. Body weight was 5,515 kg, 88kg more than at the time of the second surgery.

This is the first published report of an African bull elephant undergoing bilateral cataract removal using phacoemulsification and irrigation/aspiration. The lack of significant postoperative inflammation and uneventful recovery of the elephant suggests that this surgical procedure along with proper preoperative planning and postoperative medical management can be a safe and effective treatment option for elephants with cataracts.

Chapman, S. N., et al. (2019). "Asian elephants exhibit post-reproductive lifespans." *BMC Evol Biol* **19**(1): 193.

BACKGROUND: The existence of extended post-reproductive lifespan is an evolutionary puzzle, and its taxonomic prevalence is debated. One way of measuring post-reproductive life is with post-reproductive representation, the proportion of adult years lived by females after cessation of reproduction. Analyses of post-reproductive representation in mammals have claimed that only humans and some toothed whale species exhibit extended post-reproductive life, but there are suggestions of a post-reproductive stage for false killer whales and Asian elephants. Here, we investigate the presence of post-reproductive lifespan in Asian elephants using an extended demographic dataset collected from semi-captive timber elephants in Myanmar. Furthermore, we investigate the sensitivity of post-reproductive representation values to availability of long-term data over 50 years. **RESULTS:** We find support for the presence of an extended post-reproductive stage in Asian elephants, and that post-reproductive representation and its underlying demographic rates depend on the length of study period in a long-lived animal. **CONCLUSIONS:** The extended post-reproductive lifespan is unlikely due to physiological reproductive cessation, and may instead be driven by mating preferences or condition-dependent fertility. Our results also show that it is crucial to revisit such population measures in long-lived species as more data is collected, and if the typical lifespan of the species exceeds the initial study period.

Chave, E., et al. (2019). "Variation in metabolic factors and gonadal, pituitary, thyroid, and adrenal hormones in association with musth in African and Asian elephant bulls." *Gen Comp Endocrinol* **276**: 1-13.

Longitudinal analyses of serum testosterone, luteinizing hormone (LH), follicle-stimulating hormone (FSH), prolactin, glucose, insulin, triglycerides, cholesterol, total and free thyroxine (T4), total triiodothyronine (T3), thyroid stimulating hormone (TSH), and cortisol were conducted to investigate pituitary, metabolic, and adrenal changes related to testicular function and musth status in zoo-housed elephant bulls. Blood samples were collected twice a month for 12 months from 14 African and 12 Asian bulls at 17 facilities in North America. Building on previous studies, our results show that musth is associated with increased testosterone, LH, FSH, and cortisol secretion, and a decrease in thyroid hormone (total and free T4) production. In addition, glucose and triglycerides were higher during musth than non-musth periods, indicative of altered sugar and fat metabolism. There were significant differences associated with age for LH, FSH and testosterone, all increasing, whereas the glucose-to-insulin ratio (G:I) decreased with age. A species comparison found African and Asian elephants differed in measures of insulin, prolactin, cholesterol and the G:I. Across all hormones, high inter-individual variability was observed, making it difficult to define a general musth endocrine profile or to assess musth status from single samples. These results highlight the need for facilities hosting bulls to closely and consistently monitor each individual from an early age and throughout musth and non-musth periods to determine the pattern for each male.

Chel, H. M., et al. (2019). "First record and analysis of the COI gene of *Cobboldia elephantis* obtained from a captive Asian elephant from Myanmar." *Parasitol Int*: 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.

Chusyd, D. E., et al. (2019). "Fat mass compared to four body condition scoring systems in the Asian elephant (*Elephas maximus*)."
Zoo Biol **38**(5): 424-433.

Captive elephant populations are not self-sustaining due to health concerns possibly related to obesity. Categorizing obesity relies on qualitative analyses like body condition scores (BCS). However, elephant indices have not been validated against measured body composition. The objective was to compare BCS systems to body composition determined by deuterium dilution in 28 zoo-kept Asian elephants. Elephants were weighed and given deuterated water orally (0.05 ml/kg). Blood was collected at ~0, 24, 120, 240, 360, and 480 hr after dosing. Photographs were taken to score the elephant based on four BCS systems (BCSWemmer [0 to 11 scoring], BCSMorfeld [1 to 5 scoring], BCSFernando [0 to 10 scoring], BCSWijeyamohan [1 to 10 scoring]). Based on regression analysis, relative fat ranged from -305 kg to 515 kg, where negative values indicate less and positive values indicate more fat than expected for the elephant's mass in this population. BCSFernando was associated with relative fat ($p = .020$, $R(2) = 0.194$). Relative fat, adjusted for sex and age in the statistical model, was associated with BCSWemmer ($p = .027$, $R(2) = 0.389$), BCSFernando ($p = .002$, $R(2) = 0.502$), and BCSWijeyamohan ($p = .011$, $R(2) = 0.426$). Inclusion of zoo and familial relatedness resulted in all BCS systems associated with relative fat ($p \leq .015$). Only BCSFernando predicted relative fat, unadjusted, suggesting it is the most capable system for practical use. Compared to absolute fat, relative fat may be more biologically relevant as greater fat relative to body mass is more likely to lead to health issues.

Comizzoli, P., et al. (2019). "Reproductive Science as an Essential Component of Conservation Biology: New Edition."
Adv Exp Med Biol **1200**: 1-10.

The previous edition of this book mainly provided a snapshot of the state of the art in terms of species-specific reproductive biology and emerging technologies. The influence of environmental changes on reproductive fitness was introduced but not fully explored. The objectives of this second edition were to (1) emphasize the need for holistic and global efforts to understand and sustain reproduction in a constantly changing environment and (2) provide more knowledge in the reproductive physiology of different taxa. The first section of the book is dedicated to survival and adaptation of species in a changing environment (including chapters on environmental impacts in different taxa, as well as the role of microbiomes). The second section focuses on progress in understanding, assisting or even suppressing reproduction in wild species, keeping in mind the influence of environmental factors as well. It contains chapters from the previous edition that were updated (reproduction in elephants, koalas, marsupials, amphibians, and corals), new chapters on species such as sharks and rays, and contributions about the increasing role of reproductive manipulations, such as assisted reproduction and contraception. While the present book emphasizes the overarching issue of environmental impacts on reproduction (resulting in infertility, subfecundity, or fitness), it also highlights the challenges of maintaining wild species in captivity, including those associated with ensuring good welfare. Captive environments can influence reproduction in a multitude of ways, some unexpected, such as the selection of unwanted genetic traits, an essential dimension to be considered to ensure the success of conservation breeding programs. Lastly, new approaches, such as the use of allostatic load indexes and reproductive microbiome analyses also will be closely examined for the first time in rare and endangered species to address conservation issues.

Conte, J., et al. (2019). "ELEquant: a developmental framework and validation of forensic and conservation real-time PCR assays."
Mol Biol Rep **46**(2): 2093-2100.

A framework for the development and validation of a qPCR assay for species identification and DNA quantification for conservation and forensic purposes is presented. Elephants are commonly poached

for their ivory tusks, which is the primary driving force behind their endangered status. In addition to poaching and trade, habitat loss due to logging and mining has also resulted in loss of elephants. Crimes against animals can be deterred and/or further prosecution sought through testing with forensic genetic techniques. The creation of novel genetic assays can greatly impact wildlife forensic science investigations in identifying the species. Molecular genetic techniques can help enforce conservation efforts; however, they must be properly developed and validated to be of evidentiary quality for court systems. African and Asian elephant buccal cells were used as model in this work. The assay provides a method to differentiate biological fluids of both genera of elephants simultaneously. It can be used for identification of elephant derived products and presents valuable quantification for optimized further testing, such as microsatellite detection.

Crawley, J. A. H., et al. (2019). "Investigating changes within the handling system of the largest semi-captive population of Asian elephants." PLoS ONE **14**(1): e0209701.

The current extinction crisis leaves us increasingly reliant on captive populations to maintain vulnerable species. Approximately one third of Asian elephants (*Elephas maximus*) are living in semi-captive conditions in range countries. Their relationship with humans stretches back millennia, yet elephants have never been fully domesticated. We rely on the expertise of traditional handlers (mahouts) to manage these essentially wild animals, yet this profession may be threatened in the modern day. Here, we study the handling system of semi-captive timber elephants in Myanmar; the largest global semi-captive population (~5 000). We investigate how recent changes in Myanmar may have affected the keeping system and mahout-elephant interactions. Structured interviews investigated changes to mahout attitude and experience over the last two decades, as perceived by those who had worked in the industry for at least 10 years ($n = 23$) and as evaluated in current mahouts ($n = 210$), finding mahouts today are younger (median age 22yrs), less experienced (median experience 3yrs), and change elephants frequently, threatening traditional knowledge transfer. Mahout-elephant interactions manifested as 5 components ('job appreciation'; 'experience is necessary'; 'human-elephant interaction'; 'own knowledge'; 'elephant relationship'), according to Principal Components Analysis. Experienced mahouts and mahouts of bulls and younger elephants were more likely to agree that 'experience is necessary' to be a mahout. Mahouts with difficult elephants scored lower on 'human-elephant interaction' and a mahout's perception of their 'own knowledge' increased with more experience. Our finding of change in terms of mahout experience, age and commitment in the largest semi-captive elephant population suggests need for formal training and assessment of impacts on elephant welfare; these are findings applicable to thousands of elephants under similar management.

Davies, A. B. and G. P. Asner (2019). "Elephants limit aboveground carbon gains in African savannas." Glob Chang Biol.

Understanding the drivers of vegetation carbon dynamics is essential for climate change mitigation and effective policy formulation. However, most efforts focus on abiotic drivers of plant biomass change, with little consideration for functional roles performed by animals, particularly at landscape scales. We combined repeat airborne Light Detection and Ranging with measurements of elephant densities, abiotic factors, and exclusion experiments to determine the relative importance of drivers of change in aboveground woody vegetation carbon stocks in Kruger National Park, South Africa. Despite a growing elephant population, aboveground carbon density (ACD) increased across most of the landscape over the 6-year study period, but at fine scales, bull elephant density was the most important factor determining carbon stock change, with ACD losses recorded only where bull densities exceeded 0.5 bulls/km². Effects of bull elephants were, however, spatially restricted and landscape dependent, being especially pronounced along rivers, at mid-elevations, and on steeper slopes. In contrast, elephant herds and abiotic drivers had a comparatively small influence on the direction or magnitude of carbon stock change. Our findings demonstrate that animals can have a substantive influence on regional-scale carbon dynamics and warrant consideration in carbon cycling models and policy formulation aimed at carbon management and climate change mitigation.

de Mori, B., et al. (2019). "Scientific and Ethical Issues in Exporting Welfare Findings to Different Animal Subpopulations: The Case of Semi-Captive Elephants Involved in Animal-Visitor Interactions (AVI) in South Africa." *Animals (Basel)* **9**(10).

Elephants are charismatic, cognitively highly-developed animals, whose management conditions can vary along a "wild-captive continuum." Several protocols have been proposed for the assessment of zoo elephants' welfare. It is important to investigate the possible limitations, if any, of extending findings from zoo elephants to conspecifics in a different dynamic in said "wild-captive continuum." In this paper, findings regarding two issues will be discussed: those regarding the external validity and those regarding the acceptability of management procedures as applied to semi-captive (i.e., able to roam freely for part of the day) elephants involved in visitor-interaction programs in South Africa. In a questionnaire-based survey, half of the responding experts stated that at least some of the welfare issues they ranked as the five most important in captive elephants' management had a different relevance for semi-captive individuals, resulting in 23.6% of the issues being rated differently. Moreover, there was no agreement among the experts on the ethical acceptability of any of the investigated procedures used in the management of semi-captive elephants involved in visitor-interaction programs. Caution is thus needed when exporting findings from one subpopulation of animals to another kept in different conditions and more scientific and ethical research is needed on the topic.

de Silva, S. and P. Leimgruber (2019). "Demographic Tipping Points as Early Indicators of Vulnerability for Slow-Breeding Megafaunal Populations." *Frontiers in Ecology and Evolution* **7**.

Decisions based on trends in population abundance and distribution may fail to protect populations of slow-breeding, long-lived megafauna from irrevocable decline if they ignore demographic constraints. For such taxa, we urge that effort be directed at understanding the interactions among vital rates governing population growth rates, rather than on predicting probabilities of extinction. The proximity of a population to demographic tipping points, i.e., where growth rate switches from positive to negative, can signal vulnerability to perturbation long before numbers drop below a point of no return. We define the "demographic safe space" as the combination of key vital rates that support a non-negative growth rate and illustrate this approach for Asian elephants. Through simulations, we find that even with optimal reproduction, Asian elephant populations cannot tolerate annual female mortality rates exceeding 7.5%. If adult mortality is very low (3%/year), populations can tolerate high annual mortality in calves below age 3 (up to 31.5%/year), or slow female reproduction (primiparity at 30 years or average inter-birth interval of up to 7.68 years). We then evaluate the potential impact of current threats, showing that near-optimal reproduction and high calf survival is necessary to offset even modestly increased mortality among adult female age classes. We suggest that rather than rely on simple counts or "viability" assessments, conservation planners for slow-breeding megafauna should consider demographic tipping points and strive to keep populations within their safe spaces.

Dooley, A. C., Jr., et al. (2019). "Mammot pacificus sp. nov., a newly recognized species of mastodon from the Pleistocene of western North America." *PeerJ* **7**.

A new species of mastodon from the Pleistocene of western North America, *Mammot pacificus* sp. nov. is herein recognized, with specimens identified throughout California and from two localities in southern Idaho. This new taxon differs from the contemporaneous *M. americanum* in having narrower teeth, most prominently in M3/m3, as well as six sacral vertebrae, femur with a proportionally greater mid-shaft diameter, and no mandibular tusks at any growth stage. All known Pleistocene *Mammot* remains from California are consistent with our diagnosis of *M. pacificus*, which indicates that *M. americanum* was not present in California.

Dubost, J. M., et al. (2019). "From plant selection by elephants to human and veterinary pharmacopeia of mahouts in Laos." *J Ethnopharmacol* **244**: 112157.

ETHNOPHARMACOLOGICAL RELEVANCE: To what extent has animal observation contributed to the development of human pharmacopeias? We approach this question here through the study of mahouts' knowledge regarding the responses by elephants to their health problems, and the human medicinal uses of plants and the care of domestic animals that result from their observations.

MATERIALS AND METHODS: 32 mahouts were interviewed in Thongmyxay district and 28 at the Elephant Conservation Center in the province of Xayabury. Interviews focused on the elephants' diet, health problems, plant items they consume in particular physiological or pathological contexts and the treatments that mahouts provide them. For each plant mentioned, the part of the plant consumed and mode of preparation and administration if used by mahouts were recorded. Species samples were then collected and later identified by specialists.

RESULTS: 114 species were recorded as being consumed by elephants during interviews with mahouts and forest outings with them to collect samples. Twenty species were identified as used by elephants in particular pathological conditions or physiological states. According to interviewed mahouts, the consumption of certain plants improves the health of the elephant. We observed clear convergences between the observations interpreted by the mahouts as self-medication behaviour from elephants and their own medicinal practices (for human and veterinary purposes).

CONCLUSION: Beyond a mere reproduction of elephant self-medication behaviours observed, the human or veterinary medicinal cares derived from these observations are the result of complex arrangements integrating all available medicinal and conceptual resources into elaborate preparations. We recommend that mahouts' knowledge about traditional medicinal care given to elephants be further compiled, as it could have a beneficial impact on veterinary health care provided in elephant resorts and elephants' well-being.

Edwards, K. L., et al. (2019). "The development of an immunoassay to measure immunoglobulin A in Asian elephant feces, saliva, urine and serum as a potential biomarker of well-being." *Conserv Physiol* 7(1): coy077. Additional measures of well-being would be beneficial to the management of a variety of species in human care, including elephants. Immunoglobulin A (IgA) is an immune protein associated with pathogen defense, which has been demonstrated to decrease during times of stress, and increase in response to positive stimuli. This paper describes the development and validation of an enzyme immunoassay (EIA) for the quantification of Asian elephant (*Elephas maximus*) IgA in feces, saliva, urine, and serum. Samples were collected weekly from four females for 6 months to assess IgA and glucocorticoid (GC) concentrations, establish relationships between these two biomarkers, and determine variability in IgA within and between individuals, and across sample types. IgA was quantified in all four sample types, although urinary concentrations were low and sometimes undetectable in individual samples. Concentrations were highly variable within and between individuals, with fecal, salivary and serum IgA, and fecal, salivary and urinary GCs all differing significantly across individuals. Contrary to previous findings, IgA and GC were generally not correlated. Serum IgA was less variable within individuals, with the exception of one female that experienced a brief illness during the study. However, marked inter-individual differences were still apparent. When data from all individuals were combined, fecal IgA was significantly predicted by salivary and urinary IgA; however, this relationship did not hold when individuals were analyzed separately. Analysis of a fifth female that exhibited a more severe systemic illness demonstrated clear increases in fecal IgA and GC, suggesting these may also be useful health biomarkers. Further investigation is needed to determine what sample type is most reflective of biological state in elephants, and how IgA concentrations are associated with health and positive and negative welfare states. Based on observed variability, a longitudinal approach likely will be necessary to use IgA as a measure of well-being.

Edwards, K. L., et al. (2019). "Relationships between housing and management factors and clinical health events in elephants in North American zoos." *PLoS ONE* 14(6): e0217774.

Elephants experience a number of health issues that can contribute to their well-being and survival. In managed populations, housing conditions and management practices can influence individual health, so potential risk factors associated with morbidity or mortality should be identified to ensure the best

possible standards of care. The goal of this study was to determine if the number of clinical events experienced could be a useful welfare indicator in zoo elephants, and to determine factors associated with key pathologies. We used an epidemiological approach to investigate how intrinsic (species, sex, age) and extrinsic (housing, management) factors were associated with both the total number of clinical events, and each of the four most prevalent pathology types (gastrointestinal issues, skin lesions, lameness, foot lesions), over a 12-month period. The study included 220 (127 African; 93 Asian) elephants housed at 61 facilities across North America. More than 1100 clinical events were identified. Species and sex differences were apparent in the types of pathology encountered, and unsurprisingly, the number of clinical events was positively correlated with age. Factors relating to housing (percent time with indoor/outdoor choice, space experience inside, number of unique environments an elephant was housed in, percent time on soft substrate) and management (enrichment diversity, spread of feeding opportunities) were also related to the number of clinical events. However, relationships were often counter to our initial hypotheses, highlighting caution in assuming cause and effect from correlational analyses such as these. Other welfare indicators such as serum and fecal glucocorticoids and serum prolactin were also associated with health status, being higher or more variable in individuals with a greater number of events. This approach provides insight into housing and management factors related to the health of these species in zoos, and in some cases, may reflect management changes that have already been made to mitigate existing or anticipated health concerns.

Fernando, P., et al. (2019). "First country-wide survey of the Endangered Asian elephant: Towards better conservation and management in Sri Lanka." *Oryx*: 1-10.

The Endangered Asian elephant *Elephas maximus* comes into widespread conflict with agrarian communities, necessitating active management. The species' distribution is of primary importance for management planning. However, data-based countrywide distribution maps have not been available for any of the 13 Asian elephant range states. We conducted a 5 × 5 km grid-based questionnaire survey in Sri Lanka to produce an island-wide elephant distribution map. Elephants occur over 59.9% of Sri Lanka and people are resident in 69.4% of elephant range, indicating the challenge of separating people and elephants at a landscape scale. Elephants in Sri Lanka have lost 16.1% of their range since 1960 but their current distribution remains largely contiguous. We found the range of adult males was 15.1% greater, and less seasonal, than that of herds, possibly because males have a higher tolerance for conflict with people. The distribution of conflict coincided with the co-occurrence of humans and elephants. We conclude that a human-elephant coexistence model is the only viable option for effectively mitigating human-elephant conflict and conserving elephants in Sri Lanka. The findings are currently being used to effect a paradigm change in elephant conservation and management in the country. © 2019 Fauna & Flora International.

Firdausy, L. W., et al. (2019). "Morphological and molecular identification of *Pfenderius heterocaeca* (Trematode: Paramphistomoidea) from Sumatran elephant (*Elephas maximus sumatranus*)." *Vet World* **12**(8): 1341-1345.

Background and Aim: Paramphistomiasis is common in tropical countries such as Indonesia and affects livestock and various endemic wild animals such as Sumatran elephants. However, the specific species of paramphistomoid worm that causes paramphistomiasis are rarely reported. The study aims at identifying paramphistomoid worm that infects Sumatran elephants. Materials and Methods: Flukes were collected from the feces of five semi-captive Sumatran elephants that lived at Tegal Yoso Elephant Response Unit in Way Kambas National Park, in 2018, after treatment of oxclozanide 1 g at the dose of approximately 5-8 mg/kg of body weight. Eight paramphistomoid worms were flattened and stained in Semichon's carmine for morphological identification, and five other worms were used for molecular identification at second internal transcribed spacer (ITS-2) of ribosomal deoxyribonucleic acid sequence. Results: Forty-five flukes were collected from five Sumatran elephants in Lampung, Indonesia. Eight paramphistomoid worms were morphologically identified as *Pfenderius heterocaeca* and five isolates did not show any variation in ITS-2. Phylogenetic analysis showed that there was a

close genetic relationship between our sample and *Chiorchis fabaceus* that had a family similar to the samples. Conclusion: Based on the morphological and molecular characteristics, the paramphistomoids found in Sumatran elephant on Way Kambas National Park are *P. heterocaeca*.

Fuery, A., et al. (2019). "Lethal hemorrhagic disease and clinical illness associated with the elephant EEHV1 virus are caused by primary infection: Implications for the detection of diagnostic proteins." *J Virol.*

Elephant endotheliotropic herpesvirus (EEHV) can cause lethal hemorrhagic disease in juvenile Asian elephants, both in captivity and in the wild. Most deaths associated with this 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 EEHV types using a luciferase immunoprecipitation system (LIPS) for antibody profiling and a panel of conserved EEHV recombinant proteins and proteins unique to EEHV1. The results show that elephants dying from EEHV1 hemorrhagic disease or ill from EEHV infection were seronegative for the EEHV species that caused this disease or illness, indicating that these 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 long standing question in the field. By applying a relatively new assay, the luciferase immunoprecipitation system (LIPS), combined with the genomic sequences of these 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 EEHV types 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.

G, G. U. (2019). "New Entodiniomorphid Ciliates, *Buetschlia minuta* n. sp., *B. cirrata* n. sp., *Charonina elephanti* n. sp., from Asian Elephants of Turkey." *Zootaxa* 4545(3): 419-433.

Three new entodiniomorphid species, *Buetschlia minuta* n. sp., *Buetschlia cirrata* n. sp., and *Charonina elephanti* n. sp., were described from the hindgut of Asian elephants (*Elephas maximus*) from Gaziantep, Turkey. *B. minuta* n. sp. has an ovoid body shape with a truncated anterior end and a rounded posterior end, an adoral ciliary zone surrounding the cytostome, somatic ciliary rows in the anterior two thirds of the body, an ovoid macronucleus without a constant position, and a concretion vacuole in the anterior one third of the body. *B. cirrata* n. sp. has an ovoid body shape with the anterior end truncated and the posterior end rounded, an adoral ciliary zone surrounding the cytostome, unevenly distributed somatic cilia, an ovoid macronucleus without a constant position, and a concretion vacuole in the anterior one third of the body. *C. elephanti* n. sp. has an ovoid body shape with both ends rounded, an ovoid macronucleus without a constant position, two buccal ciliary zones, an adoral ciliary zone, a vestibular ciliary zone, three somatic ciliary zones, a dorsal ciliary zone, two posterior ciliary zones, dorsal and ventral, and a vestibulum with a Y-shaped infraciliature.

Goldenberg, S. Z., et al. (2019). "Increasing conservation translocation success by building social functionality in released populations." *Global Ecology and Conservation* 18.

The importance of animal behavior to successful wildlife translocations has been acknowledged in recent decades, and it has been increasingly considered and more frequently incorporated into translocation management and research. However, explicit consideration of social behavior is often

overlooked in this context. Social relationships take a variety of forms (e.g., cooperative partners, members of a dominance hierarchy, territorial neighbors) and play important roles in survival, reproduction, and resource exploitation. We review the ways in which concepts from studies of social behavior in wild populations may be leveraged to increase translocation success. Social structure and cohesion, social roles, social learning, and social competency may all be important to consider in building populations that are resilient and likely to persist. We argue that relevant data collected at all stages of translocation, including candidate selection, and during pre-release, release, and post-release monitoring, may inform the establishment of functional social structure post-release in species dependent on social processes. Integrating knowledge of social behavior into management decisions may be particularly useful when comparing the success of alternative release protocols or release candidate behavioral traits. Complementary datasets on a range of fitness-related metrics post-release will further leverage our understanding of social establishment in translocated populations. We illustrate the potential of these ideas using Asian and African elephants as a model. Both species are particularly challenging to manage but are translocated frequently; thus, evidence-based protocols for conservation translocations of elephants are urgently needed. (C) 2019 The Authors. Published by Elsevier B.V.

Goswami, V. R., et al. (2019). "Towards a reliable assessment of Asian elephant population parameters: the application of photographic spatial capture-recapture sampling in a priority floodplain ecosystem." Sci Rep **9**(1): 8578.

The hitherto difficult task of reliably estimating populations of wide-ranging megafauna has been enabled by advances in capture-recapture methodology. Here we combine photographic sampling with a Bayesian spatially-explicit capture-recapture (SCR) model to estimate population parameters for the endangered Asian elephant *Elephas maximus* in the productive floodplain ecosystem of Kaziranga National Park, India. Posterior density estimates of herd-living adult females and sub-adult males and females (herd-adults) was 0.68 elephants/km² (95% Credible Intervals, CrI = 0.56-0.81) while that of adult males was 0.24 elephants/km² (95% CrI = 0.18-0.30), with posterior density estimates highlighting spatial heterogeneity in elephant distribution. Estimates of the space-usage parameter suggested that herd-adults ([Formula: see text] = 5.91 km, 95% CrI = 5.18-6.81) moved around considerably more than adult males ([Formula: see text] = 3.64 km, 95% CrI = 3.09-4.34). Based on elephant movement and age-sex composition, we derived the population that contributed individuals sampled in Kaziranga to be 908 herd-adults, 228 adult males and 610 young (density = 0.46 young/km², SD = 0.06). Our study demonstrates how SCR is suited to estimating geographically open populations, characterising spatial heterogeneity in fine-scale density, and facilitating reliable monitoring to assess population status and dynamics for science and conservation.

Goswami, V. R., et al. (2019). "Author Correction: Towards a reliable assessment of Asian elephant population parameters: the application of photographic spatial capture-recapture sampling in a priority floodplain ecosystem." Sci Rep **9**(1): 14774.

An amendment to this paper has been published and can be accessed via a link at the top of the paper.

Goswami, V. R., et al. (2019). "Author Correction: Towards a reliable assessment of Asian elephant population parameters: the application of photographic spatial capture-recapture sampling in a priority floodplain ecosystem." Sci Rep **9**(1): 14774.

An amendment to this paper has been published and can be accessed via a link at the top of the paper.

Greene, W., et al. (2019). "A review of Asian and African elephant gastrointestinal anatomy, physiology and pharmacology." Journal of Zoo and Aquarium Research **7**(1): 1-14.

Elephants are susceptible to a variety of gastrointestinal problems. Knowledge of elephant nutrition

and gastrointestinal anatomy, physiology and pharmacology is essential for successful treatment, especially because diagnostic options are limited. The horse is considered the most appropriate model for extrapolation to the elephant. While similarities do exist, elephant-specific information is needed, especially in the areas of nutritional requirements. This review presents the current state of knowledge regarding the elephant gastrointestinal system and encourages research in those areas where information is questionable or lacking.

Hall, N. H., et al. (2019). "Oncotic pressure and the effects of water deprivation in healthy captive Asian elephants." J Vet Diagn Invest **31**(4): 572-575.

We evaluated the oncotic pressure (plasma colloid osmotic pressure, pic) in a group of healthy, captive Asian elephants (*Elephas maximus*; n = 21) with a colloid osmometer with a membrane cutoff of >20,000 daltons. The median pic for these elephants was 26.3 mm Hg with an interquartile interval of 25.5-26.8 mm Hg. The mean pic value was 26.0 mm Hg +/- SD 1.1. We found moderate correlation between albumin measured by electrophoresis and pic (r = 0.622; p = 0.003). After a 16-h water deprivation test in a subset of elephants (n = 16), a difference in pic was not detected, despite a significant increase in serum total proteins, urea, and osmolality. These results indicate that pic is not a sensitive indicator of hydration status in elephants after a short period of water deprivation. Use of oncotic pressure as a diagnostic tool in diseased Asian elephants warrants further investigation.

Harris, L., et al. (2019). "Compliance with ivory trade regulations in the United Kingdom among traders." Conserv Biol.

Global demand for elephant ivory is contributing to illegal poaching and significant decline of African elephant (*Loxodonta africana*) populations. To help mitigate decline, countries with legal domestic ivory markets were recommended by the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) to close domestic markets for commercial trade. However, implementing stricter regulations on wildlife trade does not necessarily mean compliance with rules will follow. Using an online questionnaire, we examined the relationship between compliance with ivory trade regulations among 115 ivory traders in the United Kingdom and four dimensions hypothesised to influence compliance with conservation regulations from the field of socio-psychology, theories of deterrence, behaviour and legitimacy. We found that although most traders support regulations, a high number of traders did not always check that they comply with them when trading objects containing ivory. The main factors influencing compliance with ivory trade regulations were their ability to comply, and their perceptions of the regulations and punishments to deter illegal trade. These findings demonstrate the utility of conservation criminology to improve wildlife trade regulations and identify opportunities to reduce illegal ivory entering the market in the United Kingdom. Compliance could be improved by clearer regulations that facilitate easier detection of illegal ivory products and stronger prosecution of violations. This article is protected by copyright. All rights reserved.

Hauenstein, S., et al. (2019). "African elephant poaching rates correlate with local poverty, national corruption and global ivory price." Nat Commun **10**(1): 2242.

Poaching is contributing to rapid declines in elephant populations across Africa. Following high-profile changes in the political environment, the overall number of illegally killed elephants in Africa seems to be falling, but to evaluate potential conservation interventions we must understand the processes driving poaching rates at local and global scales. Here we show that annual poaching rates in 53 sites strongly correlate with proxies of ivory demand in the main Chinese markets, whereas between-country and between-site variation is strongly associated with indicators of corruption and poverty. Our analysis reveals a recent decline in annual poaching mortality rate from an estimated peak of over 10% in 2011 to <4% in 2017. Based on these findings, we suggest that continued investment in law enforcement could further reduce poaching, but is unlikely to succeed without action that simultaneously reduces ivory demand and tackles corruption and poverty.

Hauenstein, S., et al. (2019). "African elephant poaching rates correlate with local poverty, national corruption

and global ivory price." Nature Communications **10**(1).

Poaching is contributing to rapid declines in elephant populations across Africa. Following high-profile changes in the political environment, the overall number of illegally killed elephants in Africa seems to be falling, but to evaluate potential conservation interventions we must understand the processes driving poaching rates at local and global scales. Here we show that annual poaching rates in 53 sites strongly correlate with proxies of ivory demand in the main Chinese markets, whereas between-country and between-site variation is strongly associated with indicators of corruption and poverty. Our analysis reveals a recent decline in annual poaching mortality rate from an estimated peak of over 10% in 2011 to <4% in 2017. Based on these findings, we suggest that continued investment in law enforcement could further reduce poaching, but is unlikely to succeed without action that simultaneously reduces ivory demand and tackles corruption and poverty. © 2019, The Author(s).

Hedwig, D., et al. (2019). "Acoustic structure of forest elephant rumbles: a test of the ambiguity reduction hypothesis." Anim Cogn **22**(6): 1115-1128.

Quantitative assessments of the structure of vocalizations are a fundamental prerequisite to understand a species' vocal communication system and, more broadly, the selective pressures shaping vocal repertoires. For example, to reduce ambiguity in signal interpretation in the absence of auxiliary visual cues, species in densely vegetated habitats should exhibit more discrete vocal signals than species in open habitats. To test this "ambiguity reduction hypothesis", we conducted the first quantitative assessment of the rumble vocalizations of the forest elephant. Based on 686 forest elephant rumbles recorded with autonomous acoustic recording units at four sites across Central Africa, we used model-based cluster analyses paired with subsequent evaluation of cluster-discreteness and discriminant function analyses to quantify the structure of rumbles based on 23 source- and filter-related acoustic parameters. Model-based cluster analyses suggest that rumbles can be classified into five to eight types. Similar to previous findings in savannah elephants and contrary to the ambiguity reduction hypothesis, average silhouette coefficients below 0.34 indicated that these rumble types were highly intergraded. However, discriminant function analyses predicted rumble types with at least 75% accuracy whereby the location of the minimum fundamental frequency, middle slope and peak frequency contributed most to separation between types. In line with an increasing number of studies highlighting that a distinction between discrete and graded repertoires may have little biological significance, we propose that ambiguity reduction may take place through the evolution of perceptual and cognitive mechanisms, rather than acting on vocal production.

Heger, A., et al. (2019). "Fatal attack on a pedestrian by an escaped circus elephant." Forensic Sci Int **300**: e1-e3.

We report the case of a 65-year-old man who was attacked and killed by a female elephant that had previously escaped from a nearby circus. According to a witness the man was lifted up by the tusks, flung into the air and stomped upon. At autopsy the body showed signs of severe blunt force trauma and impalement, including multiple lacerations of the skin, a crushed thorax, a spinal fracture and a fractured humerus. The spinal cord and the major abdominal vessels were severed. There have been very few elephant attacks in Europe; this is the first reported case in Germany.

Huang, C., et al. (2019). "Habitat suitability and connectivity inform a co-management policy of protected area network for Asian elephants in China." PeerJ **7**: e6791.

Enlarging protected area networks (PANs) is critical to ensure the long-term population viability of Asian elephants (*Elephas maximus*), which are threatened by habitat loss and fragmentation. Strict policies of PAN enlargement that focus on wildlife conservation have failed largely due to difficulties in encouraging stakeholder participation and meeting the elephant habitat requirement. A co-management policy that promotes sustainable resource use, wildlife conservation, and stakeholder participation may have greater feasibility than the strict policies in a developing world. Here, we identified the suitable habitat of elephants using maximum entropy models and examined whether

habitat suitability is indirectly associated with local economic development in human-dominated landscapes. We found that (1) the suitable habitat was mainly in areas of forest matrix (50% natural forest cover) with multiple land-use practices rather than relatively intact forest and near communities (mean distance two km) and (2) habitat suitability was negatively associated with local economic development ($rP = -0.37$, $P = 0.04$). From the standpoint of elephant habitat and its socio-economic background, our results indicate that co-management will be more effective than the currently strict approaches of enlarging PAN. Additionally, our results provide on-ground information for elephant corridor design in southern China.

Ihwagi, F. W., et al. (2019). "Poaching lowers elephant path tortuosity: implications for conservation." Journal of Wildlife Management **83**(5): 1022-1031.

Poaching is the most immediate threat to African elephants (*Loxodonta africana*). Several continental-wide surges in poaching have occurred since the latter half of the twentieth century, and the latest surge occurred from 2007 to 2012. The behavioral responses of elephants to poaching risk has not been studied widely because of a lack of high-resolution movement data collected simultaneously with verified causes of mortality. We managed to collate 2 such datasets from 2004 to 2013. We studied the spatial-temporal changes in movement behavior of 11 elephants in their core areas. Past studies have focused on elephant movement along corridors. We tested for the effect of poaching risk on their path straightness (i.e., tortuosity) while controlling for other environmental and human activities in the landscape using a set of generalized linear mixed models. To test for temporal variation of tortuosity, we used a time-series linear model. Elephants turned less frequently while they were in poaching locations and at times with a high level of poaching activity, even though their speed did not change. The variation of tortuosity is a good indicator of differences in poaching risk as perceived by the elephants, which could complement patrol-based anti-poaching efforts by wildlife managers, especially in remote, inaccessible landscapes. (c) 2019 The Authors. The Journal of Wildlife Management published by Wiley Periodicals, Inc. on behalf of The Wildlife Society

Jackson, J., et al. (2019). "Long-term trends in wild-capture and population dynamics point to an uncertain future for captive elephants." Proc Biol Sci **286**(1899): 20182810.

Maintaining sustainable populations in captivity without supplementation through wild-capture is a major challenge in conservation that zoos and aquaria are working towards. However, the capture of wild animals continues for many purposes where conservation is not the primary focus. Wild-capture hinders long-term conservation goals by reducing remaining wild populations, but the direct and long-term indirect consequences of wild-capture for captive population viability are rarely addressed using longitudinal data. We explored the implications of changes in wild-capture on population dynamics in captivity over 54 years using a multi-generational studbook of working Asian elephants (*Elephas maximus*) from Myanmar, the largest remaining captive elephant population. Here we show that population growth and birth rates declined between 1960 and 2014 with declines in wild-capture. Importantly, wild-caught females had reduced birth rates and a higher mortality risk. However, despite the disadvantages of wild-capture, the population may not be sustainable without it, with immediate declines owing to an unstable age-structure that may last for 50 years. Our results highlight the need to assess the long-term demographic consequences of wild-capture to ensure the sustainability of captive and wild populations as species are increasingly managed and conserved in altered or novel environments.

Joone, C. J., et al. (2019). "Researching immunocontraceptive vaccines with mares (*Equus caballus*) as both a target and model for African elephant (*Loxodonta africana*) cows: A review." Anim Reprod Sci **207**: 146-152.

A sequence of studies is reviewed that reported the domestic horse (*Equus caballus*) mare as an appropriate and accessible research platform for recording clinical and laboratory data post-immunisation with anti-GnRH and -zona pellucida (ZP) immunocontraceptive vaccines. Experience with a native porcine ZP (pZP) vaccine in African elephant (*Loxodonta africana*) cows highlighted needs for improving vaccine formulations and more clearly defining associated ovarian effects and

safety profiles. Initially, the efficacy, reversibility and safety of the GnRH vaccine Improvac((R)) in mares was demonstrated using reproductive tract ultrasonography and concurrently measuring serum antibody titres and progesterone concentrations. Results informed the study design and minimally invasive monitoring of post-treatment ovarian steroid responses of this vaccine in free-ranging African elephant cows. A subsequent sequence of studies reported reversible contraceptive and immunological efficacy in pony mares immunised with pZP formulated with Freund's adjuvants. By comparison, mares treated with a recombinant ZP3 and ZP4 (reZP) vaccine showed disappointing responses. Unexpectedly, most pZP-treated mares showed ovarian inactivity. In attempting to understand this response, results showed the involvement of cytotoxic (CD8+) T-cells negatively correlated to serum ovarian steroid and anti-Mullerian hormone (AMH) levels. Of concern was the prevalence of injection-site lesions ascribable to Freund's adjuvants. Following this, mares treated with both pZP and a novel reZP vaccine formulated with non-Freund's adjuvants showed comparable immunological responses and ovarian inactivity, notably without adverse treatment reactions. In addition, measuring AMH showed promise for monitoring ovarian function in anti-ZP-treated animals.

Kanagaraj, R., et al. (2019). "Predicting range shifts of Asian elephants under global change." Diversity And Distributions **25**(5): 822-838.

Aim Climate change alters the water cycle, potentially affecting the distribution of species. Using an ensemble of species distribution models (SDMs), we predicted changes in distribution of the Asian elephant in South Asia due to increasing climatic variability under warming climate and human pressures. Location India and Nepal. Methods We compiled a comprehensive geodatabase of 115 predictor variables, which included climatic, topographic, human pressures and land use, at a resolution of 1 km², and an extensive database on current distribution of elephants. For variable selection, we first developed 14 candidate models based on different hypotheses on elephant habitat selection. For each candidate model, a series of 240 individual models were evaluated using several metrics. Using three climatic and one land use change datasets for two greenhouse gas scenarios, ensemble SDMs were used to predict future projections. Results Nine predictor variables were selected for ensemble SDMs. Elephant distribution is driven predominantly by changes in climatic water balance (>60%), followed by changes in temperature and human-induced disturbance. The results suggest that around 41.8% of the 256,518 km² of habitat available at present will be lost by the end of this century due to combined effects of climate change and human pressure. Projected habitat loss will be higher in human-dominated sites at lower elevations due to intensifying droughts, leading elephants to seek refuge at higher elevations along valleys with greater water availability in the Himalayan Mountains. Main conclusions Changes in climatic water balance could play a crucial role in driving species distributions in regions with monsoonal climates. In response, species would shift their range upwards along gradients of water availability and seasonal droughts. Conservation and management of elephant populations under global change should include design of movement corridors to enable dispersal of the elephant and other associated species to more conducive environments.

Kariuki, E., et al. (2019). "Ixodid ticks (Acari: Ixodidae) collected from African savanna elephants (*Loxodonta africana*) and African forest elephants (*Loxodonta cyclotis*)." Onderstepoort J Vet Res **86**(1): e1-e5.

Eight ixodid tick species were collected from 173 African savanna elephants (*Loxodonta africana*) in Kenya, northern Mozambique and Zimbabwe, and two species were collected from six African forest elephants (*Loxodonta cyclotis*) in the Republic of Congo. A new host record is reported for *Amblyomma eburneum*. A list of ticks collected from elephants in various African countries, and stored in the United States National Tick Collection, is supplied as well as an annotated checklist of the 27 ixodid tick species that have been collected from African elephants. The geographic distributions and alternative hosts of the various tick species collected from elephants are briefly discussed.

Kariuki, E., et al. (2019). "Ixodid ticks (Acari: Ixodidae) collected from African savanna elephants (*Loxodonta africana*) and African forest elephants (*Loxodonta cyclotis*)." Onderstepoort J Vet Res **86**(1): e1-e5.

Eight ixodid tick species were collected from 173 African savanna elephants (*Loxodonta africana*) in Kenya, northern Mozambique and Zimbabwe, and two species were collected from six African forest elephants (*Loxodonta cyclotis*) in the Republic of Congo. A new host record is reported for *Amblyomma eburneum*. A list of ticks collected from elephants in various African countries, and stored in the United States National Tick Collection, is supplied as well as an annotated checklist of the 27 ixodid tick species that have been collected from African elephants. The geographic distributions and alternative hosts of the various tick species collected from elephants are briefly discussed.

Kariuki, E., et al. (2019). "Ixodid ticks (Acari: Ixodidae) collected from African savanna elephants (*Loxodonta africana*) and African forest elephants (*Loxodonta cyclotis*)." *Onderstepoort J Vet Res* 86(1): e1-e5.
 Eight ixodid tick species were collected from 173 African savanna elephants (*Loxodonta africana*) in Kenya, northern Mozambique and Zimbabwe, and two species were collected from six African forest elephants (*Loxodonta cyclotis*) in the Republic of Congo. A new host record is reported for *Amblyomma eburneum*. A list of ticks collected from elephants in various African countries, and stored in the United States National Tick Collection, is supplied as well as an annotated checklist of the 27 ixodid tick species that have been collected from African elephants. The geographic distributions and alternative hosts of the various tick species collected from elephants are briefly discussed.

Kariuki, E., et al. (2019). "Ixodid ticks (Acari: Ixodidae) collected from African savanna elephants (*Loxodonta africana*) and African forest elephants (*Loxodonta cyclotis*)." *Onderstepoort J Vet Res* 86(1): e1-e5.
 Eight ixodid tick species were collected from 173 African savanna elephants (*Loxodonta africana*) in Kenya, northern Mozambique and Zimbabwe, and two species were collected from six African forest elephants (*Loxodonta cyclotis*) in the Republic of Congo. A new host record is reported for *Amblyomma eburneum*. A list of ticks collected from elephants in various African countries, and stored in the United States National Tick Collection, is supplied as well as an annotated checklist of the 27 ixodid tick species that have been collected from African elephants. The geographic distributions and alternative hosts of the various tick species collected from elephants are briefly discussed.

Kartzinel, T. R., et al. (2019). "Covariation of diet and gut microbiome in African megafauna." *Proceedings of the National Academy of Sciences of the United States of America* 116(47): 23588-23593.
 A major challenge in biology is to understand how phylogeny, diet, and environment shape the mammalian gut microbiome. Yet most studies of nonhuman microbiomes have relied on relatively coarse dietary categorizations and have focused either on individual wild populations or on captive animals that are sheltered from environmental pressures, which may obscure the effects of dietary and environmental variation on microbiome composition in diverse natural communities. We analyzed plant and bacterial DNA in fecal samples from an assemblage of 33 sympatric large-herbivore species (27 native, 6 domesticated) in a semiarid East African savanna, which enabled high-resolution assessment of seasonal variation in both diet and microbiome composition. Phylogenetic relatedness strongly predicted microbiome composition ($r = 0.91$) and was weakly but significantly correlated with diet composition ($r = 0.20$). Dietary diversity did not significantly predict microbiome diversity across species or within any species except kudu; however, diet composition was significantly correlated with microbiome composition both across and within most species. We found a spectrum of seasonal sensitivity at the diet–microbiome nexus: Seasonal changes in diet composition explained 25% of seasonal variation in microbiome composition across species. Species' positions on (and deviations from) this spectrum were not obviously driven by phylogeny, body size, digestive strategy, or diet composition; however, domesticated species tended to exhibit greater diet–microbiome turnover than wildlife. Our results reveal marked differences in the influence of environment on the degree of diet–microbiome covariation in free-ranging African megafauna, and this variation is not well explained by canonical predictors of nutritional ecology. © 2019 National Academy of Sciences. All rights reserved.

Kerr, T. J., et al. (2019). "Seroprevalence of *Mycobacterium tuberculosis* Complex in Free-ranging African

Elephants (*Loxodonta africana*) in Kruger National Park, South Africa." *J Wildl Dis.*

Tuberculosis (TB) is a pathogenic disease that affects a range of wildlife species, including African elephants (*Loxodonta africana*). The recent discovery of fatal disease caused by infection with *Mycobacterium tuberculosis* in a bull elephant in the Kruger National Park (KNP), which is a bovine TB endemic area, emphasizes the importance this disease could have on both wild and captive elephant populations globally. Elephants with culture-confirmed TB have previously been shown to produce strong antibody-responses before the mycobacteria can be isolated. Therefore, we used two serologic assays that detect TB antibodies to retrospectively screen a cohort of 222 free-ranging African elephants sampled between 2004 and 2018 in KNP. The estimated TB seroprevalence for this free-roaming elephant population was between 6% (95% confidence interval [CI], 2-12%) and 9% (95% CI, 6-15%) based on the two tests. Overall, males had a higher TB seroprevalence than females, and adults (≥ 25 yr) had a higher TB seroprevalence than younger elephants (≤ 24 yr) on both rapid tests. The relatively high TB seroprevalence that we found highlighted the value of conducting retrospective studies in free-ranging wildlife populations in order to better understand the potential risk of disease.

Kerr, T. J., et al. (2019). "Seroprevalence of mycobacterium tuberculosis complex in free-ranging african elephants (*Loxodonta africana*) in Kruger national park, South Africa." *Journal of Wildlife Diseases* **55**(4): 923-927.

Tuberculosis (TB) is a pathogenic disease that affects a range of wildlife species, including African elephants (*Loxodonta africana*). The recent discovery of fatal disease caused by infection with *Mycobacterium tuberculosis* in a bull elephant in the Kruger National Park (KNP), which is a bovine TB endemic area, emphasizes the importance this disease could have on both wild and captive elephant populations globally. Elephants with culture-confirmed TB have previously been shown to produce strong antibody-responses before the mycobacteria can be isolated. Therefore, we used two serologic assays that detect TB antibodies to retrospectively screen a cohort of 222 free-ranging African elephants sampled between 2004 and 2018 in KNP. The estimated TB seroprevalence for this free-roaming elephant population was between 6% (95% confidence interval [CI], 2–12%) and 9% (95% CI, 6–15%) based on the two tests. Overall, males had a higher TB seroprevalence than females, and adults (≤ 25 yr) had a higher TB seroprevalence than younger elephants (≤ 24 yr) on both rapid tests. The relatively high TB seroprevalence that we found highlighted the value of conducting retrospective studies in free-ranging wildlife populations in order to better understand the potential risk of disease.
© Wildlife Disease Association 2019.

Ketchaisri, O., et al. (2019). "The use of a human's location and social cues by Asian elephants in an object-choice task." *Anim Cogn.*

Asian elephants have previously demonstrated an ability to follow olfactory cues, but not human-provided social cues like pointing and gazing or orienting to find hidden food (Plotnik et al. in *PLoS One* 8:e61174, 2013; *Anim Behav* 88:91-98, 2014). In a study conducted with African elephants, however, elephants were able to follow a combination of these social cues to find food, even when the experimenter's position was counter to the location of the food. The authors of the latter study argued that the differences in the two species' performances might have been due to methodological differences in the study designs (Smet and Byrne in *Curr Biol* 23(20):2033-2037, 2013). To further investigate the reasons for these potential differences, we partially adapted Smet and Byrne (2013)'s design for a group of Asian elephants in Thailand. In a two-object-choice task in which only one of two buckets was baited with food, we found that, as a group, the elephants did not follow cues provided by an experimenter when she was positioned either equidistant between the buckets or closer to the incorrect bucket when providing the cues. The elephants did, however, follow cues when the experimenter was closer to the correct bucket. In addition, there was individual variability in the elephants' performance within and across experimental conditions. This indicates that in general, for Asian elephants, the pointing and/or gazing cues alone may not be salient enough; local enhancement in the form of the experimenter's position in relation to the food reward may represent a crucial,

complementary cue. These results suggest that the variability within and between the species in their performance on these tasks could be due to a number of factors, including methodology, the elephants' experiences with their handlers, ecological differences in how Asian and African elephants use non-visual sensory information to find food in the wild, or some combination of the three.

Khonmee, J., et al. (2019). "Effect of time and temperature on stability of progestagens, testosterone and cortisol in Asian elephant blood stored with and without anticoagulant." *Conserv Physiol* **7**(1): coz031.

The value of biological samples collected in the field is compromised if storage conditions result in analyte degradation, especially in warmer climates like Thailand. We evaluated the effects of time and temperature on immunoactive steroid hormone stability in Asian elephant (*Elephas maximus*) blood stored with and without an anti-coagulant before centrifugation. For each elephant (5 male, 5 female), whole blood was aliquoted ($n = 2$ ml each) into 13 red top (without anticoagulant) or purple top (with anticoagulant) tubes. One tube from each treatment was centrifuged immediately and the serum or plasma frozen at -20 degrees C (Time 0, T0). The remaining 12 aliquots were divided into stored temperature groups: 4 degrees C, room temperature (RT, ~22 degrees C), and 37 degrees C, and centrifuged after 6, 24, 48 and 62 h of storage. Serum and plasma concentrations of progestagens in females, testosterone in males and cortisol in both sexes were quantified by validated enzyme immunoassays. Steroid concentration differences from T0 were determined by a randomized complete block ANOVA and Dunnett's tests. The only evidence of hormone degradation was cortisol and testosterone concentrations in serum stored at 37 degrees C. Testosterone concentrations declined by 34% at 48 h and 52% at 62 h, cortisol was decreased by 19% after 48 h and 27% after 62 h at 37 degrees C, respectively. None of the other aliquots displayed significant changes over time at any temperature. In conclusion, steroids appear to be stable in blood for nearly 3 days at room or refrigeration temperatures before centrifugation; steroids in samples with ethylenediaminetetraacetic acid were particularly stable. However, warmer temperatures may negatively affect steroids stored without anti-coagulant, perhaps due to red blood cell metabolism. Thus, under field conditions with no access to cold or freezer temperatures, collection of plasma is a better choice for elephants up to at least 62 h before centrifugation.

Kiffner, C., et al. (2019). "Land use, REDD+ and the status of wildlife populations in Yaeda Valley, northern Tanzania." *PLoS ONE* **14**(4): e0214823.

REDD+ projects primarily focus on reducing carbon emissions from deforestation and forest degradation in developing countries. These projects are regularly evaluated against their core objective of conserving carbon stocks, but their contribution to biodiversity conservation has rarely been assessed. To assess the conservation value of the area and the relative performance of a REDD+ land use plan in Yaeda Valley, a semi-arid savannah ecosystem in northern Tanzania, we implemented an annual wildlife monitoring scheme. Based on direct sightings and indirect signs of wildlife, obtained from stratified walking transects conducted annually from 2015-2018, we estimated annual trends of mammal species richness and wildlife densities in three REDD+ and three non-REDD+ land-use strata. Our surveys document a near complete mammal community in the area. Species accumulation curves, and subsequent statistical comparisons, indicated highest mammal species richness in the woodland habitats (both REDD+ and non REDD+ strata) as compared to more human and livestock impacted areas, and suggested constant species richness from 2015-2018. To estimate stratum- and year-specific livestock and wildlife densities (cattle, donkey, goat and sheep combined, Thomson's gazelle, Kirk's dik-dik) and wildlife sign densities (aardvark, bushbuck, bushpig, Kirk's dik dik, eland, elephant, Maasai giraffe, greater kudu, hyena, impala, lesser kudu, warthog, wildebeest, Plains zebra), we fitted species-specific detection functions in a distance sampling framework. Species-specific densities varied between 2015 and 2018 and showed substantial increases and occasional declines in other species-stratum combinations. However, population growth rates were not systematically associated with specific land-use strata. Although our results do not explicitly provide evidence that REDD+ land-use plans directly co-benefit wildlife conservation, they show that REDD+ areas have the potential to maintain intact wildlife assemblages. To ensure effective long-term conservation

outcomes, we advocate for a more formal integration of wildlife conservation goals in the REDD+ scheme.

King'ori, E., et al. (2019). "Molecular identification of Ehrlichia, Anaplasma, Babesia and Theileria in African elephants and their ticks." *PLoS ONE* **14**(12): e0226083.

Although historical records indicate the presence of Ehrlichia and Babesia in African elephants, not much is known about their prevalence and diversity in elephants and their ticks, *Amblyomma thollonii* and *Rhipicephalus humeralis*. We amplified and sequenced the hypervariable V4 region of the 18S rRNA gene of Babesia and Theileria and the heat shock protein gene (groEL) of Ehrlichia/Anaplasma in DNA extracted from elephant blood (n = 104) and from elephant ticks (n = 52). Our results showed that the African elephants were infected with a novel Babesia spp. while *A. thollonii* was infected with Theileria bicornis and Theileria cf. velifera. This is the first record of T. bicornis; a protozoan that is linked to fatal infection in rhinoceros in a tick. Elephants and their ticks were all infected with a species of Ehrlichia like that identified in Japanese deer. The prevalence of Babesia spp., Theileria spp. and Ehrlichia spp. in ticks was higher than that of their elephant hosts. About 13.5% of elephants were positive for Theileria or Babesia while 51% of *A. thollonii* ticks and 27% of *R. humeralis* ticks were positive for Theileria or Babesia. Moreover, 5.8% of elephants were positive for Ehrlichia or Anaplasma compared to 19.5% in *A. thollonii* and 18% in *R. humeralis*. There was no association between the positive result in ticks and that of their elephant hosts for either Babesia spp., Theileria spp. or Ehrlichia spp. Our study reveals that the African elephants are naturally infected with Babesia spp and Ehrlichia spp and opens up an opportunity for further studies to determine the role of elephant as reservoirs of tick-borne pathogens, and to investigate their potential in spreading these pathogens as they range extensively. The presence of T. bicornis in *A. thollonii* also suggests a need for experiments to confirm its vector competence.

Kobayashi, Y., et al. (2019). "An endogenous adeno-associated virus element in elephants." *Virus Res* **262**: 10-14.

An endogenous viral element derived from adeno-associated virus containing a nearly intact open reading frame (ORF) of the rep gene (enAAV-rep) has been identified in the genomes of various mammals including degu and African elephant. Particularly, in degu, mRNA expression of enAAV-rep has been observed specifically in the liver. Here we newly identified enAAV-rep in Asian elephant and rock hyrax, both of which are afrotherians. The enAAV-rep of African and Asian elephants appeared to be orthologous and originated from an integration event of the entire genome of AAV into the ancestral genome of elephants more than 6 million years ago, whereas that of rock hyrax appeared to have originated independently. Negative selection operating at the amino acid sequence level was detected for the ORF of enAAV-rep in elephants. As in degu, mRNA expression of enAAV-rep was specifically observed in the liver in Asian elephant. Integrations of enAAV-rep appeared to have occurred independently on the evolutionary lineages of elephants and degu, suggesting that the AAV Rep protein has been co-opted repeatedly in the mammalian liver.

Kohda, M., et al. (2019). "If a fish can pass the mark test, what are the implications for consciousness and self-awareness testing in animals?" *PLoS Biology* **17**(2).

The ability to perceive and recognise a reflected mirror image as self (mirror self-recognition, MSR) is considered a hallmark of cognition across species. Although MSR has been reported in mammals and birds, it is not known to occur in any other major taxon. Potentially limiting our ability to test for MSR in other taxa is that the established assay, the mark test, requires that animals display contingency testing and self-directed behaviour. These behaviours may be difficult for humans to interpret in taxonomically divergent animals, especially those that lack the dexterity (or limbs) required to touch a mark. Here, we show that a fish, the cleaner wrasse *Labroides dimidiatus*, shows behaviour that may reasonably be interpreted as passing through all phases of the mark test: (i) social reactions towards the reflection, (ii) repeated idiosyncratic behaviours towards the mirror, and (iii) frequent observation of their reflection. When subsequently provided with a coloured tag in a modified mark test, fish attempt

to remove the mark by scraping their body in the presence of a mirror but show no response towards transparent marks or to coloured marks in the absence of a mirror. This remarkable finding presents a challenge to our interpretation of the mark test—do we accept that these behavioural responses, which are taken as evidence of self-recognition in other species during the mark test, lead to the conclusion that fish are self-aware? Or do we rather decide that these behavioural patterns have a basis in a cognitive process other than self-recognition and that fish do not pass the mark test? If the former, what does this mean for our understanding of animal intelligence? If the latter, what does this mean for our application and interpretation of the mark test as a metric for animal cognitive abilities?

Kohda, M., et al. (2019). "If a fish can pass the mark test, what are the implications for consciousness and self-awareness testing in animals?" *PLoS Biology* **17**(2).

The ability to perceive and recognise a reflected mirror image as self (mirror self-recognition, MSR) is considered a hallmark of cognition across species. Although MSR has been reported in mammals and birds, it is not known to occur in any other major taxon. Potentially limiting our ability to test for MSR in other taxa is that the established assay, the mark test, requires that animals display contingency testing and self-directed behaviour. These behaviours may be difficult for humans to interpret in taxonomically divergent animals, especially those that lack the dexterity (or limbs) required to touch a mark. Here, we show that a fish, the cleaner wrasse *Labroides dimidiatus*, shows behaviour that may reasonably be interpreted as passing through all phases of the mark test: (i) social reactions towards the reflection, (ii) repeated idiosyncratic behaviours towards the mirror, and (iii) frequent observation of their reflection. When subsequently provided with a coloured tag in a modified mark test, fish attempt to remove the mark by scraping their body in the presence of a mirror but show no response towards transparent marks or to coloured marks in the absence of a mirror. This remarkable finding presents a challenge to our interpretation of the mark test—do we accept that these behavioural responses, which are taken as evidence of self-recognition in other species during the mark test, lead to the conclusion that fish are self-aware? Or do we rather decide that these behavioural patterns have a basis in a cognitive process other than self-recognition and that fish do not pass the mark test? If the former, what does this mean for our understanding of animal intelligence? If the latter, what does this mean for our application and interpretation of the mark test as a metric for animal cognitive abilities?. © 2019 Kohda et al.

Koirala, R. K., et al. (2019). "The effects of age, sex and season on the macronutrient composition of the diet of the domestic Asian elephant." *Journal of Applied Animal Research* **47**(1): 5-16.

Limited data are available on the relationship between seasonal diets and macronutrient and energy intake of domestic Asian elephants. The effects of age, sex and season on the nutrient composition and intake of food were investigated using 16 domesticated Asian elephants of different ages and sexes. There were no significant seasonal differences in the protein content of the major food plants. However, a seasonal variation in the intake of protein was evident. We used geometric modelling of non-protein (NP) neutral detergent fibre (NDF) and protein to examine seasonal nutrient variability within different ages, sexes and physiological states. The model suggested that most individual elephants maintained their recommended metabolizable energy intake from their diet across all seasons. However, we had anticipated less energy intake from poor diet due to less protein and higher NDF in the feeding ground during winter, pre-monsoon and monsoon seasons. Despite eating a lower variety of plants with less protein and higher NDF, elephants maintained a consistent pattern of diet intake in these seasons, suggesting that they acquired the recommended energy intake by regulating their diet, most likely through over-ingesting low-quality, non-complementary food as they did not have the opportunity to select from a variety of plants. [GRAPHICS] .

Koirala, R. K., et al. (2019). "The effects of age, sex and season on the macronutrient composition of the diet of the domestic Asian elephant." *Journal of Applied Animal Research* **47**(1): 5-16.

Limited data are available on the relationship between seasonal diets and macronutrient and energy intake of domestic Asian elephants. The effects of age, sex and season on the nutrient composition

and intake of food were investigated using 16 domesticated Asian elephants of different ages and sexes. There were no significant seasonal differences in the protein content of the major food plants. However, a seasonal variation in the intake of protein was evident. We used geometric modelling of non-protein (NP) neutral detergent fibre (NDF) and protein to examine seasonal nutrient variability within different ages, sexes and physiological states. The model suggested that most individual elephants maintained their recommended metabolizable energy intake from their diet across all seasons. However, we had anticipated less energy intake from poor diet due to less protein and higher NDF in the feeding ground during winter, pre-monsoon and monsoon seasons. Despite eating a lower variety of plants with less protein and higher NDF, elephants maintained a consistent pattern of diet intake in these seasons, suggesting that they acquired the recommended energy intake by regulating their diet, most likely through over-ingesting low-quality, non-complementary food as they did not have the opportunity to select from a variety of plants. [GRAPHICS] .

Kumar, V., et al. (2019). "Non-Invasive Assessment of Physiological Stress in Captive Asian Elephants." Animals (Basel) **9**(8).

Asian elephant (*Elephas maximus*) populations, both in the wild and in captivity, have been continually declining over the decades. The present study examined the physiological stress response of captive Asian elephants in relation to body condition score and different working conditions. A total of 870 dung samples of 37 captive elephants (24 males and 13 females) from four facilities were collected to examine fecal glucocorticoid metabolite concentrations (fGCM). The elephants in forest camps with exposure to natural habitats had a higher body condition score than those in more confined spaces. Wild born elephants and females (except in one case) had higher concentrations of fGCM than captive born elephants and males, respectively. Elephants engaged in the Dussehra festival had elevated fGCM concentrations than their counterparts at Mysore zoo. We recommend a few management practices for the long-term survival of rapidly declining captive elephant populations.

Kumar, V., et al. (2019). "Non-Invasive Assessment of Physiological Stress in Captive Asian Elephants." Animals (Basel) **9**(8).

Asian elephant (*Elephas maximus*) populations, both in the wild and in captivity, have been continually declining over the decades. The present study examined the physiological stress response of captive Asian elephants in relation to body condition score and different working conditions. A total of 870 dung samples of 37 captive elephants (24 males and 13 females) from four facilities were collected to examine fecal glucocorticoid metabolite concentrations (fGCM). The elephants in forest camps with exposure to natural habitats had a higher body condition score than those in more confined spaces. Wild born elephants and females (except in one case) had higher concentrations of fGCM than captive born elephants and males, respectively. Elephants engaged in the Dussehra festival had elevated fGCM concentrations than their counterparts at Mysore zoo. We recommend a few management practices for the long-term survival of rapidly declining captive elephant populations.

Kumar, V., et al. (2019). "Non-Invasive Assessment of Physiological Stress in Captive Asian Elephants." Animals (Basel) **9**(8).

Asian elephant (*Elephas maximus*) populations, both in the wild and in captivity, have been continually declining over the decades. The present study examined the physiological stress response of captive Asian elephants in relation to body condition score and different working conditions. A total of 870 dung samples of 37 captive elephants (24 males and 13 females) from four facilities were collected to examine fecal glucocorticoid metabolite concentrations (fGCM). The elephants in forest camps with exposure to natural habitats had a higher body condition score than those in more confined spaces. Wild born elephants and females (except in one case) had higher concentrations of fGCM than captive born elephants and males, respectively. Elephants engaged in the Dussehra festival had elevated fGCM concentrations than their counterparts at Mysore zoo. We recommend a few management practices for the long-term survival of rapidly declining captive elephant populations.

Lahdenperä, M., et al. (2019). "Capture from the wild has long-term costs on reproductive success in Asian elephants." *Proc Biol Sci* **286**(1912): 20191584.

Capturing wild animals is common for conservation, economic or research purposes. Understanding how capture itself affects lifetime fitness measures is often difficult because wild and captive populations live in very different environments and there is a need for long-term life-history data. Here, we show how wild capture influences reproduction in 2685 female Asian elephants (*Elephas maximus*) used in the timber industry in Myanmar. Wild-caught females demonstrated a consistent reduction in breeding success relative to captive-born females, with significantly lower lifetime reproduction probabilities, lower breeding probabilities at peak reproductive ages and a later age of first reproduction. Furthermore, these negative effects lasted for over a decade, and there was a significant influence on the next generation: wild-caught females had calves with reduced survival to age 5. Our results suggest that wild capture has long-term consequences for reproduction, which is important not only for elephants, but also for other species in captivity.

Li, X., et al. (2019). "Elephant APOBEC3A cytidine deaminase induces massive double-stranded DNA breaks and apoptosis." *Sci Rep* **9**(1): 728.

The incidence of developing cancer should increase with the body mass, yet is not the case, a conundrum referred to as Peto's paradox. Elephants have a lower incidence of cancer suggesting that these animals have probably evolved different ways to protect themselves against the disease. The paradox is worth revisiting with the realization that most mammals encode an endogenous APOBEC3 cytidine deaminase capable of mutating single stranded DNA. Indeed, the mutagenic activity of some APOBEC3 enzymes has been shown to introduce somatic mutations into genomic DNA. These enzymes are now recognized as causal agent responsible for the accumulation of CG- > TA transitions and DNA breaks leading to chromosomal rearrangements in human cancer genomes. Here, we identified an elephant A3Z1 gene, related to human APOBEC3A and showed that it could efficiently deaminate cytidine, 5-methylcytidine and produce DNA breaks leading to massive apoptosis, similar to other mammalian APOBEC3A enzymes where body mass varies by up to four orders of magnitude. Consequently, it could be considered that eAZ1 might contribute to cancer in elephants in a manner similar to their proposed role in humans. If so, eAZ1 might be particularly well regulated to counter Peto's paradox.

Li, X., et al. (2019). "Elephant APOBEC3A cytidine deaminase induces massive double-stranded DNA breaks and apoptosis." *Sci Rep* **9**(1): 728.

The incidence of developing cancer should increase with the body mass, yet is not the case, a conundrum referred to as Peto's paradox. Elephants have a lower incidence of cancer suggesting that these animals have probably evolved different ways to protect themselves against the disease. The paradox is worth revisiting with the realization that most mammals encode an endogenous APOBEC3 cytidine deaminase capable of mutating single stranded DNA. Indeed, the mutagenic activity of some APOBEC3 enzymes has been shown to introduce somatic mutations into genomic DNA. These enzymes are now recognized as causal agent responsible for the accumulation of CG->TA transitions and DNA breaks leading to chromosomal rearrangements in human cancer genomes. Here, we identified an elephant A3Z1 gene, related to human APOBEC3A and showed that it could efficiently deaminate cytidine, 5-methylcytidine and produce DNA breaks leading to massive apoptosis, similar to other mammalian APOBEC3A enzymes where body mass varies by up to four orders of magnitude. Consequently, it could be considered that eAZ1 might contribute to cancer in elephants in a manner similar to their proposed role in humans. If so, eAZ1 might be particularly well regulated to counter Peto's paradox.

Lipworth, S., et al. (2019). "SNP-IT tool for identifying subspecies and associated lineages of *Mycobacterium tuberculosis* complex." *Emerging Infectious Diseases* **25**(3): 482-488.

The clinical phenotype of zoonotic tuberculosis and its contribution to the global burden of disease are

poorly understood and probably underestimated. This shortcoming is partly because of the inability of currently available laboratory and in silico tools to accurately identify all subspecies of the *Mycobacterium tuberculosis* complex (MTBC). We present SNPs to Identify TB (SNP-IT), a single-nucleotide polymorphism-based tool to identify all members of MTBC, including animal clades. By applying SNP-IT to a collection of clinical genomes from a UK reference laboratory, we detected an unexpectedly high number of *M. orygis* isolates. *M. orygis* is seen at a similar rate to *M. bovis*, yet *M. orygis* cases have not been previously described in the United Kingdom. From an international perspective, it is possible that *M. orygis* is an underestimated zoonosis. Accurate identification will enable study of the clinical phenotype, host range, and transmission mechanisms of all subspecies of MTBC in greater detail. © 2019, Centers for Disease Control and Prevention (CDC). All rights reserved.

Mahato, G., et al. (2019). "Endotheliotropic herpesvirus infection in Asian elephants (*Elephas maximus*) of Assam, India." *Vet World* **12**(11): 1790-1796.

BACKGROUND AND AIM: Elephant endotheliotropic herpesvirus (EEHV) is an emerging disease of elephant. Therefore, a study was conducted to know the actual status of the disease in Assam State of India. **MATERIALS AND METHODS:** A total of 289 Asian elephants of Assam were screened during 2 years of study from April 2017 to March 2019. The clinical symptoms of diseased as well as gross and histopathological changes of dead elephants were recorded for the diagnosis of the disease. Virus involved in the occurrence of the disease was confirmed by polymerase chain reaction (PCR). **RESULTS:** In the present study, a total of three elephant calves out of 22 were found positive to EEHV1A. On the other hand, three adult asymptomatic elephants were also found positive for EEHV1 on screening 267 captive Asian elephants of Assam. The amplified PCR product showed band size of 520, 600, and 930 bp. The PCR amplified product with size 600 bp had shown the gene sequence for EEHV1U77/HEL. Gross lesions include congested blood vessels of the liver and intestinal mucosa, foci of petechiae in the spleen, and heart and focal ulceration in the dorsal surface of the tongue. Microscopically, the kidneys showed intertubular edema and focal areas of degeneration associated with coagulative necrosis of the tubular epithelium. The liver showed hydropic degeneration and fatty changes of the hepatocytes. There was a massive proliferation of fibroblasts in the interlobular spaces which penetrated the necrosed areas of the hepatic lobules. **CONCLUSION:** A total of three wild rescued elephant calves and three asymptomatic adults were found positive for EEHV1A during the 2 years of study. The PCR amplified product with size 600 bp had shown the gene sequence for EEHV1U77/HEL.

Mallet, C., et al. (2019). "Interspecific variation in the limb long bones among modern rhinoceroses—extent and drivers." *PeerJ* **7**: e7647.

Among amniotes, numerous lineages are subject to an evolutionary trend toward body mass and size increases. Large terrestrial species may face important constraints linked to weight bearing, and the limb segments are particularly affected by such constraints due to their role in body support and locomotion. Such groups showing important limb modifications related to high body mass have been called "graviportal." Often considered graviportal, rhinoceroses are among the heaviest terrestrial mammals and are thus of particular interest to understand the limb modifications related to body mass and size increase. Here, we present a morphofunctional study of the shape variation of the limb long bones among the five living rhinos to understand how the shape may vary between these species in relation with body size, body mass and phylogeny. We used three dimensional geometric morphometrics and comparative analyses to quantify the shape variation. Our results indicate that the five species display important morphological differences depending on the considered bones. The humerus and the femur exhibit noticeable interspecific differences between African and Asiatic rhinos, associated with a significant effect of body mass. The radius and ulna are more strongly correlated with body mass. While the tibia exhibits shape variation both linked with phylogeny and body mass, the fibula displays the greatest intraspecific variation. We highlight three distinct morphotypes of bone shape, which appear in accordance with the phylogeny. The influence of body mass also appears unequally expressed on the different bones. Body mass increase among the five extant species is

marked by an increase of the general robustness, more pronounced attachments for muscles and a development of medial parts of the bones. Our study underlines that the morphological features linked to body mass increase are not similar between rhinos and other heavy mammals such as elephants and hippos, suggesting that the weight bearing constraint can lead to different morphological responses.

Mallet, C., et al. (2019). "Interspecific variation in the limb long bones among modern rhinoceroses-extent and drivers." *PeerJ* 7: e7647.

Among amniotes, numerous lineages are subject to an evolutionary trend toward body mass and size increases. Large terrestrial species may face important constraints linked to weight bearing, and the limb segments are particularly affected by such constraints due to their role in body support and locomotion. Such groups showing important limb modifications related to high body mass have been called "graviportal." Often considered graviportal, rhinoceroses are among the heaviest terrestrial mammals and are thus of particular interest to understand the limb modifications related to body mass and size increase. Here, we present a morphofunctional study of the shape variation of the limb long bones among the five living rhinos to understand how the shape may vary between these species in relation with body size, body mass and phylogeny. We used three dimensional geometric morphometrics and comparative analyses to quantify the shape variation. Our results indicate that the five species display important morphological differences depending on the considered bones. The humerus and the femur exhibit noticeable interspecific differences between African and Asiatic rhinos, associated with a significant effect of body mass. The radius and ulna are more strongly correlated with body mass. While the tibia exhibits shape variation both linked with phylogeny and body mass, the fibula displays the greatest intraspecific variation. We highlight three distinct morphotypes of bone shape, which appear in accordance with the phylogeny. The influence of body mass also appears unequally expressed on the different bones. Body mass increase among the five extant species is marked by an increase of the general robustness, more pronounced attachments for muscles and a development of medial parts of the bones. Our study underlines that the morphological features linked to body mass increase are not similar between rhinos and other heavy mammals such as elephants and hippos, suggesting that the weight bearing constraint can lead to different morphological responses.

Mallet, C., et al. (2019). "Interspecific variation in the limb long bones among modern rhinoceroses-extent and drivers." *PeerJ* 7: e7647.

Among amniotes, numerous lineages are subject to an evolutionary trend toward body mass and size increases. Large terrestrial species may face important constraints linked to weight bearing, and the limb segments are particularly affected by such constraints due to their role in body support and locomotion. Such groups showing important limb modifications related to high body mass have been called "graviportal." Often considered graviportal, rhinoceroses are among the heaviest terrestrial mammals and are thus of particular interest to understand the limb modifications related to body mass and size increase. Here, we present a morphofunctional study of the shape variation of the limb long bones among the five living rhinos to understand how the shape may vary between these species in relation with body size, body mass and phylogeny. We used three dimensional geometric morphometrics and comparative analyses to quantify the shape variation. Our results indicate that the five species display important morphological differences depending on the considered bones. The humerus and the femur exhibit noticeable interspecific differences between African and Asiatic rhinos, associated with a significant effect of body mass. The radius and ulna are more strongly correlated with body mass. While the tibia exhibits shape variation both linked with phylogeny and body mass, the fibula displays the greatest intraspecific variation. We highlight three distinct morphotypes of bone shape, which appear in accordance with the phylogeny. The influence of body mass also appears unequally expressed on the different bones. Body mass increase among the five extant species is marked by an increase of the general robustness, more pronounced attachments for muscles and a development of medial parts of the bones. Our study underlines that the morphological features linked

to body mass increase are not similar between rhinos and other heavy mammals such as elephants and hippos, suggesting that the weight bearing constraint can lead to different morphological responses.

Martinez, L., et al. (2019). "Detection, survival and infectious potential of *Mycobacterium tuberculosis* in the environment: a review of the evidence and epidemiological implications." The European respiratory journal **53**(6).

Much remains unknown about *Mycobacterium tuberculosis* transmission. Seminal experimental studies from the 1950s demonstrated that airborne expulsion of droplet nuclei from an infectious tuberculosis (TB) patient is the primary route of transmission. However, these findings did not rule out other routes of *M. tuberculosis* transmission. We reviewed historical scientific evidence from the late 19th/early 20th century and contemporary studies investigating the presence, persistence and infectiousness of environmental *M. tuberculosis*. We found both experimental and epidemiological evidence supporting the presence and viability of *M. tuberculosis* in multiple natural and built environments for months to years, presumably following contamination by a human source. Furthermore, several studies confirm *M. tuberculosis* viability and virulence in the environment using guinea pig and mouse models. Most of this evidence was historical; however, several recent studies have reported consistent findings of *M. tuberculosis* detection and viability in the environment using modern methods. Whether *M. tuberculosis* in environments represents an infectious threat to humans requires further investigation; this may represent an untapped source of data with which to further understand *M. tuberculosis* transmission. We discuss potential opportunities for harnessing these data to generate new insights into TB transmission in congregate settings. Copyright ©ERS 2019.

Menon, V. and S. K. R. Tiwari (2019). "Population status of Asian elephants *Elephas maximus* and key threats." International Zoo Yearbook **53**(1): 17-30.

The Asian elephant *Elephas maximus* is distributed in 13 countries across South Asia and South East Asia spread over an area of 486 800 km² with a population of c. 48 323–51 680 in the wild and c. 15 000 in captivity. The major threats to the survival of the species are habitat shrinkage and fragmentation, human–elephant conflict, poaching and illegal trade of elephant body parts. The elephant populations of Vietnam, Sumatra and Myanmar are under great threat with only 100–130 elephants left in the wild in Vietnam. Apart from ivory, the trade of other body parts of elephants, especially the skin trade, has increased in last few years further threatening the elephant population. This trade could result in indiscriminate killing of elephants of both sexes threatening the fragile elephant population in the region. Human–elephant conflict has become a significant threat for the conservation of Asian elephants across their range of distribution and needs to be managed urgently to prevent retaliation. The welfare and care of elephants in captivity is a major concern as are the training methods used with these elephants. There is also a need to create and conform to a uniform registration system for elephants in human care to prevent illegal trade of individuals. © 2019 The Zoological Society of London

Miller, M. A., et al. (2019). "Fatal Tuberculosis in a Free-Ranging African Elephant and One Health Implications of Human Pathogens in Wildlife." Front Vet Sci **6**: 18.

Tuberculosis (TB) in humans is a global public health concern and the discovery of animal cases of *Mycobacterium tuberculosis* (Mtb) infection and disease, especially in multi-host settings, also has significant implications for public health, veterinary disease control, and conservation endeavors. This paper describes a fatal case of Mtb disease in a free-ranging African elephant (*Loxodonta africana*) in a high human TB burden region. Necropsy revealed extensive granulomatous pneumonia, from which Mtb was isolated and identified as a member of LAM3/F11 lineage; a common lineage found in humans in South Africa. These findings are contextualized within a framework of emerging Mtb disease in wildlife globally and highlights the importance of the One Health paradigm in addressing this anthroponotic threat to wildlife and the zoonotic implications.

Mokobela, M. J., et al. (2019). "Foster local expertise in Botswana's elephant-hunting debate." *Nature* **573**(7774): 346.

Mukherjee, T., et al. (2019). "Changing landscape configuration demands ecological planning: Retrospect and prospect for megaherbivores of North Bengal." *PLoS ONE* **14**(12): e0225398.

The Gorumara National Park (GNP) is an important conservation area located in the northern region of West Bengal State, India, as it provides habitat for three megaherbivores: Indian One-horned rhinoceros (*Rhinoceros unicornis*), Asian elephants (*Elephas maximus*) and Gaurs (*Bos gaurus*). It harbours one of the last population of the one-horned rhino. In the present study, landscape change and configuration were investigated by comparing three Landsat images, from 1998, 2008 and 2018. The images were classified into six different landcover classes following standard methodology. The present study also involves evaluation of landscape and anthropogenic predictors influence on the megaherbivores of GNP, followed by future landcover simulation for the year 2028. The result shows a significant decrease in the grassland cover from 18.87 km² to 8.27 km² from 1998 to 2018, whereas the woodland cover has increased from 50.14 km² to 62.09 km² between 1998 and 2018. The landscape configuration indices such as Number of Patches (NP), Patch Density (PD), Interspersion and Juxtaposition (IJI), Aggregation Index (AI) and Mean Shape Index (SHAPE AM) indicated that the landscapes has lost complexity in the spatial placement of patches of different Land Use and Land Cover (LULC) classes. Also, the landscape over the three decades has become uniform in terms of diversity of patches, because of earlier plantation activities by the forest managers. Result also indicated that grassland, along with its class metrics are the top predictors contributing 43.6% in explaining the spatial distribution of megaherbivores in GNP. Results from the simulated landcover of 2028 suggest a possible decline in overall grassland by 6.23% and a subsequent upsurge in woodland by 6.09% from 2018. The present result will be useful in guiding the forest management in developing habitat improvement strategies for the long- term viability of megaherbivore populations of rhino, gaur and elephant in the GNP.

Mukherjee, T., et al. (2019). "Changing landscape configuration demands ecological planning: Retrospect and prospect for megaherbivores of North Bengal." *PLoS ONE* **14**(12): e0225398.

The Gorumara National Park (GNP) is an important conservation area located in the northern region of West Bengal State, India, as it provides habitat for three megaherbivores: Indian One-horned rhinoceros (*Rhinoceros unicornis*), Asian elephants (*Elephas maximus*) and Gaurs (*Bos gaurus*). It harbours one of the last population of the one-horned rhino. In the present study, landscape change and configuration were investigated by comparing three Landsat images, from 1998, 2008 and 2018. The images were classified into six different landcover classes following standard methodology. The present study also involves evaluation of landscape and anthropogenic predictors influence on the megaherbivores of GNP, followed by future landcover simulation for the year 2028. The result shows a significant decrease in the grassland cover from 18.87 km² to 8.27 km² from 1998 to 2018, whereas the woodland cover has increased from 50.14 km² to 62.09 km² between 1998 and 2018. The landscape configuration indices such as Number of Patches (NP), Patch Density (PD), Interspersion and Juxtaposition (IJI), Aggregation Index (AI) and Mean Shape Index (SHAPE AM) indicated that the landscapes has lost complexity in the spatial placement of patches of different Land Use and Land Cover (LULC) classes. Also, the landscape over the three decades has become uniform in terms of diversity of patches, because of earlier plantation activities by the forest managers. Result also indicated that grassland, along with its class metrics are the top predictors contributing 43.6% in explaining the spatial distribution of megaherbivores in GNP. Results from the simulated landcover of 2028 suggest a possible decline in overall grassland by 6.23% and a subsequent upsurge in woodland by 6.09% from 2018. The present result will be useful in guiding the forest management in developing habitat improvement strategies for the long- term viability of megaherbivore populations of rhino, gaur and elephant in the GNP.

Mukherjee, T., et al. (2019). "Changing landscape configuration demands ecological planning: Retrospect and prospect for megaherbivores of North Bengal." *PLoS ONE* **14**(12): e0225398.

The Gorumara National Park (GNP) is an important conservation area located in the northern region of West Bengal State, India, as it provides habitat for three megaherbivores: Indian One-horned rhinoceros (*Rhinoceros unicornis*), Asian elephants (*Elephas maximus*) and Gaurs (*Bos gaurus*). It harbours one of the last population of the one-horned rhino. In the present study, landscape change and configuration were investigated by comparing three Landsat images, from 1998, 2008 and 2018. The images were classified into six different landcover classes following standard methodology. The present study also involves evaluation of landscape and anthropogenic predictors influence on the megaherbivores of GNP, followed by future landcover simulation for the year 2028. The result shows a significant decrease in the grassland cover from 18.87 km² to 8.27 km² from 1998 to 2018, whereas the woodland cover has increased from 50.14 km² to 62.09 km² between 1998 and 2018. The landscape configuration indices such as Number of Patches (NP), Patch Density (PD), Interspersion and Juxtaposition (IJI), Aggregation Index (AI) and Mean Shape Index (SHAPE AM) indicated that the landscapes has lost complexity in the spatial placement of patches of different Land Use and Land Cover (LULC) classes. Also, the landscape over the three decades has become uniform in terms of diversity of patches, because of earlier plantation activities by the forest managers. Result also indicated that grassland, along with its class metrics are the top predictors contributing 43.6% in explaining the spatial distribution of megaherbivores in GNP. Results from the simulated landcover of 2028 suggest a possible decline in overall grassland by 6.23% and a subsequent upsurge in woodland by 6.09% from 2018. The present result will be useful in guiding the forest management in developing habitat improvement strategies for the long- term viability of megaherbivore populations of rhino, gaur and elephant in the GNP.

Mukul, S. A., et al. (2019). "Rohingya refugees and the environment." *Science* **364**(6436): 138.

Mumby, H. S. (2019). "Mahout Perspectives on Asian Elephants and Their Living Conditions." *Animals (Basel)* **9**(11).

The skills, knowledge, and expertise of mahouts have been recognized by organizations and individual managers who are responsible for captive elephants and by academics, where they have been a source of studies from the ethnographic to animal behavior research. In this study, I used semi-structured interviews in local languages to explore individual experiences of mahouts in Nepal. I also investigated perspectives on elephant welfare, including the use of corral (fenced) enclosures. I undertook a further key informant interview in English to gain more discursive perspectives on the topics. Our results revealed that mahouts at the study site are unlikely to come from multi-generational families of mahouts. All mahouts referenced the religious significance of elephants in their country when describing broader local perspectives. Many mahouts explained both positive and negative implications for differing strategies in housing captive elephants, often balanced the competing interests of elephant welfare with their own need for elephants to follow verbal communication, and their responsibility for the safety of the elephants, other staff, and tourists. The fine-balancing perspectives of mahouts, taking both humans and elephants into account, underlines their role as an important source of knowledge of captive Asian elephants in range countries, and their potential role as co-producers of research linked to welfare. This approach could also be of relevance to the welfare of ex-situ Asian elephants.

Naha, D., et al. (2019). "Assessment and prediction of spatial patterns of human-elephant conflicts in changing land cover scenarios of a human-dominated landscape in North Bengal." *PLoS ONE* **14**(2): e0210580.

It is of utmost importance to research on the spatial patterns of human-wildlife conflicts to understand the underlying mechanism of such interactions, i.e. major land use changes and prominent ecological drivers. In the north eastern part of India there has been a disparity between nature, economic

development and fragmentation of wildlife habitats leading to intense conflicts between humans and Asian elephants (*Elephas maximus*) in recent times. Both the elephant and human population have increased in the past few decades with large tracts of forests converted to commercial tea plantations, army camps and human settlements. We analyzed data maintained by the wildlife department on human deaths and injuries caused by elephant attacks between 2006-2016 to understand spatial and temporal patterns of human-elephant conflict, frequency and distribution. The average annual number of human deaths and injuries to elephant attacks between 2006 to 2016 was estimated to be 212 (SE 103) with the highest number of such incidents recorded in 2010-2011. Based on a grid based design of 5 km² and 25 km² resolution, the main spatial predictors of human-elephant conflicts identified through Maxent presence only models are annual mean precipitation, altitude, distance from protected area, area under forests, tea plantations and agriculture. Major land use changes were assessed for this region from 2008 to 2018 using satellite imageries in Arc GIS and a predicted imagery of 2028 was prepared using Idrisi Selva. Based on the 2018 imagery it was found that forest area had increased by 446 km² within 10 years (2008-2018) and the annual rate of change was 12%. Area under agriculture had reduced by 128 km² with an annual (-) rate of change of 2.5%. Area under tea plantation declined by 307 km² with an annual (-) rate of change of 12% whereas area under human settlements increased by 61 km² with an annual (-) rate of change of 44%. Hotspots of human-elephant conflicts were identified in an east west direction primarily around protected areas, tea plantations and along major riverine corridors. During informal interactions with farmers, tea estate labors it was revealed that local community members chased and harassed elephants from agriculture fields, human settlements under the influence of alcohol and thus were primary victims of fatal interactions. Our analytical approach can be replicated for other species in sites with similar issues of human-wildlife conflicts. The hotspot maps of conflict risk will help in developing appropriate mitigation strategies such as setting up early warning systems, restoration of wildlife corridors especially along dry river beds, using deterrents and barriers for vulnerable. Awareness about alcohol related incidents and basic biology of elephants should be organized regularly involving non-governmental organizations targeting the marginalized farmers and tea estate workers.

Ngama, S., et al. (2019). "Do topography and fruit presence influence occurrence and intensity of crop-raiding by forest elephants (*Loxodonta africana cyclotis*)?" *PLoS ONE* **14**(3): e0213971.

Crop damage by forest elephants (*Loxodonta africana cyclotis*) and the resulting human-elephant conflict are issues of great concern for both the conservation of the species and the protection of rural livelihoods in Central Africa. Addressing these problems requires identifying the factors that facilitate or impede crop-raiding by forest elephants. Yet to date, the environmental or anthropogenic factors that influence the occurrence and intensity of crop-raiding by forest elephants are largely unknown. We used a multivariate approach to investigate conditions under which forest elephants raid some fields and not others in the buffer zone of Monts de Cristal National Park (MCNP), Gabon. We first interviewed 121 farmers from 11 villages situated within 10 km of MCNP regarding the occurrence of elephant crop-raiding of their fields. We then collected data on 39 explanatory variables to characterize the agricultural fields. Of these, the most important predictors of elephant raid occurrence of crop damage were presence of fruit trees, elephant deterrents (scarecrows, fire, wire string fences and empty barrels), and field topography. We secondly assessed the effect of stage of crop growth, presence of fruit trees, field topography and presence of elephant deterrents on crop-raiding occurrence and intensity by counting raids and measuring areas of crop damage every week in 17 plantations over 19 weeks in the most elephant-impacted zone of the study area. We found that fruit presence and stage of crop growth led to more intense damage to crops, whereas local deterrents did not inhibit raiding events and crop damage by elephants. We report a tradeoff between non-timber forest products (NTFP) services and crop-raiding by elephants. We show for the first time that steep topography impedes elephant damage to crops with no raids recorded in fields with surrounding slopes greater than 25%. We discuss whether farming on steep fields could be used as a strategy for mitigating crop-raiding to favor human-elephant coexistence and enhance elephant conservation.

Ngatia, J. N., et al. (2019). "Distinguishing extant elephants ivory from mammoth ivory using a short sequence of cytochrome b gene." *Sci Rep* **9**(1): 18863.

Trade in ivory from extant elephant species namely Asian elephant (*Elephas maximus*), African savanna elephant (*Loxodonta africana*) and African forest elephant (*Loxodonta cyclotis*) is regulated internationally, while the trade in ivory from extinct species of Elephantidae, including woolly mammoth, is unregulated. This distinction creates opportunity for laundering and trading elephant ivory as mammoth ivory. The existing morphological and molecular genetics methods do not reliably distinguish the source of ivory items that lack clear identification characteristics or for which the quality of extracted DNA cannot support amplification of large gene fragments. We present a PCR-sequencing method based on 116bp target sequence of the cytochrome b gene to specifically amplify elephantid DNA while simultaneously excluding non-elephantid species and ivory substitutes, and while avoiding contamination by human DNA. The partial Cytochrome b gene sequence enabled accurate association of ivory samples with their species of origin for all three extant elephants and from mammoth. The detection limit of the PCR system was as low as 10 copy numbers of target DNA. The amplification and sequencing success reached 96.7% for woolly mammoth ivory and 100% for African savanna elephant and African forest elephant ivory. This is the first validated method for distinguishing elephant from mammoth ivory and it provides forensic support for investigation of ivory laundering cases.

Ngatia, J. N., et al. (2019). "Distinguishing extant elephants ivory from mammoth ivory using a short sequence of cytochrome b gene." *Sci Rep* **9**(1): 18863.

Trade in ivory from extant elephant species namely Asian elephant (*Elephas maximus*), African savanna elephant (*Loxodonta africana*) and African forest elephant (*Loxodonta cyclotis*) is regulated internationally, while the trade in ivory from extinct species of Elephantidae, including woolly mammoth, is unregulated. This distinction creates opportunity for laundering and trading elephant ivory as mammoth ivory. The existing morphological and molecular genetics methods do not reliably distinguish the source of ivory items that lack clear identification characteristics or for which the quality of extracted DNA cannot support amplification of large gene fragments. We present a PCR-sequencing method based on 116bp target sequence of the cytochrome b gene to specifically amplify elephantid DNA while simultaneously excluding non-elephantid species and ivory substitutes, and while avoiding contamination by human DNA. The partial Cytochrome b gene sequence enabled accurate association of ivory samples with their species of origin for all three extant elephants and from mammoth. The detection limit of the PCR system was as low as 10 copy numbers of target DNA. The amplification and sequencing success reached 96.7% for woolly mammoth ivory and 100% for African savanna elephant and African forest elephant ivory. This is the first validated method for distinguishing elephant from mammoth ivory and it provides forensic support for investigation of ivory laundering cases.

Ngatia, J. N., et al. (2019). "Distinguishing extant elephants ivory from mammoth ivory using a short sequence of cytochrome b gene." *Sci Rep* **9**(1): 18863.

Trade in ivory from extant elephant species namely Asian elephant (*Elephas maximus*), African savanna elephant (*Loxodonta africana*) and African forest elephant (*Loxodonta cyclotis*) is regulated internationally, while the trade in ivory from extinct species of Elephantidae, including woolly mammoth, is unregulated. This distinction creates opportunity for laundering and trading elephant ivory as mammoth ivory. The existing morphological and molecular genetics methods do not reliably distinguish the source of ivory items that lack clear identification characteristics or for which the quality of extracted DNA cannot support amplification of large gene fragments. We present a PCR-sequencing method based on 116bp target sequence of the cytochrome b gene to specifically amplify elephantid DNA while simultaneously excluding non-elephantid species and ivory substitutes, and while avoiding contamination by human DNA. The partial Cytochrome b gene sequence enabled accurate association of ivory samples with their species of origin for all three extant elephants and from mammoth. The detection limit of the PCR system was as low as 10 copy numbers of target DNA.

The amplification and sequencing success reached 96.7% for woolly mammoth ivory and 100% for African savanna elephant and African forest elephant ivory. This is the first validated method for distinguishing elephant from mammoth ivory and it provides forensic support for investigation of ivory laundering cases.

Ngatia, J. N., et al. (2019). "Distinguishing extant elephants ivory from mammoth ivory using a short sequence of cytochrome b gene." *Sci Rep* **9**(1): 18863.

Trade in ivory from extant elephant species namely Asian elephant (*Elephas maximus*), African savanna elephant (*Loxodonta africana*) and African forest elephant (*Loxodonta cyclotis*) is regulated internationally, while the trade in ivory from extinct species of Elephantidae, including woolly mammoth, is unregulated. This distinction creates opportunity for laundering and trading elephant ivory as mammoth ivory. The existing morphological and molecular genetics methods do not reliably distinguish the source of ivory items that lack clear identification characteristics or for which the quality of extracted DNA cannot support amplification of large gene fragments. We present a PCR-sequencing method based on 116bp target sequence of the cytochrome b gene to specifically amplify elephantid DNA while simultaneously excluding non-elephantid species and ivory substitutes, and while avoiding contamination by human DNA. The partial Cytochrome b gene sequence enabled accurate association of ivory samples with their species of origin for all three extant elephants and from mammoth. The detection limit of the PCR system was as low as 10 copy numbers of target DNA. The amplification and sequencing success reached 96.7% for woolly mammoth ivory and 100% for African savanna elephant and African forest elephant ivory. This is the first validated method for distinguishing elephant from mammoth ivory and it provides forensic support for investigation of ivory laundering cases.

Ngatia, J. N., et al. (2019). "Distinguishing extant elephants ivory from mammoth ivory using a short sequence of cytochrome b gene." *Sci Rep* **9**(1): 18863.

Trade in ivory from extant elephant species namely Asian elephant (*Elephas maximus*), African savanna elephant (*Loxodonta africana*) and African forest elephant (*Loxodonta cyclotis*) is regulated internationally, while the trade in ivory from extinct species of Elephantidae, including woolly mammoth, is unregulated. This distinction creates opportunity for laundering and trading elephant ivory as mammoth ivory. The existing morphological and molecular genetics methods do not reliably distinguish the source of ivory items that lack clear identification characteristics or for which the quality of extracted DNA cannot support amplification of large gene fragments. We present a PCR-sequencing method based on 116bp target sequence of the cytochrome b gene to specifically amplify elephantid DNA while simultaneously excluding non-elephantid species and ivory substitutes, and while avoiding contamination by human DNA. The partial Cytochrome b gene sequence enabled accurate association of ivory samples with their species of origin for all three extant elephants and from mammoth. The detection limit of the PCR system was as low as 10 copy numbers of target DNA. The amplification and sequencing success reached 96.7% for woolly mammoth ivory and 100% for African savanna elephant and African forest elephant ivory. This is the first validated method for distinguishing elephant from mammoth ivory and it provides forensic support for investigation of ivory laundering cases.

Norkaew, T., et al. (2019). "Influence of season, tourist activities and camp management on body condition, testicular and adrenal steroids, lipid profiles, and metabolic status in captive Asian elephant bulls in Thailand." *PLoS ONE* **14**(3): e0210537.

We previously found relationships between body condition and physiological function affecting health and welfare of female tourist camp elephants in Thailand, and used that approach to conduct a similar study of bull elephants in the same camps (n = 13). A body condition score (BCS) was done every other month, and fecal glucocorticoid metabolite (FGM) concentrations were measured twice monthly for 1 year. Effects of season, camp management and tourist activity on lipid profiles [total cholesterol (TC), low density lipoproteins (LDL), high density lipoproteins (HDL), triglycerides (TG)] and metabolic

factors [insulin, glucose, fructosamine, glucose to insulin ratio (G:I)] were determined and correlated to measures of body condition, testosterone and FGM. Positive correlations were found between BCS and TG, between FGM and TG, HDL and glucose, and between testosterone and HDL, whereas BCS and testosterone were negatively associated with the G:I. There was a significant positive relationship between FGM and testosterone. Elevated FGM concentrations were associated with altered lipid and metabolic profiles and were higher in winter compared to summer and rainy seasons. Insulin and glucose levels were higher, while the G:I was lowest in the winter season. Strong positive associations were found between TC and HDL, LDL and HDL and glucose, and glucose and insulin. By contrast, negative relationships were found between the G:I and HDL and glucose, and between insulin and G:I. Differences also were found between High and Low tourist season months for FGM, insulin, and G:I. Last, there was notable variation among the camps in measured parameters, which together with tourist season effects suggests camp management may affect physiological function and welfare; some negatively like feeding high calorie treats, others positively, like exercise. Last, compared to females, bull elephants appear to be in better physical health based on normal BCSs, lower insulin levels and higher G:I ratios.

Norkaew, T., et al. (2019). "Associations among tourist camp management, high and low tourist seasons, and welfare factors in female Asian elephants in Thailand." *PLoS ONE* **14**(6): e0218579.

This study investigated how camp management and tourist activities affect body condition, adrenocortical function, lipid profiles and metabolic status in female tourist elephants. We compared twice monthly serum insulin, glucose, fructosamine, total cholesterol (TC), triglyceride (TG), low density lipoprotein (LDL), high density lipoprotein (HDL), and fecal glucocorticoid metabolite (FGM) concentrations to body condition scores (BCS) at five camps with different management styles (e.g., tourist activities, work type, diet) between the High (November-February) and Low (March-October) tourist seasons. There were significant camp effects on health parameters, with BCS, TC, HDL, insulin and glucose being among the highest, and G:I being the lowest (less healthy) in elephants at an observation camp compared to those at camps where elephants received exercise by providing rides to tourists. Differences between High and Low tourist season months also were found for all measures, except TG and FGM concentrations. Both work time and walking distance were negatively correlated to glucose, fructosamine and insulin, while walking distance was negatively related to FGM concentrations. By contrast, positive associations were found between tourist number and BCS, TG, and insulin, perhaps related to tourists feeding elephants. Quantity of supplementary diet items (e.g., bananas, sugar cane, pumpkin) were positively correlated with FGM concentrations, glucose, fructosamine, and insulin. This study provides evidence that body condition, adrenal activity, metabolic markers, and lipid profiles in captive elephants may be affected by visitor numbers, work activities, and the amount of supplementary foods offered by tourists. Some activities appear to have negative (e.g., feeding), while others (e.g., exercise) may have positive effects on health and welfare. We conclude that camps adopting a more hands-off approach to tourism need to ensure elephants remain healthy by providing environments that encourage activity and rely on more natural diets or foraging.

Nuntanee, S. and S. Daranee (2019). "Effect of Motorized Elephant-Assisted Therapy Program on Balance Control of Children with Autism Spectrum Disorder." *Occup Ther Int* **2019**: 5914807.

Children with autism spectrum disorder (ASD) have poor balance, and this limitation has effects on their daily living activities. The purpose of this study was to create the motorized elephant-assisted therapy program (METP) and examine the effect of the METP on balance control improvement in individuals with ASD. Twenty participants, aged 8 to 19 years, were recruited from occupational therapy clinics around Chiang Mai city and were divided into 2 groups: control and experimental. Participants' balance control was tested by measuring their postural sways in a bipedal stance by using a Swaymeter under four conditions: "floor-eyes open," "floor-eyes closed," "foam-eyes open," and "foam-eyes closed." Pretests were administered one week before participation in the METP, and then, posttests were administered one week after completing the METP. Each participant took a 1.5-

hour session of the METP, twice a week for a 4-week duration. In one session, 2 participants were assigned to work with two motorized elephants in 4 activities: washing the elephant, climbing up and down the elephant, riding the elephant, and playing a game while riding the elephant. Results showed that the pretest control and experimental groups were not significantly different in their balance control, but at posttest, the postural sway of the experimental group was significantly different from that of the control group in two conditions: floor-eyes open and floor-eyes closed. Their lesser anteroposterior range of postural sway showed that the experimental group gained balance control improvement. In conclusion, the finding of this study showed that the METP could be an alternative treatment method to facilitate better balance control in individuals with ASD.

Nuntanee, S. and S. Daranee (2019). "Effect of Motorized Elephant-Assisted Therapy Program on Balance Control of Children with Autism Spectrum Disorder." Occup Ther Int **2019**: 5914807.

Children with autism spectrum disorder (ASD) have poor balance, and this limitation has effects on their daily living activities. The purpose of this study was to create the motorized elephant-assisted therapy program (METP) and examine the effect of the METP on balance control improvement in individuals with ASD. Twenty participants, aged 8 to 19 years, were recruited from occupational therapy clinics around Chiang Mai city and were divided into 2 groups: control and experimental. Participants' balance control was tested by measuring their postural sways in a bipedal stance by using a Swaymeter under four conditions: "floor-eyes open," "floor-eyes closed," "foam-eyes open," and "foam-eyes closed." Pretests were administered one week before participation in the METP, and then, posttests were administered one week after completing the METP. Each participant took a 1.5-hour session of the METP, twice a week for a 4-week duration. In one session, 2 participants were assigned to work with two motorized elephants in 4 activities: washing the elephant, climbing up and down the elephant, riding the elephant, and playing a game while riding the elephant. Results showed that the pretest control and experimental groups were not significantly different in their balance control, but at posttest, the postural sway of the experimental group was significantly different from that of the control group in two conditions: floor-eyes open and floor-eyes closed. Their lesser anteroposterior range of postural sway showed that the experimental group gained balance control improvement. In conclusion, the finding of this study showed that the METP could be an alternative treatment method to facilitate better balance control in individuals with ASD.

Nuntanee, S. and S. Daranee (2019). "Effect of Motorized Elephant-Assisted Therapy Program on Balance Control of Children with Autism Spectrum Disorder." Occup Ther Int **2019**: 5914807.

Children with autism spectrum disorder (ASD) have poor balance, and this limitation has effects on their daily living activities. The purpose of this study was to create the motorized elephant-assisted therapy program (METP) and examine the effect of the METP on balance control improvement in individuals with ASD. Twenty participants, aged 8 to 19 years, were recruited from occupational therapy clinics around Chiang Mai city and were divided into 2 groups: control and experimental. Participants' balance control was tested by measuring their postural sways in a bipedal stance by using a Swaymeter under four conditions: "floor-eyes open," "floor-eyes closed," "foam-eyes open," and "foam-eyes closed." Pretests were administered one week before participation in the METP, and then, posttests were administered one week after completing the METP. Each participant took a 1.5-hour session of the METP, twice a week for a 4-week duration. In one session, 2 participants were assigned to work with two motorized elephants in 4 activities: washing the elephant, climbing up and down the elephant, riding the elephant, and playing a game while riding the elephant. Results showed that the pretest control and experimental groups were not significantly different in their balance control, but at posttest, the postural sway of the experimental group was significantly different from that of the control group in two conditions: floor-eyes open and floor-eyes closed. Their lesser anteroposterior range of postural sway showed that the experimental group gained balance control improvement. In conclusion, the finding of this study showed that the METP could be an alternative treatment method to facilitate better balance control in individuals with ASD.

Othmn, N., et al. (2019). "Shift of paradigm needed towards improving human-elephant coexistence in monoculture landscapes in Sabah." International Zoo Yearbook **53**(1): 161-173.

This article outlines the contemporary situation of the Bornean elephant *Elephas maximus borneensis* in Sabah (Malaysian Borneo), and focuses on the existing challenges that need to be addressed to enable people and elephants to coexist, particularly in man-made landscapes dominated by oil-palm plantations. Bornean elephants are confined mostly to Sabah, to the north-east 5% of the Borneo Island. Sabah started to expand its commercial plantation sector in the early 1980s and is the largest producer of palm oil in Malaysia, contributing c. 10% of global output for this commodity. The rapid pace of plantation expansion has resulted in the loss of the majority of lowland areas that are also needed by large mammal species to sustain breeding populations. Elephants are extreme lowland/floodplain specialists, and they still attempt to use their former and preferred habitat, which is now mostly dominated by oil-palm plantations. At the time of writing, the land-use planning system favoured by the government insufficiently incorporates the ecological and management needs for elephants across the entire landscape. This article also highlights the need for better collaboration and coordination between stakeholders to address the increasing rate of human-elephant conflicts in Sabah.

Paudel, S., et al. (2019). "Tuberculosis threat in Asian elephants." Science **363**(6425): 356.

Paudel, S., et al. (2019). "Mixed Mycobacterium tuberculosis Lineage Infection in 2 Elephants, Nepal." Emerg Infect Dis **25**(5): 1031-1032.

Tuberculosis in elephants is primarily caused by *Mycobacterium tuberculosis*. We identified mixed *M. tuberculosis* lineage infection in 2 captive elephants in Nepal by using spoligotyping and large sequence polymorphism. One elephant was infected with Indo-Oceanic and East African-Indian (CAS-Delhi) lineages; the other was infected with Indo-Oceanic and East Asian (Beijing) lineages.

Paudel, S., et al. (2019). "Human TB threat to wild elephants." Nature **571**(7764): 174.

Pavulraj, S., et al. (2019). "Fatal Elephant Endotheliotropic Herpesvirus Infection of Two Young Asian Elephants." Microorganisms **7**(10).

Elephant endotheliotropic herpesvirus (EEHV) can cause a devastating haemorrhagic disease in young Asian elephants worldwide. Here, we report the death of two young Asian elephants after suffering from acute haemorrhagic disease due to EEHV-1A infection. We detected widespread distribution of EEHV-1A in various organs and tissues of the infected elephants. Enveloped viral particles accumulated within and around cytoplasmic electron-dense bodies in hepatic endothelial cells were detected. Attempts to isolate the virus on different cell cultures showed limited virus replication; however, late viral protein expression was detected in infected cells. We further showed that glycoprotein B (gB) of EEHV-1A possesses a conserved cleavage site Arg-X-Lys/Arg-Arg that is targeted by the cellular protease furin, similar to other members of the Herpesviridae. We have determined the complete 180 kb genome sequence of EEHV-1A isolated from the liver by next-generation sequencing and de novo assembly. As virus isolation in vitro has been unsuccessful and limited information is available regarding the function of viral proteins, we have attempted to take the initial steps in the development of suitable cell culture system and virus characterization. In addition, the complete genome sequence of an EEHV-1A in Europe will facilitate future studies on the epidemiology and diagnosis of EEHV infection in elephants.

Pfeifer, S. J., et al. (2019). "Mammoth ivory was the most suitable osseous raw material for the production of Late Pleistocene big game projectile points." Scientific Reports **9**.

Late Pleistocene societies throughout the northern hemisphere used mammoth and mastodon ivory not only for art and adornment, but also for tools, in particular projectile points. A comparative analysis of the mechanical properties of tusk dentine from woolly mammoth (*Mammuthus primigenius*) and

African elephant (*Loxodonta africana*) reveals similar longitudinal stiffness values that are comparable to those of cervid antler compacta. The longitudinal bending strength and work of fracture of proboscidean ivory are very high owing to its substantial collagen content and specific microstructure. In permafrost, these properties can be fully retained for thousands of years. Owing to the unique combination of stiffness, toughness and size, ivory was obviously the most suitable osseous raw material for massive projectile points used in big game hunting.

Pfeifer, S. J., et al. (2019). "Mammoth ivory was the most suitable osseous raw material for the production of Late Pleistocene big game projectile points." *Sci Rep* **9**(1): 2303.

Late Pleistocene societies throughout the northern hemisphere used mammoth and mastodon ivory not only for art and adornment, but also for tools, in particular projectile points. A comparative analysis of the mechanical properties of tusk dentine from woolly mammoth (*Mammuthus primigenius*) and African elephant (*Loxodonta africana*) reveals similar longitudinal stiffness values that are comparable to those of cervid antler compacta. The longitudinal bending strength and work of fracture of proboscidean ivory are very high owing to its substantial collagen content and specific microstructure. In permafrost, these properties can be fully retained for thousands of years. Owing to the unique combination of stiffness, toughness and size, ivory was obviously the most suitable osseous raw material for massive projectile points used in big game hunting.

Plotnik, J. M., et al. (2019). "Elephants have a nose for quantity." *Proc Natl Acad Sci U S A* **116**(25): 12566-12571.

Animals often face situations that require making decisions based on quantity. Many species, including humans, rely on an ability to differentiate between more and less to make judgments about social relationships, territories, and food. Habitat-related choices require animals to decide between areas with greater and lesser quantities of food while also weighing relative risk of danger based on group size and predation risk. Such decisions can have a significant impact on survival for an animal and its social group. Many species have demonstrated a capacity for differentiating between two quantities of food and choosing the greater of the two, but they have done so based on information provided primarily in the visual domain. Using an object-choice task, we demonstrate that elephants are able to discriminate between two distinct quantities using their olfactory sense alone. We presented the elephants with choices between two containers of sunflower seeds. The relationship between the amount of seeds within the two containers was represented by 11 different ratios. Overall, the elephants chose the larger quantity of food by smelling for it. The elephants' performance was better when the relative difference between the quantities increased and worse when the ratio between the quantities of food increased, but was not affected by the overall quantity of food presented. These results are consistent with the performance of animals tested in the visual domain. This work has implications for the design of future, cross-phylogenetic cognitive comparisons that ought to account for differences in how animals sense their world.

Poor, E. E., et al. (2019). "The road to deforestation: Edge effects in an endemic ecosystem in Sumatra, Indonesia." *PLoS ONE* **14**(7): e0217540.

Worldwide, roads are a main driver of deforestation and degradation as they increase forest access along the forest edge. In many tropical areas, unofficial roads go unreported and unrecorded, resulting in inaccurate estimates of intact forested areas. This is the case in central Sumatra, which boasts populations of critically endangered Sumatran elephants (*Elephas maximus sumatrensis*), tigers (*Panthera tigris sumatrae*) and other endemic flora and fauna that make the area globally unique. However, maps do not reflect the reality of forest loss in the area. Here we present new maps from 2002 and 2016 of digitized and ground-truthed roads in one of Sumatra's unique lowland tropical protected areas, Tesso Nilo National Park. Using our newly created roads dataset, we examine the distribution of forest with respect to distance to roads. Our data show >2,400 km of roads within the national park in 2016 -nearly a 10-fold increase from roads known in 2002. Most forest (82-99%) within Tesso Nilo falls within 100 m, 500 m, and 1000 m of road edges. Length of road increased

157% and road density increased from 1.06 km/km² to 2.63 km/km² from 2002-2016. Our results suggest that this endemic ecosystem is facing substantial threat from roads and their associated impacts. Without swift management action, such as road closures and increased enforcements by park management, this ecosystem, and its endemic wildlife, could be lost. It is imperative that protected areas worldwide more rigorously consider roads and road effects on ecosystem fragmentation in their conservation plans.

Potoczniak, M. J., et al. (2019). "Development of a multiplex, PCR-based genotyping assay for African and Asian elephants for forensic purposes." *Int J Legal Med*.

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. (2019). "Hyperprolactinemic African elephant (*Loxodonta africana*) females exhibit elevated dopamine, oxytocin and serotonin concentrations compared to normal cycling and noncycling, low prolactin elephantsdagger." *Biol Reprod* **100**(6): 1549-1560.

Many zoo elephants do not cycle normally, and for African elephants, it is often associated with hyperprolactinemia. Dopamine agonists successfully treat hyperprolactinemia-induced ovarian dysfunction in women, but not elephants. The objective of this study was to determine how longitudinal dopamine, serotonin, and oxytocin patterns in African elephants are related to ovarian cycle function. We hypothesized that dopamine concentrations are decreased, while oxytocin and serotonin are increased in non-cycling, hyperprolactinemic African elephants. Weekly urine and serum samples were collected for eight consecutive months from 28 female African elephants. Females were categorized as follows: (1) non-cycling with average prolactin concentrations of 15 ng/ml or greater (HIGH; n = 7); (2) non-cycling with average prolactin concentrations below 15 ng/ml (LOW; n = 13); and (3) cycling with normal progestagen and prolactin patterns (CYCLING; n = 8). Both oxytocin and serotonin were elevated in hyperprolactinemic elephants. Thus, we propose that stimulatory factors may play a role in the observed hyperprolactinemia in this species. Interestingly, rather than being reduced as hypothesized, urinary dopamine was elevated in hyperprolactinemic elephants compared to CYCLING and LOW prolactin groups. Despite its apparent lack of regulatory control over prolactin, this new evidence suggests that dopamine synthesis and secretion are not impaired in these elephants, and perhaps are augmented.

Prado, N. A., et al. (2019). "Prolonged ovarian acyclicity is associated with a higher likelihood of developing hyperprolactinemia in zoo female African elephants." *Zoo Biol* **38**(2): 180-188.

Hyperprolactinemia is a common disorder of the hypothalamic-pituitary axis, and a cause of ovarian dysfunction in women. Currently, over half of non-cycling African elephant females in North America also are hyperprolactinemic, suggesting a similar link between these two conditions may exist. The objective of this study was to determine the relationship between acyclicity and prolactin status by comparing mean prolactin concentrations of bi-weekly samples collected over a 1-year period in 2012 with 20 years of historical weekly progestagen data to assess cyclicity. Females were categorized as: 1) non-cycling with an average prolactin concentration of 15 ng/ml or greater (HIGH; n = 17); 2) non-cycling with an average prolactin concentration below 15 ng/ml (LOW; n = 16); and 3) typical temporal patterns of progestagen and prolactin secretion (NORMAL; n = 45), and evaluated based on length of time (in years) they had experienced ovarian inactivity. Results showed that the majority of HIGH prolactin elephants had been acyclic for at least 5 years, and in a number of cases (n = 9) for over 10 years. By contrast, most of the LOW prolactin elephants had experienced acyclicity for less than 5

years. Finally, there was a positive association between duration of acyclicity and mean prolactin concentrations, with an increase in the likelihood of having higher prolactin concentrations the longer an individual was acyclic. This study highlights the importance of longitudinal hormonal datasets to examine temporal changes in biological functioning and better understand the etiology of infertility problems.

Prahardani, R., et al. (2019). "Morphology and morphometry of adult nematodes on Sumatran elephants (*Elephas maximus sumatranus*) in Way Kambas National Park area, Indonesia." *Vet World* **12**(2): 249-253.

Background and Aim: Worms from nematodes are the most numerous and the most detrimental in elephants. Most adult worms are located in the digestive tract. Nematode infection is at higher risk in young elephants, which caused several cases such as anemia, hypoalbuminemia, enteritis, and even death. This study aimed to determine the morphology and morphometry of adult nematodes on Sumatran elephants in Way Kambas National Park area. Materials and Methods: Nematode samples were obtained from Sumatran elephants' feces (*Elephas maximus sumatranus*) in Way Kambas National Park, Lampung Province, after being given Kalbazen((R)) containing albendazole 1000 mg at a dose of 10 mg/kg by the veterinarian in charge of the National Park area. For the morphological and morphometric examinations, we used an Olympus BX 51 microscope equipped with Olympus DP 12 camera and were conducted at the Parasitology Laboratory, Faculty of Veterinary Medicine, Universitas Gadjah Mada. The scanning electron microscopic (SEM) analysis was carried out at the Biology Research Center of the Indonesian Institute of Sciences (Lembaga Ilmu Pengetahuan Indonesia). Results: The results of macroscopic observations of the obtained nematodes showed that the nematodes which were found have the characteristics of round, slim, and white color. The size of a female worm was larger than a male worm. Microscopic examination in four anterior papillae indicated that the dorsal lobe in the copulatory bursa was longer than lateral lobe. The result of inspection with the SEM showed a leaf crown consisting of 10 elements, a pair of amphids laterally, and two pairs of papilla in a submedian region. Conclusion: Based on our morphology and morphometry examinations of adult nematodes in Sumatran elephant (*E. maximus sumatranus*) in Way Kambas National Park area, the adult nematodes which were found are species of *Quilonia travancra*.

Presotto, A., et al. (2019). "Spatial mapping shows that some African elephants use cognitive maps to navigate the core but not the periphery of their home ranges." *Anim Cogn*.

Strategies of navigation have been shown to play a critical role when animals revisit resource sites across large home ranges. The habitual route system appears to be a sufficient strategy for animals to navigate while avoiding the cognitive cost of traveling using the Euclidean map. We hypothesize that wild elephants travel more frequently using habitual routes to revisit resource sites as opposed to using the Euclidean map. To identify the elephants' habitual routes, we created a python script, which accounted for frequently used route segments that constituted the habitual routes. Results showed elephant navigation flexibility traveling at Kruger National Park landscape. Elephants shift strategies of navigation depend on the familiarity of their surroundings. In the core area of their home range, elephants traveled using the Euclidean map, but intraindividual differences showed that elephants were then converted to habitual routes when navigating within the less familiar periphery of their home range. These findings are analogous to the recent experimental results found in smaller mammals that showed that rats encode locations according to their familiarity with their surroundings. In addition, as recently observed in monkeys, intersections of habitual routes are important locations used by elephants when making navigation decisions. We found a strong association between intersections and new segment usage by elephants when they revisit resource sites, suggesting that intersection choice may contribute to the spatial representations elephants use when repeatedly revisiting resource sites.

Presotto, A., et al. (2019). "Spatial mapping shows that some African elephants use cognitive maps to navigate the core but not the periphery of their home ranges." *Anim Cogn* **22**(2): 251-263.

Strategies of navigation have been shown to play a critical role when animals revisit resource sites

across large home ranges. The habitual route system appears to be a sufficient strategy for animals to navigate while avoiding the cognitive cost of traveling using the Euclidean map. We hypothesize that wild elephants travel more frequently using habitual routes to revisit resource sites as opposed to using the Euclidean map. To identify the elephants' habitual routes, we created a python script, which accounted for frequently used route segments that constituted the habitual routes. Results showed elephant navigation flexibility traveling at Kruger National Park landscape. Elephants shift strategies of navigation depend on the familiarity of their surroundings. In the core area of their home range, elephants traveled using the Euclidean map, but intraindividual differences showed that elephants were then converted to habitual routes when navigating within the less familiar periphery of their home range. These findings are analogous to the recent experimental results found in smaller mammals that showed that rats encode locations according to their familiarity with their surroundings. In addition, as recently observed in monkeys, intersections of habitual routes are important locations used by elephants when making navigation decisions. We found a strong association between intersections and new segment usage by elephants when they revisit resource sites, suggesting that intersection choice may contribute to the spatial representations elephants use when repeatedly revisiting resource sites.

Prstojević, A., et al. (2019). "Elephants, snorkels, pressures: modeling snorkeling at depth." Adv Physiol Educ **43**(2): 155-158.

Pucora, E., et al. (2019). "Resting postures in terrestrial mammalian herbivores." Journal of Mammalogy **100**(2): 552-563.

For ruminants and arboreal herbivores (sloths and colobine monkeys), an influence of digestive physiology on resting postures has been postulated that is linked to the interplay of digestive anatomy and the gravity vector. To further explore this putative relationship, we observed 253 individual terrestrial mammalian herbivores at zoological gardens, noting 29,478 resting events in 36 species during the day and 7,383 resting events of 18 species at night, providing a catalogue of mammalian resting postures. We confirm the constraint of ruminants to sternal recumbency and expand this observation to camelids, which rely on a similar sorting mechanism in their forestomach for rumination, but which use lateral recumbency to a slight but distinctively larger proportion. Generally, larger herbivores rest more in a standing position, and use lateral recumbency more when lying. The use of lateral recumbency in large hindgut fermenters (perissodactyls, elephants) and nonruminant foregut fermenters (macropods, hippos) corresponds to the concept that there is no interplay between gravity and digestive physiology in these species. By contrast, peccaries, hyraxes, and hystricomorph rodents never used lateral recumbency. While this may be related to body size, body shape, or other species-specific characteristics, it also suggests that the interplay of gravity and digestive processes, in particular with the colonic separation mechanism in hystricomorph rodents, should be further investigated. © 2019 American Society of Mammalogists.

Puyravaud, E.-P., et al. (2019). "Deforestation Increases Frequency of Incidents With Elephants (*Elephas maximus*)." Tropical Conservation Science **12**.

Damages by the Asian elephant (*Elephas maximus*) range from crop raiding to loss of human lives, and understanding the underlying causes thereof could help reduce such incidents. Land-use change could be among the major causes of elephant incidents since they are long-lived and tend to have particular home ranges. To test this hypothesis, we assessed deforestation rates in sites between the Nilgiris Biosphere Reserve and the Bhadra Tiger Reserve, Western Ghats of India between the 1960s and 2000s. Deforestation was calculated in windows of varying sizes to account for spatial scale responses. The locations of 624 incidents between April 2008 and March 2011 were used, and a database of 20,000 random locations provided contrasts. We used sets of 250 logistic regressions at each scale of deforestation to ensure that the significance of deforestation was independent of the randomly sampled contrast locations. A total of 6,761 km² of forest and scrubland have disappeared from private forests in 50 years, with an average deforestation rate of $-0.85\% \cdot y^{-1}$. The distribution of

incidents followed an exponential decay with increasing distance from protected areas and a beta distribution against deforestation. Logistic regressions indicated a significant effect of deforestation at the small scale (1 km²) particularly and 4 km²). These results show that (a) incidents occur mostly near protected areas, and barriers or adaptation of livelihoods could address this problem and (b) deforestation is associated with increasing incidents with elephants. Avoiding deforestation and maintaining elephant population connectivity may help avoid incidents.

Quarta, G., et al. (2019). "Radiocarbon dating of ivory: Potentialities and limitations in forensics." Forensic Sci Int **299**: 114-118.

The determination of the age of elephant ivory is a crucial aspect in the fight against illegal ivory trade which is still a relevant problem having triggered the decline of elephant populations due to poaching in different areas of the globe. Indeed, the absolute dating of the ivory allows, in forensics practice, to establish whether a determined sample or object was obtained and imported illegally, violating the international trade ban. In this frame the use radiocarbon dating has surely a great potential and is widely used. In this paper we review the potential of the method in this field, highlighting its advantages and drawbacks. In particular we show, through the discussion of real cases, how it is possible to improve the achievable chronological resolution by refining the obtained ages through the proper use of available information and considerations.

Rajapakse, R., et al. (2019). "Molecular characterization of *Fasciola jacksoni* from wild elephants (*Elephas maximus maximus*) of Sri Lanka: a taxonomic evaluation." Parasitology **146**(10): 1247-1255.

Fasciola jacksoni is a significant contributor to the health and mortality of Asian elephants, particularly those in Sri Lanka. Despite the impact of fascioliasis on elephant populations, it is a neglected veterinary disease with limited taxonomic understanding. Molecular characterization and phylogenetic analysis of *F. jacksoni* were carried out to evaluate its suggested basal position in the Fasciolidae. Adult worms were collected during post-mortem of elephants, and eggs were collected from living elephants in National parks across Sri Lanka. Using the mitochondrial genes nicotinamide dehydrogenase subunit 1 (*nad1*) and cytochrome oxidase subunit 1 (*cox1*), and a partial 28S ribosomal DNA (28S rDNA), DNA sequences were generated from the *F. jacksoni* adult and egg material. Maximum likelihood (ML) phylogenetic analyses did not resolve *F. jacksoni* to be basal to the Fasciolidae. Furthermore, the ML analyses showed that the genus *Fasciola* was not monophyletic and that *F. jacksoni* was a sister species to the deer liver fluke *Fascioloides magna*. A clear framework is required to determine the taxonomic status of *F. jacksoni* and this current study provides the first detailed application of molecular techniques from multiple hosts across Sri Lanka with the production of reference DNA sequences for this important parasite.

Reichert, S., et al. (2019). "Maternal age at birth shapes offspring life-history trajectory across generations in long-lived Asian elephants." J Anim Ecol.

Advanced maternal age at birth can have pronounced consequences for offspring health, survival and reproduction. If carried over to the next generation, such fitness effects could have important implications for population dynamics and the evolution of ageing, but these remain poorly understood. While many laboratory studies have investigated maternal age effects, relatively few studies have been conducted in natural populations, and they usually only present a "snapshot" of an offspring's lifetime. In the present study, we focus on how maternal age influences offspring life-history trajectories and performance in a long-lived mammal. We use a multigenerational demographic dataset of semi-captive Asian elephants to investigate maternal age effects on several offspring life-history traits: condition, reproductive success and overall survival. We show that offspring born to older mothers display reduced overall survival but higher reproductive success, and reduced survival of their own progeny. Our results show evidence of a persistent effect of maternal age on fitness across generations in a long-lived mammal. By highlighting transgenerational effects on the fitness of the next generation associated with maternal age, the present study helps increase our understanding of factors contributing to individual variation in ageing rates and fitness.

Ripple, W. J., et al. (2019). "Are we eating the world's megafauna to extinction?" *Conservation Letters* **12**(3). Many of the world's vertebrates have experienced large population and geographic range declines due to anthropogenic threats that put them at risk of extinction. The largest vertebrates, defined as megafauna, are especially vulnerable. We analyzed how human activities are impacting the conservation status of megafauna within six classes: mammals, ray-finned fish, cartilaginous fish, amphibians, birds, and reptiles. We identified a total of 362 extant megafauna species. We found that 70% of megafauna species with sufficient information are decreasing and 59% are threatened with extinction. Surprisingly, direct harvesting of megafauna for human consumption of meat or body parts is the largest individual threat to each of the classes examined, and a threat for 98% (159/162) of threatened species with threat data available. Therefore, minimizing the direct killing of the world's largest vertebrates is a priority conservation strategy that might save many of these iconic species and the functions and services they provide.

Roca, A. L. (2019). "African elephant genetics: enigmas and anomalies." *J Genet* **98**. During the last two decades, our understanding of the genetics of African elephant populations has greatly increased. Strong evidence, both morphological and genetic, supports recognition of two African elephant species: the savanna elephant (*Loxodonta africana*) and the forest elephant (*L. cyclotis*). Among elephantids, phylogeographic patterns for mitochondrial DNA are highly incongruent with those detected using nuclear DNA markers, and this incongruence is almost certainly due to strongly male-biased geneflow in elephants. As our understanding of elephant population genetics has grown, a number of observations may be considered enigmatic or anomalous. Here, several of these are discussed. (i) There are a number of within-species morphological differences purported to exist among elephants in different geographic regions, which would be difficult to reconcile with the low genetic differentiation among populations. (ii) Forest elephants have a higher effective population size than savanna elephants, with nuclear genetic markers much more diverse in the forest elephants than savanna elephants, yet this finding would need to be reconciled with the life history of the two species. (iii) The savanna and forest elephants hybridize and produce fertile offspring, yet full genome analysis of individuals distant from the hybrid zone suggests that gene flow has been effectively sterilized for at least approximately 500,000 years. (iv) There are unexplored potential ramifications of the unusual mito-nuclear patterns among elephants. These questions are considered in light of high male and low female dispersal in elephants, higher variance of reproductive success among males than females, and of habitat changes driven by glacial cycles and human activity.

Rosen, L. E., et al. (2019). "SURVEY OF ANTITUBERCULOSIS DRUG ADMINISTRATION AND ADVERSE EFFECTS IN ELEPHANTS IN NORTH AMERICA." *J Zoo Wildl Med* **50**(1): 23-32. Tuberculosis, caused by *Mycobacterium tuberculosis*, is a disease causing morbidity and mortality in captive elephants (*Elephas maximus* and *Loxodonta africana*) as well as free-ranging individuals. Elephants in North America diagnosed with tuberculosis are often treated with antituberculosis drugs, unlike livestock species, which has necessitated the development of treatment guidelines adapted from recommendations for humans. There are few published reports describing empirical treatment, which may be complicated by poor patient compliance, interruptions in drug administration, and adverse effects. A survey of elephants in North America was conducted to compile information on treatment protocols, including drugs, dosages, routes of administration, serum drug concentrations, and adverse effects of antituberculosis treatment. Responses were received regarding 182 elephants, 12 of which were treated prophylactically or therapeutically with antituberculosis drugs. Treatment protocols varied among elephants, and included various combinations of isoniazid, rifampin, pyrazinamide, ethambutol, enrofloxacin, levofloxacin, and ethionamide. Serum drug concentrations also varied considerably among and within individuals. Facility staff reported 5 elephants (out of 7 treated elephants with responses) that exhibited clinical signs that may have been associated with antituberculosis drugs or treatment procedures. Anorexia, decreased water intake, constipation, depression, ataxia, limb paresis, and tremors were among the signs observed. Most adverse effects

were reported to be moderate or severe, resulting in interruption of the treatment. The results from this survey provide veterinarians and elephant managers with valuable historical data to make informed clinical management decisions regarding antituberculosis therapy in elephants.

Sach, F., et al. (2019). "African savanna elephants (*Loxodonta africana*) as an example of a herbivore making movement choices based on nutritional needs." *PeerJ* **7**.

Background: The increasing human population and global intensification of agriculture have had a major impact on the world's natural ecosystems and caused devastating effects on populations of mega-herbivores such as the African savanna elephants, through habitat reduction and fragmentation and increased human-animal conflict. Animals with vast home ranges are forced into increasingly smaller geographical areas, often restricted by fencing or encroaching anthropogenic activities, resulting in huge pressures on these areas to meet the animals' resource needs. This can present a nutritional challenge and cause animals to adapt their movement patterns to meet their dietary needs for specific minerals, potentially causing human-animal conflict. The aim of this review is to consolidate understanding of nutritional drivers for animal movement, especially that of African savanna elephants and focus the direction of future research. Peer reviewed literature available was generally geographically specific and studies conducted on isolated populations of individual species. African savanna elephants have the capacity to extensively alter the landscape and have been more greatly studied than other herbivores, making them a good example species to use for this review. Alongside this, their movement choices, potentially linked with nutritional drivers could be applicable to a range of other species. Relevant case study examples of other herbivores moving based on nutritional needs are discussed. Methods: Three databases were searched in this review: Scopus, Web of Science and Google Scholar, using identified search terms. Inclusion and exclusion criteria were determined and applied as required. Additional grey literature was reviewed as appropriate. Results: Initial searches yielded 1,870 records prior to application of inclusion and exclusion criteria. A less detailed review of grey literature, and additional peer-reviewed literature which did not meet the inclusion criteria but was deemed relevant by the authors was also conducted to ensure thorough coverage of the subject. Discussion: A review of peer reviewed literature was undertaken to examine nutritional drivers for African elephant movement, exploring documented examples from free-ranging African savanna elephants and, where relevant, other herbivore species. This could help inform prediction or mitigation of human-elephant conflict, potentially when animals move according to nutritional needs, and related drivers for this movement. In addition, appropriate grey literature was included to capture current research.

Sanders, W. J. (2019). "Proboscidea from Kanapoi, Kenya." *J Hum Evol.*

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 heterogeneity, 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.

Santos, T. L., et al. (2019). "Conservation Genetic Assessment of Savannah Elephants (*Loxodonta africana*) in the Greater Kruger Biosphere, South Africa." *Genes (Basel)* **10**(10).

Savannah elephant populations have been severely reduced and fragmented throughout its remaining range. In general, however, there is limited information regarding their genetic status, which is essential knowledge for conservation. We investigated patterns of genetic variation in savannah elephants from the Greater Kruger Biosphere, with a focus on those in previously unstudied nature reserves adjacent to Kruger National Park, using dung samples from 294 individuals and 18 microsatellites. The results of genetic structure analyses using several different methods of ordination and Bayesian clustering strongly suggest that elephants throughout the Greater Kruger National Park (GKNP) constitute a single population. No evidence of a recent genetic bottleneck was detected using three moment-based approaches and two coalescent likelihood methods. The apparent absence of a recent genetic bottleneck associated with the known early 1900s demographic bottleneck may result from a combination of rapid post-bottleneck population growth, immigration and long generation time. Point estimates of contemporary effective population size (N_e) for the GKNP were $\sim 500-700$, that is, at the low end of the range of N_e values that have been proposed for maintaining evolutionary potential and the current ratio of N_e to census population size (N_c) may be quite low (<0.1). This study illustrates the difficulties in assessing the impacts on N_e in populations that have suffered demographic crashes but have recovered rapidly and received gene flow, particularly in species with long generation times in which genetic time lags are longer. This work provides a starting point and baseline information for genetic monitoring of the GKNP elephants.

Schiffmann, C., et al. (2019). "Weigh and see-Body mass recordings versus body condition scoring in European zoo elephants (*Loxodonta africana* and *Elephas maximus*)." Zoo Biol.

Regular body mass (BM) monitoring plays a key role in preventative health care of zoo animals. In some species, including African (*Loxodonta africana*) and Asian elephants (*Elephas maximus*), the process of weighing can be challenging, and alternative methods such as visual body condition scoring (BCS) have been developed. We investigated the temporal development of both parameters regarding correlation patterns between them, and their suitability as monitoring measures in dependence of an elephant's life stage. While BM is more suitable in calves and juveniles under the age of 8 years, both BM and BCS are considered equally reliable in adult elephants. In elephants over the age of 40 years, BCS might be more suitable for assessing the physical status. Independent of species and sex, juvenile zoo elephants grow in BM nearly linearly with age, and reach a higher BM at an earlier age compared with conspecifics of free-ranging and semi-captive populations in the countries of origin. The BCS typically remains constant during this life stage, seemingly unaffected by growth. In adult animals, breeding females have a lower BM and BCS than nonbreeders, and BM and BCS typically indicate fluctuations in the same direction. In geriatric elephants (>40 years) a drop in BCS occurs commonly, while BM may even increase in this life stage. We recommend regular body mass recording in zoo elephants to enhance our knowledge of body mass development and allow the formulation of objective practical recommendations. BCS presents a valuable and simple tool for complementary monitoring of an elephant's condition, especially in adult and geriatric individuals.

Schiffmann, C., et al. (2019). "Elephant body mass cyclicity suggests effect of molar progression on chewing efficiency." Mammalian Biology **96**: 81-86.

Elephants do not replace deciduous teeth once with permanent teeth as most mammals, but replace a single cheek tooth per jaw-side five times in their lives in a process called molar progression. While this gradual process has been well-documented for the purpose of age determination, a less-considered possible side effect of this progression is that functional chewing surface fluctuates, being larger when two cheek teeth are both partially in use and smaller when only one cheek tooth is used fully. We found that body mass of both breeding and non-breeding female zoo elephants (*Elephas maximus*, *Loxodonta africana*) shows a cyclic undulation with peaks separated by many years, which is therefore unrelated to reproduction or annual seasonality. We propose variation in functional chewing surface, resulting chewing efficiency, and resulting increased food intake and/or digestive efficiency as the underlying cause. As elephants reproduce all year-round and thus are not synchronized in their molar progression pattern, climate-related fluctuations in resource availability are

likely to mask this pattern in free-ranging animals. In contrast, it emerges under the comparatively constant zoo conditions, and illustrates the relevance of the dental apparatus for herbivorous mammals. The combination of variable chewing efficiency and resource availability in free-ranging elephants may render these species particularly prone to reported inter-individual fitness differences.
© 2018 Deutsche Gesellschaft für Säugetierkunde

Schlossberg, S., et al. (2019). "Evidence of a Growing Elephant Poaching Problem in Botswana." *Curr Biol* **29**(13): 2222-2228.e2224.

Botswana holds roughly one-third of Africa's remaining savannah elephants (*Loxodonta africana*) [1, 2] and will play a key role in the future conservation of this species. To date, Botswana has been one of the safest countries for elephants, with little poaching reported [3]. Here, we present evidence of a new outbreak of elephant poaching for ivory in northern Botswana. Comparing results from 2014 and 2018 aerial surveys, we found that elephant populations were stable, but numbers of elephant carcasses have increased, especially for newer carcasses dead for less than roughly 1 year. Newer carcasses were clustered in five "hotspots" averaging 3,522 km² in area. We compared elephant populations in hotspots to the immediately surrounding areas and found that since 2014, elephants have decreased by 16% in hotspots but increased by 10% in surrounding areas. Numbers of "old" carcasses, dead for more than 1 year, increased by 78% in hotspots between 2014 and 2018 but decreased by 3% in surrounding areas. To verify that poaching has been occurring, we used helicopters to visit 148 elephant carcasses and assess their cause of death. We confirmed poaching for all 72 newer carcasses assessed. We also confirmed poaching for 62 of 76 (82%) carcasses older than 1 year, primarily in one hotspot. Poached older carcasses were all males aged 30-60 and likely killed for their large tusks. This evidence suggests that ivory poaching on the scale of hundreds of elephants per year has been occurring in northern Botswana since 2017 or possibly earlier.

Schlossberg, S., et al. (2019). "Evidence of a Growing Elephant Poaching Problem in Botswana." *Curr Biol* **29**(13): 2222-2228.e2224.

Botswana holds roughly one-third of Africa's remaining savannah elephants (*Loxodonta africana*) [1, 2] and will play a key role in the future conservation of this species. To date, Botswana has been one of the safest countries for elephants, with little poaching reported [3]. Here, we present evidence of a new outbreak of elephant poaching for ivory in northern Botswana. Comparing results from 2014 and 2018 aerial surveys, we found that elephant populations were stable, but numbers of elephant carcasses have increased, especially for newer carcasses dead for less than roughly 1 year. Newer carcasses were clustered in five "hotspots" averaging 3,522 km² in area. We compared elephant populations in hotspots to the immediately surrounding areas and found that since 2014, elephants have decreased by 16% in hotspots but increased by 10% in surrounding areas. Numbers of "old" carcasses, dead for more than 1 year, increased by 78% in hotspots between 2014 and 2018 but decreased by 3% in surrounding areas. To verify that poaching has been occurring, we used helicopters to visit 148 elephant carcasses and assess their cause of death. We confirmed poaching for all 72 newer carcasses assessed. We also confirmed poaching for 62 of 76 (82%) carcasses older than 1 year, primarily in one hotspot. Poached older carcasses were all males aged 30-60 and likely killed for their large tusks. This evidence suggests that ivory poaching on the scale of hundreds of elephants per year has been occurring in northern Botswana since 2017 or possibly earlier.

Scott, N. L. and C. A. LaDue (2019). "The behavioral effects of exhibit size versus complexity in African elephants: A potential solution for smaller spaces." *Zoo Biol* **38**(5): 448-457.

Population-level analyses suggest that habitat complexity, but not necessarily space availability, has important welfare outcomes for elephants in human care. At the Dallas Zoo, the opening of a new exhibit complex allowed us to measure the behavior of two female African elephants across three treatments to evaluate the independent effects of complexity and space. Preoccupancy observations were conducted in the elephants' older exhibit, which consisted of a smaller, more simple yard (630 m²). Subsequent postoccupancy observations measured behavior in two different spaces in the new

exhibit: a larger, complex yard (15,000 m²), and a smaller, but complex yard (1,520 m²). The elephants' overall activity levels were greater in complex habitats, regardless of their size. Similar effects of habitat complexity oversize were observed with greater rates of foraging and lower rates of being stationary. Furthermore, elephants were out of view of visitors significantly more in the small, simple yard compared to either of the more complex habitats. However, exhibit size affected the incidence of stereotypic behavior (with lower rates of stereotypy in the larger exhibit compared to the smaller yards) and investigatory behavior (elephants investigated their environments more with increasing size and complexity). Behavioral diversity also increased with exhibit size and complexity. These results indicate that space availability alone is not sufficient to enhance the behavioral welfare of zoo elephants. Therefore, facilities with limited space can still encourage species-appropriate behaviors and improved welfare for the elephants in their care by converting a small, simple area into a more complex habitat.

Seltmann, M. W., et al. (2019). "Males have more aggressive and less sociable personalities than females in semi-captive Asian elephants." *Sci Rep* **9**(1): 2668.

Personality, i.e. consistent between-individual differences in behaviour, has been documented in many species. Yet little is known about how males and females of long-lived, highly social species differ in their measures of personality structure. We investigated sex differences in the mean, variance, and covariance of three previously reported personality traits (Attentiveness, Sociability, Aggressiveness) in 150 female and 107 male Asian elephants (*Elephas maximus*) from a semi-captive population in Myanmar. These three personality traits were obtained by performing exploratory factor analysis on 28 behavioural items that had been rated by experienced elephant handlers. We found that males scored significantly higher on Aggressiveness and tended to score lower on Sociability than females. However, no sex difference was found in the mean scores of Attentiveness. Variances for the three personality traits did not differ between the sexes, suggesting that male and female elephants share the same range of personality variation. Likewise, trait covariances were similar between the sexes. While both sexes show complex sociality in the wild, female Asian elephants typically live in highly social family units, whereas male elephants' social bonds are weaker. Males usually form dominance ranks by aggressive interactions, especially during musth. Our results on a large sample of individuals living in their natural environment are thus in agreement with elephant life-histories and parallel the findings of sex differences in other long-lived highly social species with similar life-histories.

Seltmann, M. W., et al. (2019). "Males have more aggressive and less sociable personalities than females in semi-captive Asian elephants." *Sci Rep* **9**(1): 2668.

Personality, i.e. consistent between-individual differences in behaviour, has been documented in many species. Yet little is known about how males and females of long-lived, highly social species differ in their measures of personality structure. We investigated sex differences in the mean, variance, and covariance of three previously reported personality traits (Attentiveness, Sociability, Aggressiveness) in 150 female and 107 male Asian elephants (*Elephas maximus*) from a semi-captive population in Myanmar. These three personality traits were obtained by performing exploratory factor analysis on 28 behavioural items that had been rated by experienced elephant handlers. We found that males scored significantly higher on Aggressiveness and tended to score lower on Sociability than females. However, no sex difference was found in the mean scores of Attentiveness. Variances for the three personality traits did not differ between the sexes, suggesting that male and female elephants share the same range of personality variation. Likewise, trait covariances were similar between the sexes. While both sexes show complex sociality in the wild, female Asian elephants typically live in highly social family units, whereas male elephants' social bonds are weaker. Males usually form dominance ranks by aggressive interactions, especially during musth. Our results on a large sample of individuals living in their natural environment are thus in agreement with elephant life-histories and parallel the findings of sex differences in other long-lived highly social species with similar life-histories.

Sharma, N., et al. (2019). "Behavioural responses of free-ranging Asian elephants (*Elephas maximus*) towards

dying and dead conspecifics." Primates.

Reactions to dying and dead conspecifics have been observed in many non-human animals. Elephants, particularly African elephants, are thought to have an awareness of the death of their conspecifics, as they show compassionate behaviour towards others in distress. However, there is a paucity of scientific documentation on thanatological responses displayed by Asian elephants. Here, we report three detailed, directly observed cases of free-ranging Asian elephants (*Elephas maximus*) responding to dying and dead conspecifics. Behavioural responses were recorded opportunistically and described as pre-, peri- and post-mortem phases based on the status of the individual before, near or after its death. In all three observations, elephants showed approach and exploratory (sniffing and inspecting) behaviours, and epimeletic or helping (physically supporting dying calves) in pre- and peri-mortem phases. We also recorded high-frequency vocalizations (trumpets) by an adult female in the presence of a dying calf. Our observations indicate that, like their African counterparts, Asian elephants might experience distress in response to the death of conspecifics, and may have some awareness of death. This information furthers our understanding of the emotional and cognitive complexities of highly social elephants, and contributes to the growing field of elephant thanatology.

Singh, S. K., et al. (2019). "Resolving the trans-boundary dispute of elephant poaching between India and Nepal." Forensic Sci Int **1**: 146-150.

In Kangchenjunga Landscape (KL), which is shared by three countries - Bhutan, India, and Nepal, the wild elephants migrate from east of Jhapa (Nepal), through West Bengal (India) and Sibsoo (Bhutan) to further east in Assam (India). The route Jhapa-WB-Sibsoo-Assam is a known route for elephant movements where maximum casualties have been reported in the past. The present study was undertaken to ascertain the individual identity of a poached elephant in Jhapa, Nepal and ivory which was suspected to be from the same individual elephant confiscated in Siliguri, India. We undertook STR profiling of the confiscated specimens with nine polymorphic STRs. The forensic parameters has established the fact that the two analyzed samples of elephant were not identical and belong to two different individuals. The present study highlights the necessity of transboundary research for elephant conservation and monitoring their movements in Kangchenjunga Landscape and emphasizes the use of forensic genetics in curbing illegal wildlife trade.

Sirikaew, N., et al. (2019). "Proinflammatory cytokines and lipopolysaccharides up regulate MMP-3 and MMP-13 production in Asian elephant (*Elephas maximus*) chondrocytes: attenuation by anti-arthritic agents." BMC Vet Res **15**(1): 419.

BACKGROUND: Osteoarthritis (OA), the most common form of arthritic disease, results from destruction of joint cartilage and underlying bone. It affects animals, including Asian elephants (*Elephas maximus*) in captivity, leading to joint pain and lameness. However, publications regarding OA pathogenesis in this animal are still limited. Therefore, this study aimed to investigate the effect of proinflammatory cytokines, including interleukin-1 beta (IL-1beta), IL-17A, tumor necrosis factor-alpha (TNF-alpha), and oncostatin M (OSM), known mediators of OA pathogenesis, and lipopolysaccharides on the expression of cartilaginous degrading enzymes, matrix metalloproteinase (MMP)-3 and MMP-13, in elephant articular chondrocytes (ELACs) cultures. Anti-arthritic drugs and the active compounds of herbal plants were tested for their potential attenuation against overproduction of these enzymes. **RESULTS:** Among the used cytokines, OSM showed the highest activation of MMP3 and MMP13 expression, especially when combined with IL-1beta. The combination of IL-1beta and OSM was found to activate phosphorylation of the mitogen-activated protein kinase (MAPK) pathway in ELACs. Lipopolysaccharides or cytokine-induced expressions were suppressed by pharmacologic agents used to treat OA, including dexamethasone, indomethacin, etoricoxib, and diacerein, and by three natural compounds, sesamin, andrographolide, and vanillylacetone. **CONCLUSIONS:** Our results revealed the cellular mechanisms underlying OA in elephant chondrocytes, which is triggered by proinflammatory cytokines or lipopolysaccharides and suppressed by common pharmacological or natural medications used to treat human OA. These results provide a more basic understanding of the pathogenesis of elephant OA, which could be useful for adequate medical treatment of OA in this

animal.

Sosnowski, M. C., et al. (2019). "Global ivory market prices since the 1989 CITES ban." Biological Conservation **237**: 392-399.

Poaching associated with the ivory trade is estimated to cause an 8% annual loss in the world elephant population. Although international trade in ivory was banned by the Convention on the International Trade in Endangered Species in 1989, elephant populations continue to suffer. Together with global price data on ivory transactions, information on ivory product type, weight, region, legality of sale, and year of transaction, were used alongside an ivory Transaction Index (TI) and world gold price to: (1) examine the temporal and geographic trends in ivory price; (2) determine variables associated with ivory price; and (3) propose a predictive equation based on these variables. Results indicate that ivory price has been rising since the CITES ban, with highest values observed across Asia. Determinants significant to ivory market price include: (1) region; (2) type [raw, polished, carved]; (3) TI; and (4) legality. Interaction effects were present between region and legality, and between region and type. The predictive equation successfully explained 72.5% of variation in price. It is hoped that an improved understanding of the market mechanism will lead to more effective policy interventions, which can ensure a secure future for elephants as a species. © 2019 Elsevier Ltd

Soundararajan, C., et al. (2019). "Wound and gastric myiasis due to *Chrysomya bezziana* and *Cobbaldia elephantis* and its pathological lesions in wild elephants in the Nilgiris hills of Tamil Nadu." J Parasit Dis **43**(1): 134-138.

Thirty-five years old female and 12 years old male wild elephant were found dead at Seviyodu and Cherangode of Cherambadi range at Nilgiris district, Tamil Nadu state. On post mortem examination, maggots were recovered from palate of oral cavity and gastric mucosa of the stomach and identified as *Chrysomya bezziana* and *Cobbaldia elephantis*, respectively. Histopathology of oral tissue specimen revealed myonecrosis of soft palate due to myiasis and cross section of encysted larvae surrounded by fibrous capsule and inflammatory cells. This study reports the mixed infection of wound and gastric myiasis due to *C. bezziana* and *C. elephantis* and its histopathological lesions in wild elephants.

Srinivasaiah, N., et al. (2019). "All-Male Groups in Asian Elephants: A Novel, Adaptive Social Strategy in Increasingly Anthropogenic Landscapes of Southern India." Sci Rep **9**(1): 8678.

Male Asian elephants are known to adopt a high-risk high-gain foraging strategy by venturing into agricultural areas and feeding on nutritious crops in order to improve their reproductive fitness. We hypothesised that the high risks to survival posed by increasingly urbanising and often unpredictable production landscapes may necessitate the emergence of behavioural strategies that allow male elephants to persist in such landscapes. Using 1445 photographic records of 248 uniquely identified male Asian elephants over a 23-month period, we show that male Asian elephants display striking emergent behaviour, particularly the formation of stable, long-term all-male groups, typically in non-forested or human-modified and highly fragmented areas. They remained solitary or associated in mixed-sex groups, however, within forested habitats. These novel, large all-male associations, may constitute a unique life history strategy for male elephants in the high-risk but resource-rich production landscapes of southern India. This may be especially true for the adolescent males, which seemed to effectively improve their body condition by increasingly exploiting anthropogenic resources when in all-male groups. This observation further supports our hypothesis that such emergent behaviours are likely to constitute an adaptive strategy for male Asian elephants that may be forced to increasingly confront anthropogenically intrusive environments.

Srinivasaiah, N., et al. (2019). "All-Male Groups in Asian Elephants: A Novel, Adaptive Social Strategy in Increasingly Anthropogenic Landscapes of Southern India." Sci Rep **9**(1): 8678.

Male Asian elephants are known to adopt a high-risk high-gain foraging strategy by venturing into

agricultural areas and feeding on nutritious crops in order to improve their reproductive fitness. We hypothesised that the high risks to survival posed by increasingly urbanising and often unpredictable production landscapes may necessitate the emergence of behavioural strategies that allow male elephants to persist in such landscapes. Using 1445 photographic records of 248 uniquely identified male Asian elephants over a 23-month period, we show that male Asian elephants display striking emergent behaviour, particularly the formation of stable, long-term all-male groups, typically in non-forested or human-modified and highly fragmented areas. They remained solitary or associated in mixed-sex groups, however, within forested habitats. These novel, large all-male associations, may constitute a unique life history strategy for male elephants in the high-risk but resource-rich production landscapes of southern India. This may be especially true for the adolescent males, which seemed to effectively improve their body condition by increasingly exploiting anthropogenic resources when in all-male groups. This observation further supports our hypothesis that such emergent behaviours are likely to constitute an adaptive strategy for male Asian elephants that may be forced to increasingly confront anthropogenically intrusive environments.

Sriniyasaiah, N., et al. (2019). "All-Male Groups in Asian Elephants: A Novel, Adaptive Social Strategy in Increasingly Anthropogenic Landscapes of Southern India." *Scientific Reports* **9**.

Male Asian elephants are known to adopt a high-risk high-gain foraging strategy by venturing into agricultural areas and feeding on nutritious crops in order to improve their reproductive fitness. We hypothesised that the high risks to survival posed by increasingly urbanising and often unpredictable production landscapes may necessitate the emergence of behavioural strategies that allow male elephants to persist in such landscapes. Using 1445 photographic records of 248 uniquely identified male Asian elephants over a 23-month period, we show that male Asian elephants display striking emergent behaviour, particularly the formation of stable, long-term all-male groups, typically in non-forested or human-modified and highly fragmented areas. They remained solitary or associated in mixed-sex groups, however, within forested habitats. These novel, large all-male associations, may constitute a unique life history strategy for male elephants in the high-risk but resource-rich production landscapes of southern India. This may be especially true for the adolescent males, which seemed to effectively improve their body condition by increasingly exploiting anthropogenic resources when in all-male groups. This observation further supports our hypothesis that such emergent behaviours are likely to constitute an adaptive strategy for male Asian elephants that may be forced to increasingly confront anthropogenically intrusive environments.

Sripiboon, S., et al. (2019). "Subclinical infection of captive Asian elephants (*Elephas maximus*) in Thailand with elephant endotheliotropic herpesvirus." *Arch Virol*.

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.

Srivorakul, S., et al. (2019). "Possible roles of monocytes/macrophages in response to elephant endotheliotropic herpesvirus (EEHV) infections in Asian elephants (*Elephas maximus*)." *PLoS ONE* **14**(9): e0222158.

Elephant endotheliotropic herpesvirus-hemorrhagic disease (EEHV-HD) is the primary cause of acute, highly fatal, hemorrhagic diseases in young Asian elephants. Although monocytopenia is frequently observed in EEHV-HD cases, the role monocytes play in EEHV-disease pathogenesis is unknown. This study seeks to explain the responses of monocytes/macrophages in the pathogenesis of EEHV-HD. Samples of blood, frozen tissues, and formalin-fixed, paraffin-embedded (FFPE) tissues from EEHV1A-HD, EEHV4-HD, co-infected EEHV1A and 4-HD, and EEHV-negative calves were analyzed. Peripheral

blood mononuclear cells (PBMCs) from the persistent EEHV4-infected and EEHV-negative calves were also studied. The results showed increased infiltration of Iba-1-positive macrophages in the inflamed tissues of the internal organs of elephant calves with EEHV-HD. In addition, cellular apoptosis also increased in the tissues of elephants with EEHV-HD, especially in the PBMCs, compared to the EEHV-negative control. In the PBMCs of persistent EEHV4-infected elephants, cytokine mRNA expression was high, particularly up-regulation of TNF-alpha and IFN-gamma. Moreover, viral particles were observed in the cytoplasm of the persistent EEHV4-infected elephant monocytes. Our study demonstrated for the first time that apoptosis of the PBMCs increased in cases of EEHV-HD. Furthermore, this study showed that monocytes may serve as a vehicle for viral dissemination during EEHV infection in Asian elephants.

Stalmans, M. E., et al. (2019). "War-induced collapse and asymmetric recovery of large-mammal populations in Gorongosa National Park, Mozambique." *PLoS ONE* **14**(3).

How do large-mammal communities reassemble after being pushed to the brink of extinction? Few data are available to answer this question, as it is rarely possible to document both the decline and recovery of wildlife populations. Here we present the first in-depth quantitative account of war-induced collapse and postwar recovery in a diverse assemblage of large herbivores. In Mozambique's Gorongosa National Park, we assembled data from 15 aerial wildlife counts conducted before (1968-1972) and after (1994-2018) the Mozambican Civil War (1977-1992). Pre-war total biomass density exceeded 9,000 kg km⁻², but populations declined by >90% during the war. Since 1994, total biomass has substantially recovered, but species composition has shifted dramatically. Formerly dominant large herbivores-including elephant (*Loxodonta africana*), hippo (*Hippopotamus amphibius*), buffalo (*Syncerus Gaffer*), zebra (*Equus quagga*), and wildebeest (*Connochaetes taurinus*)-are now outnumbered by waterbuck (*Kobus ellipsiprymnus*) and other small to mid-sized antelopes. Waterbuck abundance has increased by an order of magnitude, with >55,000 individuals accounting for >74% of large-herbivore biomass in 2018. By contrast, elephant, hippo, and buffalo, which totaled 89% of pre-war biomass, now comprise just 23%. These trends mostly reflect natural population growth following the resumption of protection under the Gorongosa Restoration Project; reintroductions (465 animals of 7 species) accounted for a comparatively small fraction of the total numerical increase. Waterbuck are growing logistically, apparently as-yet unchecked by interspecific competition or predation (apex-carnivore abundance has been low throughout the post-war interval), suggesting a community still in flux. Most other herbivore populations have increased post-war, albeit at differing rates. Armed conflict remains a poorly understood driver of ecological change; our results demonstrate the potential for rapid post-war recovery of large-herbivore biomass, given sound protected-area management, but also suggest that restoration of community structure takes longer and may require active intervention.

Stalmans, M. E., et al. (2019). "War-induced collapse and asymmetric recovery of large-mammal populations in Gorongosa National Park, Mozambique." *PLoS ONE* **14**(3): e0212864.

How do large-mammal communities reassemble after being pushed to the brink of extinction? Few data are available to answer this question, as it is rarely possible to document both the decline and recovery of wildlife populations. Here we present the first in-depth quantitative account of war-induced collapse and postwar recovery in a diverse assemblage of large herbivores. In Mozambique's Gorongosa National Park, we assembled data from 15 aerial wildlife counts conducted before (1968-1972) and after (1994-2018) the Mozambican Civil War (1977-1992). Pre-war total biomass density exceeded 9,000 kg km⁻², but populations declined by >90% during the war. Since 1994, total biomass has substantially recovered, but species composition has shifted dramatically. Formerly dominant large herbivores-including elephant (*Loxodonta africana*), hippo (*Hippopotamus amphibius*), buffalo (*Syncerus caffer*), zebra (*Equus quagga*), and wildebeest (*Connochaetes taurinus*)-are now outnumbered by waterbuck (*Kobus ellipsiprymnus*) and other small to mid-sized antelopes. Waterbuck abundance has increased by an order of magnitude, with >55,000 individuals accounting for >74% of large-herbivore biomass in 2018. By contrast, elephant, hippo, and buffalo, which totaled 89% of pre-war biomass, now comprise just 23%. These trends mostly reflect natural population growth following

the resumption of protection under the Gorongosa Restoration Project; reintroductions (465 animals of 7 species) accounted for a comparatively small fraction of the total numerical increase. Waterbuck are growing logistically, apparently as-yet unchecked by interspecific competition or predation (apex-carnivore abundance has been low throughout the post-war interval), suggesting a community still in flux. Most other herbivore populations have increased post-war, albeit at differing rates. Armed conflict remains a poorly understood driver of ecological change; our results demonstrate the potential for rapid post-war recovery of large-herbivore biomass, given sound protected-area management, but also suggest that restoration of community structure takes longer and may require active intervention.

Takehana, K., et al. (2019). "Rapid and sensitive detection of elephant endotheliotropic herpesvirus 1 (EEHV1) in blood by loop-mediated isothermal amplification (LAMP)." J Vet Med Sci.

Elephant endotheliotropic herpesvirus type 1 (EEHV1) is the most important causative agent of an acute fatal hemorrhagic disease in Asian elephants (*Elephas maximus*). We employed loop-mediated isothermal amplification (LAMP) to develop a rapid and simple detection method for EEHV1 in blood. When used to test 21 clinical samples collected in Japan, the EEHV1 assay correctly identified one positive and 20 negative clinical samples. It was observed that when samples were spiked with synthetic DNA plasmids including EEHV1 polymerase gene, the detection limit of the LAMP assay was 10(1.2) copies/ml and 100-fold higher than that of conventional PCR. These advantages of the LAMP assay for EEHV1 detection may facilitate better veterinary practices for treating elephants suffering from the acute disease.

Takehana, K., et al. (2019). "Determination of serum bone-specific alkaline phosphatase isoenzyme activity in captive Asian elephants (*Elephas maximus*) using an agarose gel electrophoresis method." J Vet Med Sci **81**(4): 551-554.

The bone-specific alkaline phosphatase (ALP) isoenzyme activity was measured in 51 serum samples from four captive Asian elephants (*Elephas maximus*) using a conventional method with wheat germ lectin precipitation and a commercial agarose gel electrophoresis (AGE) kit; the isoenzymes were designated as bone-specific ALP (BAP) and ALP isoenzyme 3 (ALP3), respectively. This study examined the suitability of the AGE kit for analyzing blood biochemistry in Asian elephants. The serum ALP3 and BAP activities were strongly positively correlated and met the evaluation criteria for agreement using Bland-Altman analysis. The results indicate that the AGE kit can be used to examine the blood biochemistry in Asian elephants instead of the conventional method.

Talukdar, N. R., et al. (2019). "THE IMPORTANCE OF TRANS-BOUNDARY CONSERVATION OF THE ASIATIC ELEPHANT *ELEPHAS MAXIMUS* IN PATHARIA HILLS RESERVE FOREST, NORTHEASTERN INDIA." Journal of Threatened Taxa **11**(1): 13168-13170.

Taylor, L. A., et al. (2019). "Movement reveals reproductive tactics in male elephants." The Journal of animal ecology.

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 (*Loxodonta 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.

Taylor, M., et al. (2019). "Becoming care-full: contextualizing moral development among captive elephant volunteer tourists to Thailand." Journal of Ecotourism.

Tourism literature on animal ethics and animal welfare has given scarce consideration to how tourists become enrolled into caring, responsible practices towards animals. The objective of this paper is to contextualize a process of moral development—and specifically the emergence of an ethic of care—through the narratives and experiences of captive elephant volunteer tourists in Thailand. Guided by tenets of ecofeminism and a narrative methodology, our study forefronts how relational experiences prompted compassion and empathy as storied by 12 women volunteers. These volunteer tourists described how they shaped their own moral and ethical patterns through practices of witnessing abuse, questioning moral responsibilities, connecting with elephants, and advocating for improved conditions of captive individuals. As storied by the volunteers, processes of witnessing—questioning—connecting—advocating were deeply transformational, and inspired what we interpret as the development of an ethic of care. The research advances understandings of how intentional, relational engagements that prioritize animal wellbeing have the potential to facilitate among tourists processes of becoming care-full. © 2019, © 2019 Informa UK Limited, trading as Taylor & Francis Group.

Thakur, N., et al. (2019). "Balantidiasis in an Asiatic elephant and its therapeutic management." J Parasit Dis **43**(2): 186-189.

A 14 years old female Asiatic elephant was presented to the hospital with a history of mucoid watery diarrhea, inappetence and lethargy. Clinical examination revealed normal body temperature (98.2 degrees F), tachycardia (42 bpm), eupnoea (14/min), congested mucous membrane and dehydration. Haemato-biochemical parameters are well within the range. Microscopic examination of faecal sample revealed presence of live, motile and pear shaped ciliated *Balantidium coli* protozoa. Based on clinical and laboratory examination, the condition was diagnosed as balantidiasis. The animal was treated with Tab. Metronidazole (10 mg/Kg, PO, BID) for 5 days. Supportive treatment was done with antacids, hepatoprotectants and multivitamin supplements. An uneventful recovery was noticed after 5 days of treatment.

Thapa, K., et al. (2019). "Elephant (*Elephas maximus*) temporal activity, distribution, and habitat use patterns on the tiger's forgotten trails across the seasonally dry, subtropical, hilly Churia forests of Nepal." PLoS ONE **14**(5): e0216504.

Understanding spatial distribution, habitat use, and temporal activity patterns is important for species conservation planning. This information especially is crucial for mega herbivores like elephants as their ranging patterns encompass a myriad of habitats types. Churia habitat is geological fragile yet important for wildlife in Nepal and India. We used camera trapping and sign surveys covering 536 km² of Churia and surrounding areas within Chitwan National Park. Across 152 trapping locations, we accumulated 2,097 trap nights in a 60-day survey during the winter season of 2010-11. We used a non-parametric kernel density function to analyze winter activity patterns of elephants detected in camera-traps. Additionally, we walked 643 km over 76 grid cells in two surveys (winter and summer) to estimate elephant distribution and intensity of habitat use using an occupancy framework. Multi-

season models allowed us to make seasonal (winter versus summer) inferences regarding changes in habitat use based on covariates influencing use and detection. We photographed 25 mammalian species including elephants with calves with a trapping rate of 2.72 elephant photos events per 100 trap nights. Elephant winter activity pattern was found to be mainly nocturnal, with crepuscular peaks. Covariates such as normalized differential vegetation index and terrain ruggedness positively influenced elephant spatial distribution and habitat use patterns within the Churia habitat. We also found lower elephant habitat use ([Formula: see text]) of Churia in winter 0.51 (0.02) than in summer 0.57 (0.02). Elephants heavily used the eastern portion of Churia in both seasons (67-69%). Overall, Churia habitat, which is often ignored, clearly is used by elephants, with increases in summer use in the west and high use year-round in the east, and thus should no longer be neglected or forgotten in species conservation planning.

Udomtanakunchai, C., et al. (2019). "EVALUATION OF THE BONE MINERAL DENSITY OF ASIAN ELEPHANTS (ELEPHAS MAXIMUS) VIA DUAL-ENERGY X-RAY IMAGING OF TAILS." J Zoo Wildl Med **50**(2): 375-382.

Musculoskeletal problems are one of the top five causes of disease in elephants. However, recent blood chemistry analysis is the only routine protocol for bone mineral status evaluation, with no assessment method currently available for the direct measurement of elephant bone mineral density (BMD). This work applied the the dual-energy X-ray technique (DXA) technique for bone density assessment. The elephant's tail was chosen for the analysis to avoid the radiation harm. Twelve live Asian elephants (*Elephas maximus*) comprising eight males and four females with ages in the range of 4-77 yr were investigated. The BMD was calculated based on radiographic images acquired using the DXA technique carried out at 40 kVp 2 mAs and 50 kVp 2 mAs. Blood serum analysis of total calcium (Ca), phosphorus (Phos) and alkaline phosphatase (ALP) content was conducted in parallel with the physical examination to correlate age and BMD. Analyses produced an overall mean BMD value in the range of 0.54-1.39 g/cm², with that of the males higher than that of the females. The BMD was found to be negatively correlated with age, Ca, and Phos, but not with ALP. In summary, the BMD analysis of an elephant's tail might be used with blood serum Ca and Phos to predict the overall bone mineral status of the animal.

Udomtanakunchai, C., et al. (2019). "EVALUATION OF THE BONE MINERAL DENSITY OF ASIAN ELEPHANTS (ELEPHAS MAXIMUS) VIA DUAL-ENERGY X-RAY IMAGING OF TAILS." Journal of Zoo and Wildlife Medicine **50**(2): 375-382.

Musculoskeletal problems are one of the top five causes of disease in elephants. However, recent blood chemistry analysis is the only routine protocol for bone mineral status evaluation, with no assessment method currently available for the direct measurement of elephant bone mineral density (BMD). This work applied the the dual-energy X-ray technique (DXA) technique for bone density assessment. The elephant's tail was chosen for the analysis to avoid the radiation harm. Twelve live Asian elephants (*Elephas maximus*) comprising eight males and four females with ages in the range of 4-77 yr were investigated. The BMD was calculated based on radiographic images acquired using the DXA technique carried out at 40 kVp 2 mAs and 50 kVp 2 mAs. Blood serum analysis of total calcium (Ca), phosphorus (Phos) and alkaline phosphatase (ALP) content was conducted in parallel with the physical examination to correlate age and BMD. Analyses produced an overall mean BMD value in the range of 0.54-1.39 g/cm², with that of the males higher than that of the females. The BMD was found to be negatively correlated with age, Ca, and Phos, but not with ALP. In summary, the BMD analysis of an elephant's tail might be used with blood serum Ca and Phos to predict the overall bone mineral status of the animal.

Veasey, J. S. (2019). "Assessing the Psychological Priorities for Optimising Captive Asian Elephant (*Elephas maximus*) Welfare." Animals (Basel) **10**(1).

The welfare status of elephants under human care has been a contentious issue for two decades or more in numerous western countries. Much effort has gone into assessing the welfare of captive

elephants at individual and population levels with little consensus having been achieved in relation to both the welfare requirements of captive elephants, or their absolute welfare status. A methodology capable of identifying the psychological priorities of elephants would greatly assist in both managing and assessing captive elephant welfare. Here, a Delphi-based Animal Welfare Priority Identification System(©) (APWIS(©)) is trialled to evaluate the reliability of the methodology and to determine the welfare significance of individual behaviours and cognitive processes for Asian elephants (*Elaphus maximus*). APWIS(©) examines the motivational characteristics, evolutionary significance and established welfare impacts of individual behaviours and cognitive processes of each species being assessed. The assessment carried out here indicates appetitive behaviours essential for survival in the wild, together species-specific social and cognitive opportunities are likely to be important to the welfare of Asian elephant in captivity. The output of this assessment, for the first time, provides comprehensive species-specific psychological/welfare priorities for Asian elephants that should be used to inform husbandry guidelines, habitat design and management strategies and can also provide a valuable reference tool for Asian elephant welfare assessment. The effective application of these insights could lead to substantive improvements in captive Asian elephant welfare.

Vincze, B., et al. (2019). "Sex determination using circulating cell-free fetal DNA in small volume of maternal plasma in elephants." *Sci Rep* **9**(1): 15254.

The genetic sexing of animals having long gestation periods offers significant benefits in regard to breeding management among their populations living in captivity. In our study, a new increased-sensitivity PCR method for fetal sexing was developed and tested successfully on elephants, from only a small volume of maternal plasma. Suitable sensitivity was obtained by using short, reduced amplicon lengths with fluorescent labelling for capillary electrophoresis detection. The fundamental principle for this technique was based on the detection of two Y-specific markers (AmelY and SRY), the presence of which indicates the mother is carrying a male fetus and the absence of these markers designates a female fetus. As a reaction control, the X-chromosomal marker (PlpX) was used. To the best of our knowledge, this is the first report on this topic, confirming the presence of fetal cell-free DNA from the plasma of a pregnant captive elephant, and demonstrating a new opportunity for non-invasive assessment in fetal sex determination.

Vincze, B., et al. (2019). "Sex determination using circulating cell-free fetal DNA in small volume of maternal plasma in elephants." *Sci Rep* **9**(1): 15254.

The genetic sexing of animals having long gestation periods offers significant benefits in regard to breeding management among their populations living in captivity. In our study, a new increased-sensitivity PCR method for fetal sexing was developed and tested successfully on elephants, from only a small volume of maternal plasma. Suitable sensitivity was obtained by using short, reduced amplicon lengths with fluorescent labelling for capillary electrophoresis detection. The fundamental principle for this technique was based on the detection of two Y-specific markers (AmelY and SRY), the presence of which indicates the mother is carrying a male fetus and the absence of these markers designates a female fetus. As a reaction control, the X-chromosomal marker (PlpX) was used. To the best of our knowledge, this is the first report on this topic, confirming the presence of fetal cell-free DNA from the plasma of a pregnant captive elephant, and demonstrating a new opportunity for non-invasive assessment in fetal sex determination.

Vincze, B., et al. (2019). "Sex determination using circulating cell-free fetal DNA in small volume of maternal plasma in elephants." *Sci Rep* **9**(1): 15254.

The genetic sexing of animals having long gestation periods offers significant benefits in regard to breeding management among their populations living in captivity. In our study, a new increased-sensitivity PCR method for fetal sexing was developed and tested successfully on elephants, from only a small volume of maternal plasma. Suitable sensitivity was obtained by using short, reduced amplicon lengths with fluorescent labelling for capillary electrophoresis detection. The fundamental principle for this technique was based on the detection of two Y-specific markers (AmelY and SRY),

the presence of which indicates the mother is carrying a male fetus and the absence of these markers designates a female fetus. As a reaction control, the X-chromosomal marker (PlpX) was used. To the best of our knowledge, this is the first report on this topic, confirming the presence of fetal cell-free DNA from the plasma of a pregnant captive elephant, and demonstrating a new opportunity for non-invasive assessment in fetal sex determination.

Vincze, B., et al. (2019). "Sex determination using circulating cell-free fetal DNA in small volume of maternal plasma in elephants." *Sci Rep* **9**(1): 15254.

The genetic sexing of animals having long gestation periods offers significant benefits in regard to breeding management among their populations living in captivity. In our study, a new increased-sensitivity PCR method for fetal sexing was developed and tested successfully on elephants, from only a small volume of maternal plasma. Suitable sensitivity was obtained by using short, reduced amplicon lengths with fluorescent labelling for capillary electrophoresis detection. The fundamental principle for this technique was based on the detection of two Y-specific markers (AmelY and SRY), the presence of which indicates the mother is carrying a male fetus and the absence of these markers designates a female fetus. As a reaction control, the X-chromosomal marker (PlpX) was used. To the best of our knowledge, this is the first report on this topic, confirming the presence of fetal cell-free DNA from the plasma of a pregnant captive elephant, and demonstrating a new opportunity for non-invasive assessment in fetal sex determination.

Vincze, B., et al. (2019). "Sex determination using circulating cell-free fetal DNA in small volume of maternal plasma in elephants." *Sci Rep* **9**(1): 15254.

The genetic sexing of animals having long gestation periods offers significant benefits in regard to breeding management among their populations living in captivity. In our study, a new increased-sensitivity PCR method for fetal sexing was developed and tested successfully on elephants, from only a small volume of maternal plasma. Suitable sensitivity was obtained by using short, reduced amplicon lengths with fluorescent labelling for capillary electrophoresis detection. The fundamental principle for this technique was based on the detection of two Y-specific markers (AmelY and SRY), the presence of which indicates the mother is carrying a male fetus and the absence of these markers designates a female fetus. As a reaction control, the X-chromosomal marker (PlpX) was used. To the best of our knowledge, this is the first report on this topic, confirming the presence of fetal cell-free DNA from the plasma of a pregnant captive elephant, and demonstrating a new opportunity for non-invasive assessment in fetal sex determination.

Wan, X., et al. (2019). "Historical records reveal the distinctive associations of human disturbance and extreme climate change with local extinction of mammals." *Proc Natl Acad Sci U S A*.

Accelerated anthropogenic impacts and climatic changes are widely considered to be responsible for unprecedented species extinction. However, determining their effects on extinction is challenging owing to the lack of long-term data with high spatial and temporal resolution. In this study, using historical occurrence records of 11 medium- to large-sized mammal species or groups of species in China from 905 BC to AD 2006, we quantified the distinctive associations of anthropogenic stressors (represented by cropland coverage and human population density) and climatic stressors (represented by air temperature) with the local extinction of these mammals. We found that both intensified human disturbances and extreme climate change were associated with the increased local extinction of the study mammals. In the cold phase (the premodern period of China), climate cooling was positively associated with increased local extinction, while in the warm phase (the modern period) global warming was associated with increased local extinction. Interactive effects between human disturbance and temperature change with the local extinction of elephants, rhinos, pandas, and water deer were found. Large-sized mammals, such as elephants, rhinos, and pandas, showed earlier and larger population declines than small-sized ones. The local extinction sensitivities of these mammals to the human population density and standardized temperature were estimated during 1700 to 2000. The quantitative evidence for anthropogenic and climatic associations with mammalian extinction

provided insights into the driving processes of species extinction, which has important implications for biodiversity conservation under accelerating global changes.

Wan, X., et al. (2019). "Historical records reveal the distinctive associations of human disturbance and extreme climate change with local extinction of mammals." *Proc Natl Acad Sci U S A* **116**(38): 19001-19008. Accelerated anthropogenic impacts and climatic changes are widely considered to be responsible for unprecedented species extinction. However, determining their effects on extinction is challenging owing to the lack of long-term data with high spatial and temporal resolution. In this study, using historical occurrence records of 11 medium- to large-sized mammal species or groups of species in China from 905 BC to AD 2006, we quantified the distinctive associations of anthropogenic stressors (represented by cropland coverage and human population density) and climatic stressors (represented by air temperature) with the local extinction of these mammals. We found that both intensified human disturbances and extreme climate change were associated with the increased local extinction of the study mammals. In the cold phase (the premodern period of China), climate cooling was positively associated with increased local extinction, while in the warm phase (the modern period) global warming was associated with increased local extinction. Interactive effects between human disturbance and temperature change with the local extinction of elephants, rhinos, pandas, and water deer were found. Large-sized mammals, such as elephants, rhinos, and pandas, showed earlier and larger population declines than small-sized ones. The local extinction sensitivities of these mammals to the human population density and standardized temperature were estimated during 1700 to 2000. The quantitative evidence for anthropogenic and climatic associations with mammalian extinction provided insights into the driving processes of species extinction, which has important implications for biodiversity conservation under accelerating global changes.

Wan, X., et al. (2019). "Historical records reveal the distinctive associations of human disturbance and extreme climate change with local extinction of mammals." *Proc Natl Acad Sci U S A* **116**(38): 19001-19008. Accelerated anthropogenic impacts and climatic changes are widely considered to be responsible for unprecedented species extinction. However, determining their effects on extinction is challenging owing to the lack of long-term data with high spatial and temporal resolution. In this study, using historical occurrence records of 11 medium- to large-sized mammal species or groups of species in China from 905 BC to AD 2006, we quantified the distinctive associations of anthropogenic stressors (represented by cropland coverage and human population density) and climatic stressors (represented by air temperature) with the local extinction of these mammals. We found that both intensified human disturbances and extreme climate change were associated with the increased local extinction of the study mammals. In the cold phase (the premodern period of China), climate cooling was positively associated with increased local extinction, while in the warm phase (the modern period) global warming was associated with increased local extinction. Interactive effects between human disturbance and temperature change with the local extinction of elephants, rhinos, pandas, and water deer were found. Large-sized mammals, such as elephants, rhinos, and pandas, showed earlier and larger population declines than small-sized ones. The local extinction sensitivities of these mammals to the human population density and standardized temperature were estimated during 1700 to 2000. The quantitative evidence for anthropogenic and climatic associations with mammalian extinction provided insights into the driving processes of species extinction, which has important implications for biodiversity conservation under accelerating global changes.

Wan, X., et al. (2019). "Historical records reveal the distinctive associations of human disturbance and extreme climate change with local extinction of mammals." *Proc Natl Acad Sci U S A* **116**(38): 19001-19008. Accelerated anthropogenic impacts and climatic changes are widely considered to be responsible for unprecedented species extinction. However, determining their effects on extinction is challenging owing to the lack of long-term data with high spatial and temporal resolution. In this study, using historical occurrence records of 11 medium- to large-sized mammal species or groups of species in China from 905 BC to AD 2006, we quantified the distinctive associations of anthropogenic stressors

(represented by cropland coverage and human population density) and climatic stressors (represented by air temperature) with the local extinction of these mammals. We found that both intensified human disturbances and extreme climate change were associated with the increased local extinction of the study mammals. In the cold phase (the premodern period of China), climate cooling was positively associated with increased local extinction, while in the warm phase (the modern period) global warming was associated with increased local extinction. Interactive effects between human disturbance and temperature change with the local extinction of elephants, rhinos, pandas, and water deer were found. Large-sized mammals, such as elephants, rhinos, and pandas, showed earlier and larger population declines than small-sized ones. The local extinction sensitivities of these mammals to the human population density and standardized temperature were estimated during 1700 to 2000. The quantitative evidence for anthropogenic and climatic associations with mammalian extinction provided insights into the driving processes of species extinction, which has important implications for biodiversity conservation under accelerating global changes.

Wasser, S. K. and K. S. Gobush (2019). "Conservation: Monitoring Elephant Poaching to Prevent a Population Crash." Curr Biol **29**(15): 2593.

Weill, J. C. (2019). "[How the elephant resists cancer or the arrival of a zombie gene]." Med Sci (Paris) **35**(5): 410-411.

Wendler, P., et al. (2019). "Foot health of asian elephants (*elephas maximus*) in european zoos." Journal of Zoo and Wildlife Medicine **50**(3): 513-527.

Foot problems are a common concern in elephant husbandry. Studies on this topic with sample sizes greater than 100 animals have only been carried out in North America. We investigated foot health of 243 Asian elephants (*Elephas maximus*) in 69 European institutions. During on-site visits between August 2016 and July 2017, standardized pictures were taken of each elephant's nails and pads. The pictures were analyzed with respect to pathological lesions (i.e. nail cracks, abscesses), care issues (i.e. minor abnormalities, which are easily resolvable with routine foot work), and pad structure. Of all analyzed nails and pads, 35.6% revealed varying degrees of pathological lesions, with minor nail cracks and overgrown cuticles with attachment to the nails being most frequently observed. The most lateral nail (N5) on both front feet demonstrated the highest percentage of pathological lesions, providing support to a separate study showing that the mean peak pressure of an elephant's foot occurs along the most lateral digits; however, this was not observed along the most lateral nail (N5) of the rear feet. Three (of 243) elephants did not show any pathological lesions in their feet. The most common issues requiring foot care were fissures in the nail sole. The structure of the pads was categorized in four grades reflecting the percentage of surface marked by sulci. These four grades occurred at nearly equal frequency. Pearson product moment correlations revealed no significant association between the frequency of care issues and pathological lesions per nail. Despite this finding, it may be prudent to implement husbandry protocols that could alleviate commonly observed pathological and care foot issues in captive Asian elephants. A standardized approach to evaluate elephant foot health will provide a more objective way to monitor responses to management and medical decisions and ultimately contribute to the overall wellbeing of elephants in human care. © 2019 by American Association of Zoo Veterinarians.

Williams, E., et al. (2019). "Social Interactions in Zoo-Housed Elephants: Factors Affecting Social Relationships." Animals (Basel) **9**(10).

Elephants have complex social systems that are predominantly driven by ecological factors in situ. Within zoos, elephants are held in relatively static social groups and the factors observed driving social relationships in the wild are largely absent. Little research has investigated the effect of social group factors in zoos on elephant social interactions. The aim of this research was to establish whether there is a relationship between social group factors and social behaviour, in order to identify

factors that make elephant herds more or less likely to be compatible. Results will facilitate recommendations for optimum social groupings for zoo elephants. Behavioural data quantifying social interactions were collected between January 2016 and February 2017 at seven UK and Irish zoos and safari parks from 10 African and 22 Asian elephants. Social interactions were split into four categories: positive physical, positive non-physical, negative physical and negative non-physical. Social interactions were related to age (positive physical higher and negative non-physical lower in calves than adults), personality (elephants with higher sociability scores engaged in more positive interactions and less negative interactions), presence of calves in the herd (herds with calves had more positive non-physical), relatedness to other elephants in the herd (positive non-physical were higher when relatives were in the group and negative non-physical were higher between unrelated elephants) and species (Asian elephants engaged in more positive non-physical than African elephants). A greater understanding of factors that may contribute to the success of zoo-elephant social groups is important for individual and herd welfare as it will enable evidence-based decisions which have minimal impact on social structures to be executed. This knowledge will enable proactive management approaches to be undertaken and will thus be paramount in ensuring optimal welfare for elephant herds moving forwards.

Wissink-Argilaga, N., et al. (2019). "USING IN-HOUSE HEMATOLOGY TO DIRECT DECISION-MAKING IN THE SUCCESSFUL TREATMENT AND MONITORING OF A CLINICAL AND SUBSEQUENTLY SUBCLINICAL CASE OF ELEPHANT ENDOTHELIO-TROPIC HERPESVIRUS 1B." *J Zoo Wildl Med* **50**(2): 498-502.

A 3.5-yr-old asymptomatic female Asian elephant (*Elephas maximus*) with a high load of circulating EEHV1B DNA on qPCR on a routine blood sample, showed progressive depletion of monocytes, lymphocytes, and platelets. Twice daily IV ganciclovir, plasma transfusions, and fluid therapy coincided with a decreasing viral load, which may support potential efficacy of this antiviral drug. An increase in lymphocytes followed initial treatment and preceded the onset of clinical signs. Administration of short-acting glucocorticosteroids for two consecutive days preceded a reduction of lymphocytes, recovery and maturation of monocytes, and gradually decreasing clinical signs, illustrating the potential value of glucocorticosteroids in treatment of clinical EEHV. Three subsequent subclinical episodes with high monocyte and platelet counts did not require intervention. Decision-making was led not just by quantification of viral load and clinical signs, but more specifically by interpretation of the hematological changes using easily accessible, in-house blood smear analysis.

Wood, J., et al. (2019). "Analyses of African elephant (*Loxodonta africana*) diet with various browse and pellet inclusion levels." *Zoo Biol*.

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.

Yon, L., et al. (2019). "Development of a behavioural welfare assessment tool for routine use with captive elephants." *PLoS ONE* **14**(2): e0210783.

There has been much concern in recent years about the welfare of elephants in zoos across North

America and Europe. While some previous studies have assessed captive elephant welfare at a particular point in time, there has been little work to develop methods which could be used for regular, routine welfare assessment. Such assessment is important in order to track changes in welfare over time. A welfare assessment tool should be rapid, reliable, and simple to complete, without requiring specialist training and facilities; welfare assessments based on behavioural observations are well suited to this purpose. This report describes the development of a new elephant behavioural welfare assessment tool designed for routine use by elephant keepers. Tool development involved: (i) identification of behavioural indicators of welfare from the literature and from focus groups with relevant stakeholders; (ii) development of a prototype tool; (iii) testing of the tool at five UK zoological institutions, involving 29 elephants (representing 46% of the total UK captive elephant population of 63 animals); (iv) assessment of feasibility and reliability of aspects of the prototype tool; (v) assessment of the validity of each element of the tool to reflect the relevant behaviour by comparing detailed behavioural observations with data from the prototype tool; (vi) assessment of known-groups criterion validity by comparing prototype tool scores in individuals with demographics associated with better or worse welfare; (vii) development of a finalised tool which incorporated all elements of the tool which met the criteria set for validity and reliability. Elements of the tool requiring further consideration are discussed, as are considerations for appropriate application and interpretation of scores. This novel behavioural welfare assessment tool can be used by elephant-holding facilities for routine behavioural welfare monitoring, which can inform adjustments to individual welfare plans for each elephant in their collection, to help facilities further assess and improve captive elephant welfare. This study provides an example of how an evidence-based behavioural welfare assessment tool for use by animal caretakers can be developed within the constraints of zoo-based research, which could be applied to a range of captive species.

Zhang, C., et al. (2019). "Metagenomic Analysis of the Fecal Microbiomes of Wild Asian Elephants Reveals Microflora and Enzymes that Mainly Digest Hemicellulose." *J Microbiol Biotechnol* **29**(8): 1255-1265.

To investigate the diversity of gastrointestinal microflora and lignocellulose-degrading enzymes in wild Asian elephants, three of these animals living in the same group were selected for study from the Wild Elephant Valley in the Xishuangbanna Nature Reserve of Yunnan Province, China. Fresh fecal samples from the three wild Asian elephants were analyzed by metagenomic sequencing to study the diversity of their gastrointestinal microbes and cellulolytic enzymes. There were a high abundance of Firmicutes and a higher abundance of hemicellulose-degrading hydrolases than cellulose-degrading hydrolases in the wild Asian elephants. Furthermore, there were a high abundance and a rich diversity of carbohydrate active enzymes (CAZymes) obtained from the gene set annotation of the three samples, with the majority of them showing low identity with the CAZy database entry. About half of the CAZymes had no species source at the phylum or genus level. These indicated that the wild Asian elephants might possess greater ability to digest hemicellulose than cellulose to provide energy, and moreover, the gastrointestinal tracts of these pachyderms might be a potential source of novel efficient lignocellulose-degrading enzymes. Therefore, the exploitation and utilization of these enzyme resources could help us to alleviate the current energy crisis and ensure food security.

Zhao, K., et al. (2019). "Loxodonta Localizer: A Software Tool for Inferring the Provenance of African Elephants and Their Ivory Using Mitochondrial DNA." *J Hered* **110**(7): 761-768.

Illegal hunting is a major threat to the elephants of Africa, with more elephants killed by poachers than die from natural causes. DNA from tusks has been used to infer the source populations for confiscated ivory, relying on nuclear genetic markers. However, mitochondrial DNA (mtDNA) sequences can also provide information on the geographic origins of elephants due to female elephant philopatry. Here, we introduce the Loxodonta Localizer (LL; www.loxodontalocalizer.org), an interactive software tool that uses a database of mtDNA sequences compiled from previously published studies to provide information on the potential provenance of confiscated ivory. A 316 bp control region sequence, which can be readily generated from DNA extracted from ivory, is used as a query. The software generates a listing of haplotypes reported among 1917 African elephants in 24 range countries, sorted in order of

similarity to the query sequence. The African locations from which haplotype sequences have been previously reported are shown on a map. We demonstrate examples of haplotypes reported from only a single locality or country, examine the utility of the program in identifying elephants from countries with varying degrees of sampling, and analyze batches of confiscated ivory. The LL allows for the source of confiscated ivory to be assessed within days, using widely available molecular methods that do not depend on a particular platform or laboratory. The program enables identification of potential regions or localities from which elephants are being poached, with capacity for rapid identification of populations newly or consistently targeted by poachers.

Zhao, K., et al. (2019). "Loxodonta Localizer: A Software Tool for Inferring the Provenance of African Elephants and Their Ivory Using Mitochondrial DNA." *J Hered* **110**(7): 761-768.

Illegal hunting is a major threat to the elephants of Africa, with more elephants killed by poachers than die from natural causes. DNA from tusks has been used to infer the source populations for confiscated ivory, relying on nuclear genetic markers. However, mitochondrial DNA (mtDNA) sequences can also provide information on the geographic origins of elephants due to female elephant philopatry. Here, we introduce the Loxodonta Localizer (LL; www.loxodontalocalizer.org), an interactive software tool that uses a database of mtDNA sequences compiled from previously published studies to provide information on the potential provenance of confiscated ivory. A 316 bp control region sequence, which can be readily generated from DNA extracted from ivory, is used as a query. The software generates a listing of haplotypes reported among 1917 African elephants in 24 range countries, sorted in order of similarity to the query sequence. The African locations from which haplotype sequences have been previously reported are shown on a map. We demonstrate examples of haplotypes reported from only a single locality or country, examine the utility of the program in identifying elephants from countries with varying degrees of sampling, and analyze batches of confiscated ivory. The LL allows for the source of confiscated ivory to be assessed within days, using widely available molecular methods that do not depend on a particular platform or laboratory. The program enables identification of potential regions or localities from which elephants are being poached, with capacity for rapid identification of populations newly or consistently targeted by poachers.