

Recent Publications on Asian Elephants

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If you need additional information on any of the articles, please feel free to contact me. You can also let me know about new (2020) publications on Asian elephants.

A. Abdullah, A. Sayuti, H. Hasanuddin, M. Affan & G. Wilson

People's perceptions of elephant conservation and the human-elephant conflict in Aceh Jaya, Sumatra, Indonesia

European J. of Wildlife Research 65 (2019) e69

Abstract. No permission to print the abstract.

T.P.J. Athapattu, B.R. Fernando, N. Koizumi & C.D. Gamage

Detection of pathogenic leptospires in the urine of domesticated elephants in Sri Lanka

Acta Tropica 195 (2019) 78-82

Abstract. 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. © 2019 Reprinted with permission from Elsevier .

K.A. Backues & E.B. Wiedner

Recommendations for the diagnosis, treatment and management of tuberculosis, *Mycobacterium tuberculosis*, in elephants in human care

International Zoo Yearbook 53 (2019) 116-127

Abstract. 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. © 2019 The Zoological Society of London.

U.S. Bechert, J.L. Brown, E.S. Dierenfeld, P.D. Ling, C.M. Molter & B.A. Schulte

Zoo elephant research: Contributions to conservation of captive and free-ranging species

International Zoo Yearbook 53 (2019) 89-115

Abstract. African elephants *Loxodonta africana* and Asian elephants *Elephas maximus* are not thriving in many captive settings and are threatened throughout their native ranges. Many zoos support in situ conservation projects and provide opportunities to conduct ex situ research in controlled settings with comparably approachable animals. Zoo elephant projects may facilitate fieldwork with free-ranging elephants (e.g. development of non-invasive sampling and analytical tools), which may then also improve the husbandry of elephants in human care. Free-ranging elephants also benefit from drug therapies and veterinary care when they are orphaned, kept as working elephants or brought in as rehabilitation cases – especially as human–elephant conflicts become more common as a result of ever-expanding human populations. Much has been learned about the basic biology and husbandry needs of elephants but, often, the more we learn, the more questions arise. There are physiological differences between African and Asian elephants, and this should affect the management of these animals. This paper will provide brief overviews of the current state of knowledge regarding the pharmacology, nutrition, reproduction, sensory biology and diseases (primarily elephant endotheliotropic

herpesvirus infections) relevant to elephants with recommendations for future research. © 2019 The Zoological Society of London.

S.N. Chapman, J. Jackson, W. Htut, V. Lummaa & M. Lahdenperä

Asian elephants exhibit post-reproductive lifespans

BMC Evolutionary Biology 19 (2019) e193

Abstract. 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. 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. 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. © 2019 The Authors.

D.E. Chusyd, J.L. Brown, L. Golzarri-Arroyo, S.L. Dickinson, M.S. Johnson, D.B. Allison & T.R. Nagy

Fat mass compared to four body condition scoring systems in the Asian elephant (*Elephas maximus*)

Zoo Biology 38 (2019) 424-433

Abstract. 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 (BCS_{Wemmer} [0 to 11 scoring], BCS_{Morfeld} [1 to 5 scoring], BCS_{Fernando} [0 to 10 scoring], BCS_{Wijeyamohan} [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. BCS_{Fernando} 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 BCS_{Wemmer} ($p=.027$, $R^2=0.389$), BCS_{Fernando} ($p=.002$, $R^2=0.502$), and BCS_{Wijeyamohan} ($p=.011$, $R^2=0.426$). Inclusion of zoo and familial relatedness resulted in all BCS systems associated with relative fat ($p\leq.015$). Only BCS_{Fernando} 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. © 2019 Wiley Periodicals, Inc.

Gregory M. Clines

Taming the tamed elephant: Ravana, aesthetics, and the generation of humor in Ravisena's Padmapurana

South Asian History and Culture 10 (2019) 309-323

Abstract. The seventh-century Digambara author Raviṣeṇa is an important figure in the history of pre-modern South Asian literature, having composed the earliest extant Jain Rāma narrative in Sanskrit, the Padmapurāṇa ('The Deeds of Padma'), a text that stands at the forefront of centuries of Jain engagement with the Rāma story. This article examines for the first time Raviṣeṇa's use of humor in constructing the

character of Rāvaṇa, arguing first – with reference to both Bharata's Nāṭyaśāstra and the works of Kālidāsa – that Raviṣeṇa establishes humor by subtly undercutting common Sanskrit literary tropes, and, second, that this humor serves three interrelated purposes vis-à-vis Rāvaṇa. First, the humor foreshadows Rāvaṇa's primary character flaws that will lead to his abduction of Sītā and eventual death at the hands of Lakṣmaṇa. Second, the humor works to humanize Rāvaṇa, making him a sympathetic character to the reader. Third, the humor establishes Rāvaṇa in opposition to the calm and serious Rāma, thereby positing that, according to Raviṣeṇa, true heroism consists of controlling one's passions. © 2019 Informa UK Limited.

J. Conte, Margret J. Potoczniak, C. Mower & S.S. Tobe

ELequant: A developmental framework and validation of forensic and conservation real-time PCR assays

Molecular Biology Reports 46 (2019) 2093-2100

Abstract. No permission to print the abstract.

S. Curtin & L. Brown

Travelling with a purpose: An ethnographic study of the eudemonic experiences of volunteer expedition participants

Tourist Studies 19 (2019) 192-214

Abstract. Purposeful travel is apparent in new modes of tourism and particularly in volunteer holidays where tourists are searching for meaningful experiences that provide a sense of physical, emotional or spiritual fulfilment. Based on a qualitative study using participant observation, this article adopted the concept of eudemonia to explore the experiences of participants on an elephant conservation expedition to Bardia National Park, Nepal. Volunteer travel is used to connect with and understand the wider world. Rather than an escape, these journeys allowed participants to experience first-hand the hardships and realities of people in other countries; creating greater perspective and making them 'better people' on their return. Feeling virtuous can only be mobilised, however, if participants felt themselves to be useful rather than a passive or ill-equipped bystander. Findings also revealed how the return home is not always

easy; that the process of re-entry can be isolating.
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J.C. Deb, S. Phinn, N. Butt & C.A. McAlpine
Adaptive management and planning for the conservation of four threatened large Asian mammals in a changing climate

Mitigation and Adaptation Strategies for Global Change 24 (2019) 259–280

Abstract. No permission to print the abstract.

J.A. de la Torre, A.M. Lechner, E.P. Wong, D. Magintan, S. Saaban & A. Campos-Arceiz

Using elephant movements to assess landscape connectivity under Peninsular Malaysia's central forest spine land use policy

Conservation Science and Practice 1 (2019) e133

Abstract. One of the most vital and urgent global conservation challenges is to deal with the loss and fragmentation of wildlife habitats, particularly for large-bodied and wide-ranging terrestrial megafauna. The Central Forest Spine Master Plan for Ecological Linkages (CFS) was developed by the Malaysian Federal Government in 2010 to protect biodiversity and ecosystem services by securing landscape connectivity between Peninsular Malaysia's main forest blocks. Here we present an evaluation of the effectiveness of the CFS master plan to promote functional connectivity for Asian elephants, one of its focal species. The specific objectives of our study were to identify the most critical forest patches to maintain connectivity for elephants in Peninsular Malaysia, assess functional connectivity within the CFS ecological linkages, and identify alternative corridors where appropriate to enhance CFS effectiveness. We used the largest animal movement dataset in Peninsular Malaysia (220,000 GPS locations from 53 elephants) to develop models of elephant movement probability and to estimate landscape resistance using step selection functions based on landscape characteristics. According to our evaluation of 28 linkages, 57% of them provided high functional connectivity, 28% provided acceptable connectivity, and 14% provided low to no connectivity. A very important and positive finding is that the CFS linkages with the highest centrality values (i.e., the most important to

maintain overall connectivity in Peninsular Malaysia) also score highly in functional connectivity (i.e., they are actually effective corridors for elephant movement). This means that an adequate CFS implementation can lead to high levels of functional connectivity among Peninsular Malaysia's main forest blocks. Based on our assessment, we recommend to conduct some revisions on the CFS plan to ensure its effectiveness. © 2019 The Authors.

B. Dhakal & B. Thapa

Residents' perceptions of human-elephant conflict: Case study in Bahundangi, Nepal

Environment, Development and Sustainability 21 (2019) 461–481

Abstract. No permission to print the abstract.

S. Dorji, R. Rajaratnam & K. Vernes

Mammal richness and diversity in a Himalayan hotspot: The role of protected areas in conserving Bhutan's mammals

Biodiversity and Conservation 28 (2019) 3277–3297

Abstract. No permission to print the abstract.

K.L. Edwards, M.A. Miller, K. Carlstead & J.L. Brown

Relationships between housing and management factors and clinical health events in elephants in North American zoos

PLoS ONE 14 (2019) e0217774

Abstract. 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.

H. Gautam, E. Arulmalar, M.R. Kulkarni & T.N.C. Vidya

NDVI is not reliable as a surrogate of forage abundance for a large herbivore in tropical forest habitat

BioTropica 51 (2019) 443-456

Abstract. Remotely sensed vegetation indices are increasingly being used in wildlife studies but field-based support for their utility as a measure of forage availability comes largely from open-canopy habitats. We assessed whether normalized difference vegetation index (NDVI) represents forage availability for Asian elephants in a southern Indian tropical forest. We found that the number of food species was a small percentage of all plant species. NDVI was not a good measure of food abundance in any vegetation category partly because of (a) small to moderate proportional abundances of food species relative to the total abundance of all species in that category (herbs and shrubs), (b) abundant

overstory vegetation resulting in low correlations between NDVI and food abundance, despite a high proportional abundance of food species and a concordance between total abundance and food species abundance (graminoids), and (c) the relevant variables measured and important as food at the ground level (count and GBH) not being related to primary productivity (trees and recruits). NDVI had a negative relationship with the total abundance of graminoids, which represent a bulk of elephant and other herbivore diet, because of negative interaction with other vegetation and canopy cover that positively explained NDVI. Spatially interpolated total graminoid abundance modeled from field data outperformed NDVI in predicting total graminoid abundance, although interpolation models of food graminoid abundance were not satisfactory. Our results reject the utility of NDVI in mapping elephant forage abundance in tropical forests, a finding that has implications for studies of other herbivores also. © 2019 The Association for Tropical Biology and Conservation.

C. Good, P. Tyrrell, Z. Zhou & D.W. Macdonald
Elephants never forget, should art museums remember too? Historic ivory collections as ambassadors for conservation education

Biodiversity and Conservation 28 (2019) 1331-1342

Abstract. Ivory in art museum collections has been a contentious topic during recent years, with some parties calling for its destruction. But analysis of media reactions to the parallel strategy of burning modern ivory stockpiles may offer insight to the likely effectiveness of that course of action in museums: such burns have seemingly fallen short in sending a clear and enduring message to the intended demographics—be this consumers, dealers, poachers or traffickers. This prompts us to suggest an alternative to the destruction of museum ivory: that art museums with ivory collections take on the challenge and responsibility of imparting powerful conservation messages. This article explores the potential of ivory artworks as educational ambassadors, as well as the international reach of museums to target demographics in key ivory consumer regions such as South East Asia, and the ethical obligations of museums with ivory collections to

participate in conservation education. In placing a useful lens on these currently controversial artworks, museum ivory would be endowed with a new critical relevance as educational ambassadors for contemporary conservation issues, simultaneously offering justification for the preservation and display of these historic artworks that many museums are presently reluctant to exhibit. In highlighting the potential of museum ivory as a vehicle for conservation education we highlight the need for heightened holistic collaboration across disciplines to ensure that conservation messages reach diverse audiences in novel and impactful ways. © 2019 The Authors.

E.M. Gross, B.P. Lahkar, N. Subedi, V.R. Nyirenda, L.L. Lichtenfeld & O. Jakoby

Does traditional and advanced guarding reduce crop losses due to wildlife? A comparative analysis from Africa and Asia

Journal for Nature Conservation 50 (2019) e125712

Abstract. Crop damage caused by herbivorous wildlife species on farms located within conservation landscapes, is a driver of human-wildlife conflict (HWC). Guarding of farms, whereby farmers spend the night out in the fields, in areas adjacent to protected areas is, therefore, very common in many African and Asian countries. Furthermore, guarding is often combined with other crop protection measures, but little is known about the efficacy of these measures. We examined the effect that different traditional and advanced crop protection measures (active and passive guarding strategies, barriers and combinations of measures) had on the magnitude of damaged crops. For this, we examined the cost of crop damage caused by a total of 20 wildlife species in two African and two Asian study areas, where different protection types were applied. Data was compared with the cost of crop damage on unprotected fields. We continuously used a standardised HWC assessment scheme over six years (2009–2014), based on site observations and measurements in addition to interviews with victims. The analysis of crop damage costs revealed substantial losses, especially from that caused by elephants (*Loxodonta africana* and *Elephas maximus*) and

other large herbivores, such as zebra (*Equus quagga*) and common eland (*Taurotragus oryx*). Once wildlife had entered the farms, it was found that crop protection measures by farmers were only able to reduce damage costs when applied as a communal, strategic guarding system. Surprisingly, all other traditional crop protection strategies have proven ineffective in reducing crop damage costs. Electrical fences actually increased the risk of crop damage when combined with guarding and the chasing of wildlife strategies. Therefore, we recommend reviewing the practice of traditional guarding strategies and the effectiveness of fences. Furthermore, we emphasise the need for objective evaluation of HWC mitigation strategies in the long-term. © 2019 Reprinted with permission from Elsevier.

M. Hartley, A. Wood & L. Yon

Facilitating the social behaviour of bull elephants in zoos

International Zoo Yearbook 53 (2019) 62-77

Abstract. In the wild, bull elephants socialize with conspecifics of all ages and both sexes, and young bulls develop social bonds with other elephants which will be sustained throughout their lives. Significant progress has been made towards providing an environment that facilitates social behaviour and multi-generational family structure for female elephants in zoos. However, it is more complex and challenging to build facilities and manage groups of elephants in ways that allow fission–fusion herd dynamics and give the elephants choice over their environment. For bulls, this is further complicated by their potential strength and aggressive behaviour. To advance the development of best-practice management for zoo elephants and achieve high standards of welfare, it is necessary to improve our understanding of the social and behavioural needs of bull elephants, and implement radical and innovative solutions to their care. In this paper we (1) consider how the social behaviour of bull elephants is addressed in zoos, comparing their social management with their behaviour in the wild, (2) contribute novel preliminary data about how these issues are addressed, and (3) propose some new approaches to the management of bull elephants in zoos for the future. © 2019 The Zoological Society of London.

N. Irie & M. Hiraiwa-Hasegawa

Unique numerical competence of Asian elephants on the relative numerosity judgment task

Journal of Ethology 37 (2019) 111-115

Abstract. Many animals demonstrate numerical competence even without language. However, their representation is mainly based on inaccurate quantity instead of absolute numbers. Thus, their performance on numerical tasks is affected by the distance, magnitude, and the ratio of comparisons (i.e., as distance decreases, magnitudes increase, or as ratios increase the accuracy of discrimination decreases). We report that Asian elephants' numerical representation is quite different from that of other animals. We trained three Asian elephants to use a touch-panel apparatus and one female successfully learned to use the apparatus. Next, a relative numerosity judgment task was presented on the screen and the elephant was asked to touch, with the tip of her trunk, the figures with the larger numbers of items. The numbers of items in each figure ranged from 0 to 10. We found that her performance was unaffected by distance, magnitude, or the ratios of the presented numerosities but, consistent with observations of human counting, she required a longer time to respond to comparisons with smaller distances. This study provides the first experimental evidence that nonhuman animals have cognitive characteristics partially identical to human counting. © 2019 The Authors.

Ritesh Joshi & Kanchan Puri

Train-elephant collisions in a biodiversity-rich landscape: A case study from Rajaji National Park, North India

Human-Wildlife Interactions 13 (2019) 370-381

Abstract. Linear developments like railways and highways have a negative impact on ecological processes of wildlife species at a landscape level. The impacts in terms of wildlife mortality and threat to surviving populations of species have been well-studied; however, less work has been done to understand the potential causes of train-wildlife collisions, particularly large mega-fauna such as Asian elephants (*Elephas maximus*; elephant). In this case study, we review train-elephant collisions (TECs) that occurred in Rajaji National Park (RNP) and discuss some potential

causes of TECs along with mitigation measures. The RNP, located in the upper Gangetic plains of northern India, has been an elephant conservation stronghold. However, 25 elephants have been killed from 1987–2018 in TECs along 18 km of the Haridwar-Dehradun railway track, which connects the RNP with the Corbett Tiger Reserve. Most of the collisions occurred during night and in summer months. Preliminary observations suggest that the social bonds among the groups of elephants and their relatively large home ranges, coupled with the speed of the trains and sharp turning radius, appear to be related to the collisions. Based on this information, mitigation measures should include reducing the speed of the train in high-risk areas and periods as well as habitat modifications such as developing recharging natural water sources. These measures could be coordinated with railway managers and wildlife officials. Scientific studies and related outreach programs that increase awareness among local communities and railway managers about the causes, impacts, and measures could also be organized to minimize negative human-elephant interactions. © 2019 Reprinted with permission from Human-Wildlife Interactions.

U.K. Kalirathinam, S. Elangkovan, J. Kawi & F. Cabana

Sleep monitoring of an Asian elephant *Elephas maximus* calf at Night Safari, Singapore: Testing whether sleep time is a significant predictor of cortisol or the onset of positive elephant endotheliotropic herpesvirus viraemia

International Zoo Yearbook 53 (2019) 128-137

Abstract. A number of methods for measuring the welfare of elephants in human care have been used within zoological associations and rescue centres worldwide. The measurement of glucocorticoids in relation to stress has been particularly well validated. Measuring stress is especially important for Asian elephant *Elephas maximus* calves between one and 8 years of age which are highly susceptible to developing elephant endotheliotropic herpesvirus (EEHV) haemorrhagic disease. Sleep monitoring has been used as a possible means of assessing the welfare state of animals, although the efficacy of this method has not been validated. Our aim was to test whether sleep time or cortisol provided

the most significant predictor for the onset of positive EEHV blood viraemia in a 2 year-old calf at Night Safari, Singapore. Faecal samples were collected twice per week and assayed for glucocorticoids. Using closed-circuit television, the time the calf slept each night was measured between December 2017 and September 2018. Sleep was not a predictor of viraemia nor of cortisol concentration in this study. However, cortisol appeared to be related to the occurrence of viraemia. © 2019 The Zoological Society of London.

O. Ketchaisri, C. Siripunkaw & J.M. Plotnik
The use of a human's location and social cues by Asian elephants in an object-choice task

Animal Cognition 22 (2019) 907-915

Abstract. No permission to print the abstract.

R.K. Koirala, W. Ji, P. Paudel, S.C.P. Coogan, J.M. Rothman & D. Raubenheimer

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 (2019)

Abstract. 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. © 2019 The Authors.

M. Lahdenperä, J. Jackson, W. Htut & V. Lummaa

Capture from the wild has long-term costs on reproductive success in Asian elephants

Proc. R. Soc. B 286 (2019) e20191584

Abstract. 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. © 2019 The Authors.

H. Lauridsen, S. Gonzales, D. Hedwig, K.L. Perrin, C.J.A. Williams, P.H. Wrege, M.F. Bertelsen, M. Pedersen & J.T. Butcher

Extracting physiological information in experimental biology via Eulerian video magnification

BMC Biology 17 (2019) e103

Abstract. Videographic material of animals can contain inapparent signals, such as color changes or motion that hold information about physiological functions, such as heart and respiration rate, pulse wave velocity, and vocalization. Eulerian video magnification allows the enhancement of such signals to enable their detection. The purpose of this study is to demonstrate how

signals relevant to experimental physiology can be extracted from non-contact videographic material of animals. We applied Eulerian video magnification to detect physiological signals in a range of experimental models and in captive and free ranging wildlife. Neotenic Mexican axolotls were studied to demonstrate the extraction of heart rate signal of non-embryonic animals from dedicated videographic material. Heart rate could be acquired both in single and multiple animal setups of leucistic and normally colored animals under different physiological conditions (resting, exercised, or anesthetized) using a wide range of video qualities. Pulse wave velocity could also be measured in the low blood pressure system of the axolotl as well as in the high-pressure system of the human being. Heart rate extraction was also possible from videos of conscious, unconstrained zebrafish and from non-dedicated videographic material of sand lizard and giraffe. This technique also allowed for heart rate detection in embryonic chickens in ovo through the eggshell and in embryonic mice in utero and could be used as a gating signal to acquire two-phase volumetric micro-CT data of the beating embryonic chicken heart. Additionally, Eulerian video magnification was used to demonstrate how vocalization-induced vibrations can be detected in infrasound-producing Asian elephants. Eulerian video magnification provides a technique to extract inapparent temporal signals from videographic material of animals. This can be applied in experimental and comparative physiology where contact-based recordings (e.g., heart rate) cannot be acquired. © 2019 The Authors.

I. Lueders, A.-K. Oerke, T. Knauf-Witzens, D. Young & H.J. Bertschinger

Use of gonadotropin releasing hormone (GnRH) vaccines for behavioural and reproductive control in managed Asian elephant *Elephas maximus* and African elephant *Loxodonta africana* populations

International Zoo Yearbook 53 (2019) 138-150

Abstract. Object recognition is a challenging task in image processing and computer vision. In this paper, segmentation, feature extraction and classification methods are done for elephant recognition. Thresholding based segmentation technique is used for image segmentation and

k-NN classifier is used for object recognition based on the shape features of the segmented image. Infrared elephant images are considered for experimentation. The database created by us for this type of object recognition includes elephant, bear, horse, pig, tiger, and cow and lion images. The recognition rate is calculated for performance evaluation. However, implementing such algorithms on software consumes more time as image sizes and bit depths grow larger. Hence this paper aims at hardware implementation of elephant recognition to reduce the computational time. The proposed hardware is prototyped in Virtex-4 xc4vlx25 FPGA using Xilinx System Generator (XSG) tool. The hardware/software co-simulation feature allows the input and output to be displayed on Matlab window while the processing is done through FPGA. The results indicate that when the category is elephant and if the recognition status is “yes”, recognition rate is 100%. If the category is not an elephant and if the recognition status is “no”, recognition rate is still 100% also indicates, the approach is successful in elephant recognition and the computation of segmentation algorithm and shape feature extraction (area, centroid, equidiameter) in hardware reduces the computational time of elephant recognition by 89.65% as compared to software computation. © 2019 The Zoological Society of London.

C. Meehan, B. Greco, B. Lynn, K. Morfeld, G. Vicino, D. Orban, C. Gorsuch, M. Quick, L. Ripple, K. Fournier & D. Moore

The Elephant Welfare Initiative: A model for advancing evidence-based zoo animal welfare monitoring, assessment and enhancement

International Zoo Yearbook 53 (2019) 45-61



Abstract. The Elephant Welfare Initiative (EWI) is an effort supported by a community of member zoos with the common goal of advancing evidence-based elephant-care practices that enhance welfare. The idea for the EWI came about following the completion of a large-scale North American elephant welfare study, which demonstrated that daily practices, such as social management, enrichment and exercise, play a critical role in improving the welfare of elephants in zoos. In 2014, the Elephant Taxon Advisory Group of the Association of Zoos and Aquariums expressed an interest in building upon the results of this study to support the continued assessment of elephant programmes and implementation of enhanced management practices. The EWI is supported by a web-based system of software tools and resources. In contrast to traditional record-keeping systems, the EWI tools provide participants with real-time analysis as well as zoo- and elephant-level metrics for key welfare indicators and associated management practices. Members' data are pooled to create opportunities for benchmarking, and to leverage the collective efforts of individual organizations to address elephant welfare challenges and generate the data necessary to identify evidence-based strategies for enhanced outcomes. Future considerations include extending the EWI model to other species in managed settings, and to support transitional programmes for in situ elephant reintroduction efforts. © 2019 The Zoological Society of London.

V. Menon & S.K. Tiwari

Population status of Asian elephants *Elephas maximus* and key threats

International Zoo Yearbook 53 (2019) 17-30

Abstract. 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.

T. Mukherjee, L.K. Sharma, M. Thakur, G.K. Saha & K. Chandra

Changing landscape configuration demands ecological planning: Retrospect and prospect for megaherbivores of North Bengal

PLoS ONE 14 (2019) e0225398

Abstract. 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. © 2019 The Authors.

J.N. Ngatia, T.M. Lan, Y. Ma, T.D. Dinh, Z. Wang, T.D. Dahmer & Y.C. Xu

Distinguishing extant elephants ivory from mammoth ivory using a short sequence of cytochrome b gene

Scientific Reports 9 (2019) e18863

Abstract. 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 116 bp 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. © 2019 The Authors.

T. Norkaew, J.L. Brown, P. Bansiddhi, C. Somgird, C. Thitaram, V. Punyapornwithaya, K. Punturee, P. Vongchan, N. Somboon & J. Khonmee

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 (2019) e0210537

Abstract. 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.

L. Ong, K. McConkey, A. Solana-Mena & A. Campos-Arceiz

Elephant frugivory and wild boar seed predation of *Irvingia malayana*, a large-fruited tree, in a rainforest of Peninsular Malaysia

Raffles Bulletin of Zoology 67 (2019) 160-170

Abstract. *Irvingia malayana* is a large-fruited and large-seeded tree species of Southeast Asia. As a large-fruited tree, it interacts with large mammal consumers, which either disperse or consume its seeds. In this preliminary study, we describe functional differences between Asian elephants (*Elephas maximus*) and wild boars (*Sus scrofa*) in their interactions with the fruits of *I. malayana* in a rainforest in northern Peninsular Malaysia. We baited one camera trap under each of five fruiting *I. malayana* trees for a total of 86 camera trap nights and recorded a total of 145 independent visits from 12 vertebrate species. We recorded only two (1.4% of 145) visits by elephants, but they were the only animals to swallow *I. malayana* seeds (1.9% of 312 focal seeds). Wild boars were frequently recorded (29.7% of the animal visits), and they often acted as seed predators (consuming 24.4% of the 312 focal seeds). Besides these functional differences, an interesting temporal resource differentiation between the two species was also observed. Elephants consumed fresh fruits of one or two days old, while wild boars consumed fruits older than five days, probably when seeds could be accessed more efficiently. No animal species other than elephants was recorded to swallow the fruits of *I. malayana*, suggesting that elephants may be important dispersal vectors for this tree species in the tropical rainforest of Malaysia. © National University of Singapore.

Meera Anna Oommen

The elephant in the room: Histories of place, memory and conflict with wildlife along a southern Indian forest fringe

Environment and History 25 (2019) 269-300

Abstract. This paper traces past and present entanglements between people and elephants along a forest-agriculture fringe in Kerala's Western Ghats. In doing so, it explores the evolution of conservation-linked conflict and its problematic impacts. Over the centuries, the region's elephants have played a dominant role in its mountain landscapes: as antagonists to cultivators; as sources of ivory, labour and revenue to forest traders, local rulers and imperial administrators; and as cultural and religious icons straddling forests and countryside. Environmental protection arrangements in recent years ushered in a new elephant, a charismatic flagship beloved of conservationists, but also a key actor involved in fluctuating tensions along the forest edge. In this study, I explore long-term engagements between people and elephants by interrogating three critical phases in history, each incorporating a changing identity for the place in question: as a bountiful, ivory-rich forest at the turn of the Christian Era; as a site of capitalist production during the colonial period; and eventually as a contested conservation landscape. I show that these identities are predicated as much by extra-local processes such as migration and capitalist enterprises, as by embedded engagements with non-human agency. Contemporary conflict is, therefore, a complex ongoing narrative fuelled by a dynamic interaction between the persistence of human and animal memories as well as by multi-scale socio-political catalysts with long histories of influence. By ignoring historical contingencies and diverse discourses, contemporary conservation interventions may overlook the proverbial and sometimes literal elephant in the room. © 2019 The White Horse Press.

N. Othman, B. Goossens, C.P.I. Cheah, S. Nathan, R. Bumpus & M. Ancrenaz

Shift of paradigm needed towards improving human-elephant coexistence in monoculture landscapes in Sabah

International Zoo Yearbook 53 (2019) 161-173

Abstract. 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. © 2019 The Zoological Society of London.

M.A. Pardo, J.H. Poole, A.S. Stoeger, P.H. Wrege, C.E. O'Connell-Rodwell, U.K. Padmalal & S. de Silva

Differences in combinatorial calls among the 3 elephant species cannot be explained by phylogeny

Behavioral Ecology 30 (2019) 809-820

Abstract. Understanding why related species combine calls in different ways could provide insight into the selection pressures on the evolution of combinatorial communication. African savannah elephants (*Loxodonta africana*), African forest elephants (*Loxodonta cyclotis*), and Asian elephants (*Elephas maximus*) all combine broadband calls (roars, barks, and cries) and low-frequency calls (rumbles) into single utterances known as “combination calls.” We investigated whether the structure of such calls differs among species and whether any differences are better explained by phylogenetic

relationships or by socioecological factors. Here, we demonstrate for the first time that the species differ significantly in the frequency with which they produce different call combinations using data from multiple study sites. *Elephas maximus* and *L. africana* mostly produced roar-rumble combinations, whereas *L. cyclotis* produced a more even distribution of roar-rumble, rumble-roar, and rumble-roar-rumble combinations. There were also significant differences in favored structure among populations of the same species. Moreover, certain call orders were disproportionately likely to be given in particular behavioral contexts. In *L. africana*, rumble-roar-rumble combinations were significantly more likely than expected by chance to be produced by individuals separated from the group. In *E. maximus*, there was a nonsignificant trend for rumble-roar-rumbles to be given more often in response to a disturbance. Site-specific socioecological conditions appear more influential for call combination structure than phylogenetic history. © 2019 The Authors.

R. Patnaik, N. PremjitSingh, D. Paul & R. Sukumar

Dietary and habitat shifts in relation to climate of Neogene-Quaternary proboscideans and associated mammals of the Indian subcontinent

Quaternary Science Reviews 224 (2019) e105968

Abstract. Several studies have established that African proboscideans shifted their feeding strategies (browsing vs. grazing) in response to climatic and ecological changes. However, similar studies on their Indian relatives are rare. In this regard, we analysed the stable carbon ($\delta^{13}\text{C}$) and oxygen ($\delta^{18}\text{O}$) isotope composition, hypsodonty indices (HI), and lamellae numbers of both newly recovered and existing fossil material (proboscideans and associated mammals) spanning the last ~14 Ma. We also obtained intra-tooth $\delta^{13}\text{C}$ and $\delta^{18}\text{O}$ values of selected extant and extinct proboscideans as well as associated mammals to understand any intra- and inter-annual variation in dietary and water intake behaviour, respectively. Our results reveal that Middle Miocene brachyodont deinotheres (ex. *Deinotherium indicum*) and bunodont gomphotheres (ex. *Gomphotherium*) with few

cuspid pairs were browsers living in relatively closed forests under moist conditions. By Late Miocene they continued browsing in relatively open forests. Deinotheres in the subcontinent did not survive the Late Miocene climate change that led to drier conditions and the spread of grasslands. The Late Miocene endemic forms *Stegolophodon* and *Stegodon* were browsers while the immigrant *Choerolophodon* was a mixed feeder. However, Pliocene gomphotheres such as bunodont *Anancus* and brachyodont *Stegodon* adapted themselves to shrinking forests and spreading grasslands; the former sustained on grazing, whereas the latter showed flexibility in its diet ranging from browsing, mixed-feeding to pure grazing. Associated mammals such as rhinocerotids, giraffids, equids, and bovids responded in a similar manner to this climatic and ecological transition across the Late Miocene to Pliocene by shifting their diets accordingly. The Mid-Pliocene hypsodont elephantid immigrant *Elephas planifrons*, the Early Pleistocene hypsodont immigrant *E. hysudricus*, and *Elephas platycephalus*, with multiple lamellae (10–16) were also essentially grazers. Sometime around Middle Pleistocene, the giant elephantid immigrant *Palaeoloxodon namadicus*, a pure grazer, appeared on the grasslands of the subcontinent, coinciding with a shift in *E. hysudricus* diet from pure grazing to browsing. *E. hysudricus* likely gave rise to the extant *E. maximus*, a mixed feeder with higher contribution of browse to its diet. © 2019 Reprinted with permission from Elsevier.

S. Paudel, S.K. Mikota & T. Tsubota
Tuberculosis threat in Asian elephants
Science 363 (2019) 356
Abstract. none.

S. Paudel, C. Nakajima, S.K. Mikota, K.P. Gairhe, B. Maharjan, S. Subedi, A. Poudel, M. Sashika, M. Shimozuru, Y. Suzuki & T. Tsubota
Mixed *Mycobacterium tuberculosis* lineage infection in 2 elephants, Nepal
Emerging Infectious Diseases 25 (2019) 1031-1032
Abstract. 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.

S.G. Platt, D.P. Bickford, M.M. Win & T.R. Rainwater
Water-filled Asian elephant tracks serve as breeding sites for anurans in Myanmar
Mammalia 83 (2019) 287-289

Abstract. Elephants are widely recognized as ecosystem engineers. To date, most research on ecosystem engineering by elephants has focused on *Loxodonta africana* and *Loxodonta cyclotis*, and the role of *Elephas maximus* is much less well-known. We here report observations of anuran eggs and larva in water-filled tracks (n=20) of *E. maximus* in Myanmar. Our observations suggest that water-filled tracks persist for >1 year and function as small lentic waterbodies that provide temporary, predator-free breeding habitat for anurans during the dry season when alternate sites are unavailable. Trackways could also function as “stepping stones” that connect anuran populations. © 2019 Walter de Gruyter GmbH.

S.S. Pokharel, B. Singh, P.B. Seshagiri & R. Sukumar
Lower levels of glucocorticoids in crop-raiders: Diet quality as a potential ‘pacifier’ against stress in free-ranging Asian elephants in a human-production habitat

Animal Conservation 22 (2019) 177-188
Abstract. Overlapping habitats and sharing of resources between elephants and people has led to intense elephant-human conflicts, especially crop depredation by elephants, across elephant-range countries. While raiding agricultural crops, elephants face numerous threats from people through chase, injury and the risk of death which could enhance the associated energetic costs, ultimately elevating their stress levels. We hypothesized that crop-raiders (in the human-production habitat) would show higher faecal glucocorticoid metabolite (fGCM) levels, a proxy of stress-response, as compared to nonraiders (in protected forests). To study this,

208 faecal samples were collected from crop-raiding elephants in a human-production habitat and 394 samples from nonraiding elephants in protected forests during 2013 and 2015. Contrary to our expectation, fGCM levels were significantly higher in nonraiding than in crop-raiding elephants of both sexes. As one of the possible factors for lower fGCM in elephants inhabiting the human-production habitat, the influence of benefits obtained from foraging here was assessed. For this, the difference in vegetation greenness (standing biomass) between the human-production habitat and the protected forests was analysed from remotely-sensed Normalized Differential Vegetation Index (NDVI), and further confirmed by measuring dietary quality (faecal nitrogen (N) content and C:N ratio as proxies for crude protein). Interestingly, higher NDVI values (greater biomass availability), higher N content and lower faecal C:N ratio (indicating higher protein content in the diet) of elephants in the human-production habitat suggested enhanced nutritional levels here as compared to protected forests. Further, there were significant correlations between faecal C:N ratio (positive) or N content (negative) and fGCM levels. These findings suggest that crop-raiding comes with the benefits of a superior quality diet which may help in reducing human-induced stress-response in elephants inhabiting or foraging within human-production habitats. © 2018 The Zoological Society of London.

S. Pokharel, P. Seshagiri & R. Sukumar

Influence of the number of calves and lactating-adult females in a herd on the adrenocortical activity of free-ranging Asian elephants

Wildlife Research 46 (2019) 679-689

Abstract. Context. Physiological stress has the potential to influence animal population persistence. The endangered Asian elephant (*Elephas maximus*) is involved in intense conflict with humans in many parts of its range, which is likely to lead to stress for individuals and groups, and population-level impacts. Thus, it is important to understand how stress levels in them are influenced by socio-ecological factors when they are not directly exposed to human-induced threats and to use this understanding to improve

conservation and management strategies. Aims. The study was designed to provide baseline information on the link between socio-ecological factors and stress levels of undisturbed populations of elephants. The main aim of this study was to determine the influence of herd size, season, the number of calves and adult females present in a herd, their lactational status and body condition on the adrenocortical activity of free-ranging adult female Asian elephants living in protected forests without any direct exposure to human-induced threats, by measuring their faecal glucocorticoid metabolite (fGCM) levels. Methods. A total of 145 fresh faecal samples were collected from 123 identified adult female elephants inhabiting Bandipur and Nagarhole National Parks of southern India, between the years 2013 and 2015. We measured fGCM levels by employing a group-specific standardized 11-oxoetiocholanolone enzyme immunoassay (EIA). A Generalized Linear Mixed-effects Model (GLMM) was used to assess the influence of socio-ecological factors on fGCM levels of adult female elephants. Key results. When fGCM levels were analyzed with a GLMM, the following patterns were observed: fGCM levels were negatively correlated to the number of adult females (herd size) and positively correlated to the number of calves in a herd and active lactational status of an adult female. fGCM levels of adult female elephants were higher during the dry season and negatively correlated with body condition scores. Conclusions. The adrenocortical activity of female elephants is significantly influenced by the number of calves and adult females present in their herd, seasonality and their lactational status. Implications. It is important to consider the influence of multiple ecological and social correlates while assessing and interpreting the adrenocortical activity of Asian elephants. Our findings highlight the importance of maintaining the social structure of elephants in the wild to avoid detrimental effects on their physiological health. Insights from such assessments could be used to compare the stress in elephants which are involved in direct conflicts with humans to take appropriate management decisions for mitigating conflicts. © 2019 CSIRO.

E.E. Poor, E. Frimpong, M.A. Imron & M.J. Kelly

Protected area effectiveness in a sea of palm oil: A Sumatran case study

Biological Conservation 234 (2019) 123-130

Abstract. Despite the establishment of a national protected area system at the beginning of the 20th century to protect some of the world's most biodiverse forests, Indonesia has one of the highest deforestation rates in the world, due in part to the expansion of the global palm oil industry. The unique ecosystems of Sumatra, Indonesia provide habitat for critically endangered Sumatran tigers (*Panthera tigris sumatrae*), Sumatran elephants (*Elephas maximus sumatrensis*), and two species of orangutans (*Pongo abelii* and *Pongo tapanuliensis*). In this study, we use a matching method with generalized boosted models to determine the effectiveness of three nationally protected areas in preventing deforestation from 2002 to 2016. We also examine leakage – an increase in deforestation directly outside of protected areas relative to the wider landscape – to provide a clearer picture of the effects of agricultural expansion in this landscape. We found that Tesso Nilo National Park, with its lowland rain forest and conditions suitable for oil palm, offered the least protection from deforestation (avoided deforestation rate = 4.18%, $p < 0.05$ 95% CI [1.97% - 6.45%]). Bukit Tigapuluh National Park, which may experience some de facto protection (i.e. protection due to factors independent of policy) with its mountainous terrain and difficult access, had the highest avoided deforestation rate (26.36%, $p < 0.05$ 95% CI [24.17–28.55]), but had relatively high leakage (10.21%, $p < 0.05$ 95% CI [7.51–12.98]). The low avoided deforestation rate in Tesso Nilo could be due to high localized human population and/or other socio-economic factors we were unable to control for in this study. The quantitative evidence of deforestation and effectiveness of protected areas in this heavily modified landscape supports the need for increased enforcement around protected areas locally, and globally in other oil palm production regions. These actions are critical in the preservation of global, tropical endemic flora and fauna. © 2019 Reprinted with permission from Elsevier.

E.E. Poor, V.I.M. Jati, M.A. Imron & M.J. Kelly
The road to deforestation: Edge effects in an endemic ecosystem in Sumatra, Indonesia

PLoS ONE 14 (2019) e0217540

Abstract. 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. © 2019 The Authors.

R.P.V.J. Rajapakse, S.P. Lawton, K.J.K. Karunathilake, B.V.P. Perera, N.T.B. Nguyen & T.H. Le

Molecular characterization of *Fasciola jacksoni* from wild elephants (*Elephas maximus maximus*) of Sri Lanka: A taxonomic evaluation

Parasitology 146 (2019) 1247-1255

Abstract. *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. © 2019 Cambridge University Press.

L.E. Rosen, F. Olea-Poppelka, S.L. Deem, R. Isaza, D. Schmitt & M. Miller

Survey of antituberculosis drug administration and adverse effects in elephants in North America

Journal of Zoo and Wildlife Medicine 50 (2019) 23-32

Abstract. 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. © 2019 American Association of Zoo Veterinarians.

F. Sach, M. Fitzpatrick, N. Masters & D. Field
Financial planning required to keep elephants in zoos in the United Kingdom in accordance with the Secretary of State's Standards of Modern Zoo Practice for the next 30 years
International Zoo Yearbook 53 (2019) 78-88

Abstract. In June 2017, the Secretary of State's Standards of Modern Zoo Practice (SSSMZP) were updated with an appendix relating specifically to elephants (Appendix 8.8: Elephants). This update was published to bring elephant management standards in line with recognized advancing best practice. All zoos in the UK holding elephants are inspected against the new appendix, in accordance with the Zoo Licensing Act 1981, by dedicated Department for Environment, Food and Rural Affairs (Defra)-appointed inspectors. Achieving the standards set out within the new appendix will require financial investment and careful planning from all the zoos holding elephants within the UK. At the time of writing, the annual cost of keeping a breeding group of elephants at ZSL Whipsnade Zoo, UK, was calculated from data collected over the last 10 years and the financial investment required to achieve SSSMZP compliance was estimated. The commercial benefit that elephants bring to ZSL Whipsnade Zoo was also quantified using feedback from visitor surveys. The cost of keeping a breeding herd of elephants at ZSL Whipsnade Zoo was estimated at £593 021–£641 863 per year, excluding indirect staffing costs, ground rent and contributions made by the Zoological Society of London (ZSL) to field-conservation projects. Costs for achieving SSSMZP compliance will be considerably greater with substantial capital investment required. The commercial benefit was found to be extensive; with predicted significant increased visitor dwell time and secondary spend in the presence of elephants. Using ZSL Whipsnade Zoo as an example, this paper aims to consider holistically the financial costs when planning and implementing an optimum, welfare-centred, sustainable future for elephants in zoos. © 2019 The Zoological Society of London.

C. Schiffmann, J.-M. Hatt, S. Hoby, D. Codron & M. Clauss

Elephant body mass cyclicality suggests effect of molar progression on chewing efficiency

Mammalian Biology 96 (2019) 81-86

Abstract. 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.

H. Schmidt & J. Kappelhof

Review of the management of the Asian elephant *Elephas maximus* EEP: Current challenges and future solutions

International Zoo Yearbook 53 (2019) 31-44

Abstract. This article reviews the current situation in the Asian Elephant *Elephas maximus* European Association of Zoos and Aquaria Ex situ Programme (EEP). In recent years, developments in husbandry and gained knowledge about the reproductive biology of Asian elephants have contributed to increased breeding success and resulted in a mean of 15 births per year in the last 5 years. At the time of writing, the Asian elephant EEP population contains 307 individuals: 90.217 (♂♂.♀♀). Based on the life table for 1998–2018, most demographic parameters show healthy numbers [e.g. lambda (λ) = 1.025], while the population has retained 98.44% of the gene diversity. However,

this EEP is also facing multiple challenges, such as the presence of subspecies, transport barriers between some EEP participants and the societal debate about the purpose of zoos. The growing number of male elephants in the EEP population appears to be the most immediate challenge. In the short term, the authors suggest that females could be managed to conceive for the first time at 8 years of age and adhere to an interbirth interval of 7 years. This would be an attempt to decrease the reproductive rate without compromising the future reproductive potential of the population. The authors also prescribe improving facilities for elephants to allow zoos to utilize a fission–fusion housing strategy, making it possible to house the increasing number of males appropriately over the longer term. © 2019 The Authors.

P. Sharma, H. Adhikari, S. Tripathi, A.K. Ram & R. Bhattarai

Habitat suitability modeling of Asian elephant *Elephas maximus* (Mammalia: Proboscidea: Elephantidae) in Parsa National Park, Nepal and its buffer zone

Journal of Threatened Taxa 11 (2019) 14643-14654

Abstract. Asian wild elephant (*Elephas maximus*) represents one of the endangered species of large mammals in the world. The study area (Parsa National Park (PNP) and its buffer zone (BZ)) has been used as corridor and habitat by elephant. The study aims 1) to assess the suitable habitat of elephant in PNP and BZ and 2) to determine which explanatory variables better explain elephant presence in PNP. Field measurements were carried out in 67 plots for vegetation analysis. Boosted Regression Tree (BRT) was used for examining the relationship of habitat suitability of elephant and explanatory variables for example, topographic (slope, aspect, altitude), climatic (precipitation, temperature), and biotic and abiotic factors (habitat preference, ground cover, crown cover). According to the results, the habitat suitability of elephant is mainly explained by dominant species (29.6%), followed by temperature (17.1%), altitude (15.5%), habitat preference (11.4%), and precipitation (10%). The influence of the slope, ground cover, crown cover and substrate, was lowest in the study. Elephants were recorded up to 400 m a.s.l and in northeast

and southeast aspect. The suitable habitats were in the forest dominated by *Acacia catechu* and *Myrsine semicerate* receiving precipitation about 300 mm in an area with a low slope (0–5 degree). Its presence was not related to forest cover and substrate condition. The model emphasis on environmental suitability and contributes to the conservation of elephant in PNP and provides the basis for more advanced habitat analysis. The result from the modeling is useful to delineate the site that required specific planning and management intervention. © 2019 The Authors.

Jacob Shell

The enigma of the Asian elephant: Sovereignty, reproductive nature, and the limits of empire
Annals of the American Association of Geographers 109 (2019) 1154-1171

Abstract. This article examines the dependency of British teak logging and shipbuilding on elephant-based labor in Burma (Myanmar) and India during the nineteenth century. Asian elephants were essential as a means of commodity extraction, offering irreplaceable forms of mobility across difficult forest terrain. At the same time, from the standpoint of colonial control, a frustrating feature of the elephants was their unwillingness to mate when in captivity, raising the issue of how to replenish this animal workforce. Practices of elephant stewardship in Burma, where trained elephants were released into the forest on a nightly basis to roam and mate, became of great interest to the very technics of empire. This release system came with a political limitation, however: The humans in the forest adept at working this system of nightly elephant releases presented challenges to colonial control, not least because of the nature of the work such people did, which occurred in a zone beyond the view of the state. These elephant tenders, and perhaps by extension the elephants themselves, were “Zomian” in J. C. Scott’s sense of being spatially state-evasive—indeed, means of politically evasive mobility was the most robust use-value of the trained elephants. The case of colonial elephant logging stands as an important indicator that if an intelligent creature with irreplaceable labor power refuses to compromise sovereign control over its practices of reproduction, the creature

could force territorial and political concessions from the surrounding edifice of power. The article draws mainly on archival research and also on ethnographic fieldwork conducted between 2013 and 2017. Key Words: Burma (Myanmar), colonialism, elephants, logging, Zomia. © 2019 American Association of Geographers.

M.C. Sibarani, M. Di Marco, C. Rondinini & S. Kark

Measuring the surrogacy potential of charismatic megafauna species across taxonomic, phylogenetic and functional diversity on a megadiverse island

Journal of Applied Ecology 56 (2019) 1220-1231

Abstract. Conservation organisations and governments often use charismatic megafauna as surrogates to represent broader biodiversity. While these species are primarily selected as “flagships” for marketing campaigns, it is important to evaluate their surrogacy potential, i.e. the extent to which their protection benefits other biodiversity elements. Four charismatic megafauna species are used as surrogates in the megadiverse island of Sumatra: the Sumatran tiger *Panthera tigris sumatrae*, Sumatran elephant *Elephas maximus sumatranus*, Sumatran orangutan *Pongo abelii* and Sumatran rhinoceros *Dicerorhinus sumatrensis*. We examined how well each of these species performed in representing the distribution of all co-occurring terrestrial mammal species on the island, and the priority areas for the conservation of three facets of mammalian biodiversity (taxonomic, phylogenetic and functional). We used habitat suitability models to represent the distribution of 184 terrestrial mammal species, 160 phylogenetic groups and 74 functional trait groups. We then identified priority conservation areas using the spatial prioritisation software Zonation. We found that the habitat overlap between each of the four charismatic species and the other mammal species varied, ranging from a mean of 52% (SD = 27%) for the tiger to 2% (SD = 2%) for the rhino. Combining the four species together improved the representation levels only marginally compared to using the tiger only. Among the four charismatic megafauna species, the extent of suitable habitat

of Sumatran tiger covered the highest proportion of priority conservation areas. The Sumatran tiger also outperformed most of other mammal species with similar range sizes. We found that some of the top-ranked conservation areas for taxonomic (28%), phylogenetic (8%) and functional diversity (19%) did not overlap with any of the charismatic species’ suitable habitat. Synthesis and applications. Wide-ranging charismatic species can represent broader mammalian biodiversity, but they may miss some key areas with high biodiversity importance. We suggest that a combination of systematic spatial prioritisation and surrogacy analyses are important in order to determine the allocation of conservation resources in biodiversity-rich areas such as Sumatra, where an expansion of the protected area network is required. © 2019 The Authors.

S. de Silva & K. Srinivasan

Revisiting social natures: People-elephant conflict and coexistence in Sri Lanka

Geoforum 102 (2019) 182-190

Abstract. This paper examines human-wildlife conflict in and around protected areas to reflect on long-standing questions in conservation social science about protected areas and fortress thinking. It develops a more-than-human political ecology of human-elephant cohabitation and conflict in Sri Lanka to explore how changing socio-material conditions intersect to produce conservation and human-wildlife conflict in today’s world. The paper’s overarching argument is that fortress conservation is better understood as a relatively proximate cause of human-wildlife conflict and the other social impacts associated with the domain of conservation. Through its analyses, the paper deepens the critique of nature-society dualisms that is embedded in the appellation of ‘fortress conservation’ and offers insights that strengthen the reach and force of scholarship that tackles the persistent “appeal” of the “fortress” (Buscher, 2016, 115). © 2019 Reprinted with permission from Elsevier.

N. Sirikaew, S. Chomdej, S. Tangyuenyong, W. Tangjitjaroen, C. Somgird, C. Thitaram & S. Ongchai

Proinflammatory cytokines and lipopolysaccharides up regulate MMP-3 and MMP-13 production in Asian elephant (*Elephas maximus*) chondrocytes: attenuation by anti-arthritic agents

BMC Veterinary Research 15 (2019) e419

Abstract. 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-1 β), IL-17A, tumor necrosis factor-alpha (TNF- α), 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. Among the used cytokines, OSM showed the highest activation of MMP3 and MMP13 expression, especially when combined with IL-1 β . The combination of IL-1 β 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. 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. © 2019 The Authors.

C. Soundararajan, K.P. Prabhu, K. Nagarajan & T. Divya

Wound and gastric myiasis due to *Chrysomya bezziana* and *Cobboldia elephantis* and its pathological lesions in wild elephants in the Nilgiris hills of Tamil Nadu

Journal of Parasitic Diseases 43 (2019) 134-138

Abstract. No permission to print the abstract .

N.R. Talukdar, P. Choudhury & R.A. Barbhuiya
The importance of trans-boundary conservation of the Asiatic elephant *Elephas maximus* in Patharia Hills Reserve Forest, northeastern India

J. of Threatened Taxa 11 (2019) 13168-13170

Abstract. The lives of Asiatic elephants in the Patharia Hills Reserve Forest of Barak Valley, Assam are at risk. Due to serious anthropogenic pressures, human-elephant interactions have increased tremendously during recent decades. It is time conservation of the species is initiated along the Indo-Bangladesh trans-boundary line, especially their habitats and migratory corridor which can help the conservation of elephants and other species as well. © 2019 The Authors.

K. Takehana, R. Onomi, K. Hatate & N. Yamagishi

Determination of serum bone-specific alkaline phosphatase isoenzyme activity in captive Asian elephants (*Elephas maximus*) using an agarose gel electrophoresis method

Journal of Veterinary Medical Science 81 (2019) 551-554

Abstract. 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. © 2019 Japanese Society of Veterinary Science.

N. Thakur, R. Suresh, G.E. Chethan & K. Mahendran

Balantidiasis in an Asiatic elephant and its therapeutic management

Journal of Parasitic Diseases 43 (2019) 186-189

Abstract. No permission to print the abstract.

C. Udomtanakunchai, P. Pongsopawijit, W. Langkaphin, S. Lawongwan & S. Tasomkan

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 (2019) 375-382

Abstract. 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 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. © 2019 American Association of Zoo Veterinarians.

B. Vincze, A. Gáspárdy, A. Biácsi, E.Á. Papp, L. Garamvölgyi, E. Sós, S. Cseh, G. Kovács, Z. Pádár & P. Zenke

Sex determination using circulating cell-free fetal DNA in small volume of maternal plasma

in elephants

Scientific Reports 9 (2019) e15254

Abstract. 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.

M.G. Walsh, S.M. Mor & S. Hossain

The elephant–livestock interface modulates anthrax suitability in India

Proceedings of the Royal Society B 286 (2019) e20190179

Abstract. Anthrax is a potentially life-threatening bacterial disease that can spread between wild and livestock animals and humans. Transmission typically occurs indirectly via environmental exposure, with devastating consequences for human and animal health, as well as pastoralist economies. India has a high annual occurrence of anthrax in some regions, but a country-wide delineation of risk has not yet been undertaken. The current study modelled the geographical suitability of anthrax across India and its associated environmental features using a biogeographic application of machine learning. Both biotic and abiotic features contributed to risk across multiple scales of influence. The elephant–livestock interface was the dominant feature in delineating anthrax suitability. In addition, water–soil balance, soil chemistry and historical forest loss were also influential. These findings suggest that the elephant–livestock

interface plays an important role in the cycling of anthrax in India. Livestock prevention efforts targeting this interface, particularly within anthropogenic ecotones, may yield successes in reducing ongoing transmission between animal hosts and subsequent zoonotic transmission to humans. © 2019 The Authors.

P. Wendler, N. Ertl, M. Flügger, E. Sós, C. Schiffmann, M. Clauss & J.-M. Hatt

Foot health of Asian elephants (*Elephas maximus*) in European zoos

Journal of Zoo and Wildlife Medicine 50 (2019) 513-527

Abstract. 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 American Association of Zoo Veterinarians.

K. Whittemore, E. Vera, E. Martínez-Nevado, C. Sanpera & M.A. Blasco

Telomere shortening rate predicts species life span

PNAS 116 (2019) 15122-15127

Abstract. Telomere shortening to a critical length can trigger aging and shorter life spans in mice and humans by a mechanism that involves induction of a persistent DNA damage response at chromosome ends and loss of cellular viability. However, whether telomere length is a universal determinant of species longevity is not known. To determine whether telomere shortening can be a single parameter to predict species longevities, here we measured in parallel the telomere length of a wide variety of species (birds and mammals) with very different life spans and body sizes, including mouse (*Mus musculus*), goat (*Capra hircus*), Audouin's gull (*Larus audouinii*), reindeer (*Rangifer tarandus*), griffon vulture (*Gyps fulvus*), bottlenose dolphin (*Tursiops truncatus*), American flamingo (*Phoenicopterus ruber*), and Sumatran elephant (*Elephas maximus sumatranus*). We found that the telomere shortening rate, but not the initial telomere length alone, is a powerful predictor of species life span. These results support the notion that critical telomere shortening and the consequent onset of telomeric DNA damage and cellular senescence are a general determinant of species life span. © 2019 the Authors.

E. Williams, A. Carter, C. Hall & S. Bremner-Harrison

Exploring the relationship between personality and social interactions in zoo-housed elephants: Incorporation of keeper expertise

Applied Animal Behaviour Science 221 (2019) 104876

Abstract. Individual animal personalities affect experiences of zoo environments, and

thus potentially welfare. Incorporating keeper knowledge of animal personality in a reliable way has great value in optimising welfare in zoo-housed animals. Assessment of animal personality has been used to predict group compatibility and social relationships in a number of species including rhinoceros, gorilla and chimpanzees, and there is potential to do the same with zoo elephants. This study identified elephant personalities using keeper ratings, and investigated the relationship between personality and social interactions in zoo elephants. Behavioural data were collected over a period of 12 months at seven study facilities (January 2016 – February 2017). Subjects were 10 African (1 male: 9 females) and 19 Asian (3 male: 16 female) elephants housed at zoos and safari parks in the UK and Ireland. Each subject was rated using an elephant personality assessment questionnaire, comprising 21 personality adjectives with a visual analogue scale. Personality assessments were completed by 27 keepers. Reliability across keepers was established for nine adjectives and a principal components analysis revealed three personality components: ‘attentiveness’, ‘sociable’ and ‘engaged with the environment’. Correlations were observed between keeper scores of sociability and social interactions ($p < 0.05$). Elephants considered more sociable by keepers interacted positively with a greater proportion of elephants in the herd than less sociable elephants ($p < 0.05$). Current Secretary of States Standards of Modern Zoo Practice (SSSMZP) elephant management guidelines include the need for long-term management plans, including elephant behavioural profiles and herd compatibility assessments. The results show that sociability as identified by keepers relates to social interactions, illustrating the importance of inclusion of personality assessment in management plans. Future work should build on these findings; applying keeper ratings of elephant personality to a larger sample size, and exploring its potential as a predictive tool in compatibility assessments. Such a measure would help to increase the chance of successful social group formation contributing to positive zoo elephant welfare. © 2019 Reprinted with permission from Elsevier.

N. Wissink-Argilaga, A. Dastjerdi & F.M. Molenaar

Using in-house hematology to direct decision-making in the successful treatment and monitoring of a clinical and subsequently subclinical case of elephant endotheliotropic herpesvirus 1B

Journal of Zoo and Wildlife Medicine 50 (2019) 498-502

Abstract. 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. © 2019 American Association of Zoo Veterinarians.

Y. Yin, S. Liu, Y. Sun, S. Zhao, Y. An, S. Dong & A. Coxix

Identifying multispecies dispersal corridor priorities based on circuit theory: A case study in Xishuangbanna, Southwest China

Journal of Geographical Sciences 29 (2019) 1228-1245

Abstract. No permission to print the abstract.

L. Yon, E. Williams, N.D. Harvey & L. Asher
Development of a behavioural welfare assessment tool for routine use with captive elephants

PLoS ONE 14 (2019) 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. © 2019 The Authors.

A. Zachariah, P.K. Sajesh, S. Santhosh, C. Bathrachalam, M. Megha, J. Pandiyan, M. Jishnu, R.S. Kobragade, S.Y. Long, J-C Zong, E.M. Latimer, S.Y. Heaggans & G.S. Hayward
Extended genotypic evaluation and comparison of twenty-two cases of lethal EEHV1 hemorrhagic disease in wild and captive Asian elephants in India

PLoS ONE 13 (2018) e0202438

Abstract. Thirteen new lethal cases of acute hemorrhagic disease (HD) with typical histopathological features were identified in young Asian elephants (*Elephas maximus indicus*) in India between 2013 and 2017. Eight occurred amongst free-ranging wild herds, with three more in camp-raised orphans and two in captive-born calves. All were confirmed to have high levels of Elephant Endotheliotropic Herpesvirus type 1A (EEHV1A) DNA detected within gross pathological lesions from necropsy tissue by multi-locus PCR DNA sequencing. The strains involved were all significantly different from one another and from nine previously described cases from Southern India (which included one example of EEHV1B). Overall, eight selected dispersed PCR loci totaling up to 6.1-kb in size were analyzed for most of the 22 cases, with extensive subtype clustering data being obtained at four hypervariable gene loci. In addition to the previously identified U48(gH-TK) and U51(vGPCR1) gene loci, these included two newly identified E5(vGPCR5) and E54(vOX2-1) loci mapping far outside of the classic EEHV1A versus EEHV1B subtype chimeric domains and towards the novel end segments of the genome that had not been evaluated previously. The high levels of genetic divergence and mosaic scrambling observed between adjacent loci match closely to the overall range of divergence found within 45 analyzed North American and European cases, but include some common relatively unique polymorphic features and preferred subtypes that appear to distinguish most but not all Indian strains from both those in Thailand and those outside range countries. Furthermore, more than half of the Indian cases studied here involved calves living within wild herds, whereas nearly all other cases identified in Asia so far represent rescued camp orphans or captive-born calves. © 2018 The Authors.