

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 (2017) publications on Asian elephants.

K.P. Acharya, P.K. Paudel, P.R. Neupane & M. Köhl

Human-wildlife conflicts in Nepal: Patterns of human fatalities and injuries caused by large mammals

PLoS ONE 11 (2016) e0161717

Abstract. Injury and death from wildlife attacks often result in people feeling violent resentment and hostility against the wildlife involved and, therefore, may undermine public support for conservation. Although Nepal, with rich biodiversity, is doing well in its conservation efforts, human-wildlife conflicts have been a major challenge in recent years. The lack of detailed information on the spatial and temporal patterns of human-wildlife conflicts at the national level impedes the development of effective conflict mitigation plans. We examined patterns of human injury and death caused by large mammals using data from attack events and their spatiotemporal dimensions collected from a national survey of data available in Nepal over five years (2010–2014). Data were analyzed using logistic regression and chi-square or Fisher's exact tests. The results show that Asiatic elephants and common leopards are most commonly involved in attacks on people in terms of attack frequency and fatalities. Although one-horned rhinoceros and bears had a higher frequency of attacks than Bengal tigers, tigers caused more fatalities than each of these two species. Attacks by elephants peaked in winter and most frequently occurred outside protected areas in human settlements. Leopard attacks occurred almost entirely outside protected areas,

and a significantly greater number of attacks occurred in human settlements. Attacks by one-horned rhinoceros and tigers were higher in the winter, mainly in forests inside protected areas; similarly, attacks by bears occurred mostly within protected areas. We found that human settlements are increasingly becoming conflict hotspots, with burgeoning incidents involving elephants and leopards. We conclude that species-specific conservation strategies are urgently needed, particularly for leopards and elephants. The implications of our findings for minimizing conflicts and conserving these imperiled species are discussed. © 2016 The Authors.

A.S.M.L. Ahasan, M.A. Quasem, M.L. Rahman, R.B. Hasan, A.S.M.G. Kibria & S.K. Shil

Macroanatomy of the bones of thoracic limb of an Asian elephant (*Elephas maximus*)

International Journal of Morphology 34 (2016) 909-917

Abstract. Bones of forelimb were studied from a prepared skeleton of an adult female Asian elephant (*Elephas maximus*) in Anatomy Museum of Chittagong Veterinary and Animal Sciences University to understand the morphological form and structure of Asian elephant forelimb. The angle was approximately 123° between caudal border of scapula and caudal border of humerus. The scapula, humerus and bones of the antebrachium (particularly the ulna) were massive bones. The bones of manus were the short and relatively small. The dorsal border of scapula extended from the level of proximal extremity of first rib to the middle of the 6th rib. Ventral angle of scapula articulated with humerus by elongated shaped glenoid cavity (*cavitas glenoidalis*) of scapula and head of humerus (*caput humeri*). The major tubercle (*tuberculum majus*) of humerus was situated laterally to the head, which had smaller

cranial part with large caudal part and extended cranially to the head. The crest of minor tubercle (*tuberculum minus*) was present as the rough line on the medio-caudal surface of humerus that ends in a slight depressed or elevated area, known as *teres major* tuberosity (*tuberositas teres major*). The lateral supracondylar crest (*crista supracondylaris lateralis*) at the caudal surface of the shaft limit the musculo-spiral groove in body of humerus. The radius and ulna are twin bones of forearm and the attachment between ulna and radius occurs in such a way, the radius articulates craniomedially with the ulna in the proximal part. But the shaft spirals laterally over the cranial surface of the ulna to articulate distally with the medial aspect of the ulna. There were 8 carpal bones, 5 metacarpal bones and 5 digits. The comparative size of the proximal and distal row of carpal bones were ulnar carpal > radial > intermediate > accessory carpal and IV > III > II > I respectively. The gradual lengths of the metacarpal bones were III > IV > II > V > I. Digits I and V were vertical and digit II, III and IV were horizontal.

L.Y. Andaya

The social value of elephant tusks and bronze drums among certain societies in eastern Indonesia

Journal of the Humanities and Social Sciences of Southeast Asia 172 (2016) 66-89

Abstract. This study seeks to explain how and why elephant tusks and bronze kettledrums came to occupy such an important social and ritual position in certain societies in eastern Indonesia. It argues that these two objects were selected because they came to be associated with ideas of authority and rain/fertility. In making this claim, this study suggests that the ideas and symbolism associated with elephants and bronze drums in both India and Southeast Asia found relevance in, and were thus adopted by, specific societies in eastern Indonesia. Contemporary Dutch East India Company accounts and local traditions provide evidence of the role of the Javanese kingdom of Majapahit and the Makassarese kingdom of Gowa as the principal transmitters of these ideas through an extensive international trade in the highly coveted spices of eastern Indonesia. © 2016 The Author.

Y. Bi, A. Roy, D. Bhavsar, J. Xu, M. Wang, T. Wang & X. Yang

Kamala tree as an indicator of the presence of Asian elephants during the dry season in the Shivalik landscape of northwestern India

Ecological Indicators 71 (2016) 239-247

Abstract. The availability of forage resources during the dry season is often a critical factor in determining the distribution and movement of large herbivores. It has long been suspected that the Kamala tree (*Mallotus philippinensis*) can serve as an indicator of the distribution for Asian elephants during the dry season in northwestern India. However, there is little direct evidence in support of this speculation, especially at a large landscape scale. Here, we predicted the distribution of Kamala trees in the Shivalik landscape of northwestern India based on topographic and bioclimatic variables, as well as satellite-derived vegetation indices and forest canopy height data using a presence-only ecological niche model. We used the area under the receiver operating characteristic curve (AUC) and true skill statistic (TSS) to validate the model. We then examined the relationship between the occurrence probability of Kamala trees and the presence of Asian elephants with data collected during dry seasons between 2010 and 2014 using logistic regression models. Our results showed that the probability of occurrence of Kamala trees was predicted with good accuracy (AUC = 0.88 and TSS = 0.51). The logistic regression models showed that the presence of Asian elephants can be adequately predicted by the occurrence probability of Kamala trees. This result suggests that the distribution of Kamala trees is a good indicator of the presence of Asian elephants during the dry season in the Shivalik landscape. These findings may have major implications for the conservation of Asian elephants, especially in designing wildlife corridors and mitigating human-elephant conflicts. © 2016 Reprinted with permission from Elsevier.

K. Buddhachat, C. Thitaram, J.L. Brown, S. Klinhom, P. Bansiddhi, K. Penchart, K. Ouitavon, K. Sriaksorn, C. Pa-in, B. Kanchanasaka, C. Somgird & K. Nganvongpanit

Use of handheld X-ray fluorescence as a non-invasive method to distinguish between Asian

and African elephant tusks

Scientific Reports 6 (2016) e24845

Abstract. We describe the use of handheld X-ray fluorescence, for elephant tusk species identification. Asian (n = 72) and African (n = 85) elephant tusks were scanned and we utilized the species differences in elemental composition to develop a functional model differentiating between species with high precision. Spatially, the majority of measured elements (n = 26) exhibited a homogeneous distribution in cross-section, but a more heterologous pattern in the longitudinal direction. Twenty-one of 24 elements differed between Asian and African samples. Data were subjected to hierarchical cluster analysis followed by a stepwise discriminant analysis, which identified elements for the functional equation. The best equation consisted of ratios of Si, S, Cl, Ti, Mn, Ag, Sb and W, with Zr as the denominator. Next, Bayesian binary regression model analysis was conducted to predict the probability that a tusk would be of African origin. A cut-off value was established to improve discrimination. This Bayesian hybrid classification model was then validated by scanning an additional 30 Asian and 41 African tusks, which showed high accuracy (94%) and precision (95%) rates. We conclude that handheld XRF is an accurate, non-invasive method to discriminate origin of elephant tusks provides rapid results applicable to use in the field.

B.M. Chandranaik, B.P. Shivashankar, P. Giridhar & D.N. Nagaraju

Molecular characterisation and serotyping of *Pasteurella multocida* isolates from Asiatic elephants (*Elephas maximus*)

European Journal of Wildlife Research 62 (2016) 681-685

Abstract. We report the cultural and molecular characterisation of *Pasteurella multocida* isolates recovered from Asiatic elephants at Bandipur tiger reserve forest in Karnataka state, India. The forest had witnessed consecutive droughts from 2010 to 2012 and sudden heavy monsoon rains in 2013. Twenty-three elephants died during this period of heavy rains between May and July 2013. Postmortem conducted on a fresh elephant carcass revealed hemorrhagic tracheitis, haemorrhages on heart and lesions of acute

septicaemia in all other vital organs. In seven elephant carcasses where fresh samples were not available, bone marrow samples of femur bones were aseptically collected. Heart blood and spleen samples collected at postmortem and two out of seven bone marrow samples yielded the growth of *P. multocida*. The isolates were typed as *P. multocida* type B. The phylogenetic analysis of the isolates was carried out by 16S ribosomal RNA (rRNA) gene-based PCR and sequencing of 1.3 Kbp nucleotides on the 16S rRNA gene of the isolates. The isolates showed highest sequence identity with *P. multocida* isolates of bovine and caprine origin. This is the first report of molecular study on *P. multocida* from Asiatic elephants. © 2016 Springer Verlag.

Y. Chen, J. Marino, Y. Chen, Q. Tao, C.D. Sullivan, K. Shi & D.W. Macdonald

Predicting hotspots of human-elephant conflict to inform mitigation strategies in Xishuangbanna, Southwest China

PLoS ONE 11 (2016) e0162035

Abstract. Research on the spatial patterns of human-wildlife conflict is fundamental to understanding the mechanisms underlying it and to identifying opportunities for mitigation. In the state of Xishuangbanna, containing China's largest tropical forest, an imbalance between nature conservation and economic development has led to increasing conflicts between humans and Asian elephants (*Elephas maximus*), as both elephant numbers and conversion of habitable land to rubber plantations have increased over the last several decades. We analyzed government data on the compensation costs of elephant-caused damage in Xishuangbanna between 2008 and 2012 to understand the spatial and temporal patterns of conflict, in terms of their occurrence, frequency and distribution. More than 18,261 incidents were reported, including episodes involving damage to rubber trees (n = 10,999), damage to crops such as paddy, upland rice, corn, bananas and sugarcane (n = 11,020), property loss (n = 689) and attacks on humans (n = 19). The conflict data reconfirmed the presence of elephants in areas which have lacked records since the late 1990s. Zero Altered Negative Binomial models revealed that the risk of damage to crops and plantations increased with proximity

to protected areas, increasing distance from roads, and lower settlement density. The patterns were constant across seasons and types of crop damaged. Damage to rubber trees was essentially incidental as elephants searched for crops to eat. A predictive map of risks revealed hotspots of conflict within and around protected areas, the last refuges for elephants in the region, and along habitat corridors connecting them. Additionally, we analyzed how mitigation efforts can best diminish the risk of conflict while minimizing financial costs and adverse biological impacts. Our analytical approach can be adopted, adjusted and expanded to other areas with historical records of human-wildlife conflict.

A. Dastjerdi, K. Seilern-Moy, K. Darpel, F. Steinbach & F. Molenaar

Surviving and fatal elephant endotheliotropic herpesvirus-1A infections in juvenile Asian elephants – lessons learned and recommendations on anti-herpesviral therapy

BMC Veterinary Research 12 (2016) e178

Abstract. Elephant Endotheliotropic Herpesviruses (EEHVs) can cause acute haemorrhagic disease in young Asian elephants (*Elephas maximus*) and clinical EEHV infections account for the majority of their fatalities. The anti-herpesviral drug famciclovir (FCV) has been used routinely to treat viraemic at-risk elephants, but thus far without proven efficacy. This paper presents clinical and virological investigations of two EEHV-1A infected elephants treated with FCV, and discusses anti-herpesvirus therapies of viraemic elephants. Two 1.5 year old male Asian elephants at a zoological collection in the UK developed clinical EEHV-1A infections. Case 1 showed signs of myalgia for the duration of 24 hours before returning back to normal. EEHV-1A DNAemia was confirmed on the day of clinical signs and continued to be present for 18 days in total. Trunk shedding of the virus commenced 10 days after detection of initial DNAemia. Case 2 tested positive for EEHV-1A DNAemia in a routine blood screening sample in the absence of clinical signs. The blood viral load increased exponentially leading up to fatal clinical disease seven days after initial detection of DNAemia. Both calves were treated with 15 mg/kg FCV per rectum on detection of DNAemia and penciclovir,

the FCV metabolite, could be detected in the blood at assumed therapeutic levels. The early indicators for clinical disease were a marked absolute and relative drop in white blood cells, particularly monocytes prior to the detection of viraemia. The most prognostic haematological parameter at later stages of the disease was the platelet count showing a continuous sharp decline throughout, followed by a dramatic drop at the time of death. The EEHV-1A viraemic animals investigated here further highlight the ongoing threat posed by these viruses to juvenile Asian elephants. The findings call into question the efficacy of rectal FCV in clinical cases and direct towards the use of alternative anti-herpesvirus drugs and complementary treatments such as plasma infusions if no improvement in either viral load or the above-mentioned blood parameters are observed in the initial days of viraemia despite anti-herpesvirus therapy. © 2016 The Authors.

C. Duer, T. Tomasi & C.I. Abramson

Reproductive endocrinology and musth indicators in a captive Asian elephant (*Elephas maximus*)

Psychological Reports 119 (2016) 839-860

Abstract. Even in the best situations, the artificial social constructs of captivity alter natural elephant behavior and unfortunately create distress. Asian elephants are powerful and intelligent animals that require consideration for their well-being and prudent management. The males present particular difficulties due to a temporary state of heightened aggressive behavior unique to male elephants called “musth.” When he is in this state, the danger the elephant poses to other animals and the people around him is considerable. In addition to antagonistic behavior, musth is also characterized by temporal gland secretion and urine dribbling. In previous studies, musth has been attributed to elevated testosterone levels. This study attempted to enhance the knowledge base concerning these phenomena by examining hormone concentrations (n=357) in Onyx, a male Asian elephant housed at Dickerson Park Zoo, with intermittent access to females (n=1–5) over a 12-year period. Behavior and signs of musth also were recorded daily by elephant department staff. Musth indicators (temporal gland secretion,

aggression, urine dribbling) increased with musth but not prior to it. We confirmed that temporal gland secretion was a better indicator of behavioral musth than urine dribbling. Hormones concentrations increased as musth approached, and presumably initiated musth indicators, but variability was high. Therefore, these hormones cannot be used to predict the onset of musth in this individual. Rather, the free/total testosterone ratio was a good indication of the 60-day pre-musth period. In addition, testosterone production and musth indicators increased in intensity when a young bull at the zoo started entering musth. © 2016 The Authors.

E.F. Egelund, R. Isaza, A. Alsultan & C.A. Peloquin

Isoniazid and rifampin pharmacokinetics in two Asian elephants (*Elephas maximus*) infected with *Mycobacterium tuberculosis*

Journal of Zoo and Wildlife Medicine 47 (2016) 868-871

Abstract. This report describes the pharmacokinetic profiles of chronically administered oral isoniazid and rifampin in one adult male and one adult female Asian elephant (*Elephas maximus*) that were asymptotically infected with *Mycobacterium tuberculosis*. Rifampin's half-life was reduced when compared to previous single-dose pharmacokinetic profiles of healthy uninfected Asian elephants. Both elephants experienced delayed absorption of isoniazid and rifampin as compared to previous pharmacokinetic studies in this species. The altered pharmacokinetics of both drugs in repeated-dosing clinical situations underscores the need for individual therapeutic drug monitoring for tuberculosis treatment. © 2016 American Association of Zoo Veterinarians.

A. Gangadharan, S. Vaidyanathan & C.C. St. Clair

Categorizing species by niche characteristics can clarify conservation planning in rapidly-developing landscapes

Animal Conservation 19 (2016) 451-461

Abstract. In biodiversity-rich landscapes that are developing rapidly, it is generally impossible to delineate land use and prioritize conservation actions in relation to the full variability of

species and their responses to anthropogenic activity. Consequently, conservation policy often focuses on protecting habitat used by a few flagship, indicator or umbrella species like tigers *Panthera tigris* and Asian elephants *Elephas maximus*, which potentially leaves out species that do not share these habitat preferences. We demonstrate an empirical approach that clustered 14 mammals into surrogate groups that reflect their unique conservation needs. We surveyed a 787 km² multiple-use area in the Shencottah Gap of the Western Ghats, India, using foot surveys and camera-trap surveys. Using ecological niche factor analysis, we generated indices of species prevalence (marginality and tolerance) and habitat preferences (factor correlations to marginality axis). We then clustered species by both of the above index types to reveal four clusters based on prevalence and four clusters based on habitat preference. Most clusters contained at least one threatened species. Low-prevalence lion-tailed macaques *Macaca silenus* and tigers were strongly associated with closed forests and low human disturbance. But elephants, sloth bears *Melursus ursinus* and gaur *Bos gaurus* were more tolerant of anthropogenic impact, and sloth bears and gaur preferred open forests and grasslands. Dhole *Cuon alpinus* and sambar *Rusa unicolor* were associated with highly anthropogenic habitat (farmland, cash crop and forestry plantations) with high human use. Thus, reliance on flagship species for conservation planning can both underestimate and overestimate the ability of other species to persist in multiple-use landscapes; protecting flagship species would only protect species with similar habitat preferences. For species that avoid human impacts more than the flagship species, core habitat must be protected from human disturbance. For more tolerant species, conservation in anthropogenic habitat may hinge on policies that bolster coexistence with humans. © 2016 The Zoological Society of London.

R. Ghosh, R.K. Sehgal, P. Srivastava, U.K. Shukla, A.C. Nanda & D.S. Singh

Discovery of *Elephas cf. namadicus* from the late Pleistocene strata of Marginal Ganga Plain

Journal of the Geological Society of India 88

(2016) 559-568

Abstract. We describe an elephant skull recovered from a cliff section of Dhasan river of Marginal Ganga Plain. The dental morphology and cranial features of the skull have been compared with the known species of *Elephas* from the Indian subcontinent. Although it shows very near resemblance to *Elephas namadicus*, but being an isolated specimen its specific identity cannot be proclaimed with certainty. As such, the specimen is provisionally referred as *E. cf. namadicus*. The Optically Stimulated Luminescence ages place this find at ~56 ka BP. This is the first chronologically well constrained report of *E. cf. namadicus* from the Ganga Plain. © 2016 Geological Society of India. With permission from Springer.

B.J. Greco, C.L. Meehan, J.N. Hogan, K.A. Leighty, J. Mellen, G.J. Mason & J.A. Mench

The days and nights of zoo elephants: Using epidemiology to better understand stereotypic behavior of African elephants (*Loxodonta africana*) and Asian elephants (*Elephas maximus*) in North American zoos

PLoS ONE 11 (2016) e0144276

Abstract. Stereotypic behavior is an important indicator of compromised welfare. Zoo elephants are documented to perform stereotypic behavior, but the factors that contribute to performance have not been systematically assessed. We collected behavioral data on 89 elephants (47 African [*Loxodonta africana*], 42 Asian [*Elephas maximus*]) at 39 North American zoos during the summer and winter. Elephants were videoed for a median of 12 daytime hours per season. A subset of 32 elephants (19 African, 13 Asian) was also observed live for a median of 10.5 nighttime hours. Percentages of visible behavior scans were calculated from five minute instantaneous samples. Stereotypic behavior was the second most commonly performed behavior (after feeding), making up 15.5% of observations during the daytime and 24.8% at nighttime. Negative binomial regression models fitted with generalized estimating equations were used to determine which social, housing, management, life history, and demographic variables were associated with daytime and nighttime stereotypic behavior rates. Species

was a significant risk factor in both models, with Asian elephants at greater risk (daytime: $p < 0.001$, Risk Ratio = 4.087; nighttime: $p < 0.001$, Risk Ratio = 8.015). For both species, spending time housed separately ($p < 0.001$, Risk Ratio = 1.009), and having experienced inter-zoo transfers ($p < 0.001$, Risk Ratio = 1.175), increased the risk of performing higher rates of stereotypy during the day, while spending more time with juvenile elephants ($p < 0.001$, Risk Ratio = 0.985), and engaging with zoo staff reduced this risk ($p = 0.018$, Risk Ratio = 0.988). At night, spending more time in environments with both indoor and outdoor areas ($p = 0.013$, Risk Ratio = 0.987) and in larger social groups ($p = 0.039$, Risk Ratio = 0.752) corresponded with reduced risk of performing higher rates of stereotypy, while having experienced inter-zoo transfers ($p = 0.033$, Risk Ratio = 1.115) increased this risk. Overall, our results indicate that factors related to the social environment are most influential in predicting elephant stereotypic behavior rates. © 2016 The Authors.

B.J. Greco, C.L. Meehan, L.J. Miller, D.J. Shepherdson, K.A. Morfeld, J. Andrews, A.M. Baker, K. Carlstead & J.A. Mench

Elephant management in North American zoos: Environmental enrichment, feeding, exercise, and training

PLoS ONE 11 (2016) e0152490

Abstract. The management of African (*Loxodonta africana*) and Asian (*Elephas maximus*) elephants in zoos involves a range of practices including feeding, exercise, training, and environmental enrichment. These practices are necessary to meet the elephants' nutritional, healthcare, and husbandry needs. However, these practices are not standardized, resulting in likely variation among zoos as well as differences in the way they are applied to individual elephants within a zoo. To characterize elephant management in North America, we collected survey data from zoos accredited by the Association of Zoos and Aquariums, developed 26 variables, generated population level descriptive statistics, and analyzed them to identify differences attributable to sex and species. Sixty-seven zoos submitted surveys describing the management of 224 elephants and the training experiences

of 227 elephants. Asian elephants spent more time managed (defined as interacting directly with staff) than Africans (mean time managed: Asians = 56.9%; Africans = 48.6%; $p < 0.001$), and managed time increased by 20.2% for every year of age for both species. Enrichment, feeding, and exercise programs were evaluated using diversity indices, with mean scores across zoos in the midrange for these measures. There were an average of 7.2 feedings every 24-hour period, with only 1.2 occurring during the nighttime. Feeding schedules were predictable at 47.5% of zoos. We also calculated the relative use of rewarding and aversive techniques employed during training interactions. The population median was seven on a scale from one (representing only aversive stimuli) to nine (representing only rewarding stimuli). The results of our study provide essential information for understanding management variation that could be relevant to welfare. Furthermore, the variables we created have been used in subsequent elephant welfare analyses. © 2016 The Authors.

Michael Gross

The plight of the pachyderms

Current Biology 26 (2016) R865–R881

Abstract. All three surviving elephant species are facing dramatic declines. Poaching driven by consumer demand for ivory in Asia is an important driver of their demise especially in Africa, making their plight a global issue, which has to be addressed by international policy. © 2016 Reprinted with permission from Elsevier.

Gözde Gürelli

Intestinal ciliate fauna of the Asian elephant from Gaziantep, Turkey and the description of *Brevitentaculum antebum* n. g., n. sp.

European J. of Protistology 56 (2016) 26-31

Abstract. The aims of this investigation were to identify and quantify ciliates inhabiting the large intestine of Asian elephants living in Gaziantep Zoo, Turkey, and to describe a new suctorian genus and species. Species composition and distribution of intestinal ciliates voided in the feces of two Asian elephants were examined. Fifteen species of intestinal ciliates, representing seven genera, were identified. One new suctorian genus and species, *Brevitentaculum antebum* n.

g., n. sp., was described. This new species has two short truncated terminal projections, with two longitudinally lined bands located between the two projections, near the convex surface of the cell. Short rod-like tentacles are in two fascicles near each base of terminal projections on the flattened surface of the body. Ciliate densities in the two fecal samples were $4.5 \times 10^4/\text{ml}$ and $10 \times 10^4/\text{ml}$. © 2016 Reprinted with permission from Elsevier.

Matt Hartley

Assessing risk factors for reproductive failure and associated welfare impacts in elephants in European zoos

Journal of Zoo and Aquarium Research 4 (2016) 127-138

Abstract. Reproductive failure in elephants is thought to be caused or influenced by a range of factors such as obesity, infectious disease, husbandry, facilities, stress, behaviour, maternal experience, herd size and social grouping. Due to the low reproductive activity of the small zoo elephant population, scientific study into the relative importance of these factors is limited. This study takes an epidemiological approach using risk analysis methodologies to collate information from expert opinion, data set analysis and a targeted questionnaire to identify and assess a range of physical, behavioural and husbandry based risk factors, which may affect reproductive success in elephants housed in European Zoos. Much of our knowledge on reproduction in zoo elephant populations originates from North America where there are significant differences in herd structure, management practices, climate and mean age. By combining multiple sources of evidence including a large survey of reproduction in the European elephant population and eliciting expert opinion from scientists, zoo managers, veterinarians and keepers working with European zoo elephants in a structured, transparent and scientifically recognised process it has been possible to identify the most important causes of reproductive failure and assess the influence of a range of potential confounding factors. Important causes of reproductive failure included lack of access to a compatible bull, herd stability and compatibility, allomothering or maternal experience, management practices at parturition

and the impact of Elephant Endotheliotropic Herpes Virus. This work is to be used in the development of evidence-based elephant management and welfare recommendations and highlights priority areas for further research.

M. Hartley & C. Stanley

Survey of reproduction and calf rearing in Asian and African elephants in Europe

Journal of Zoo and Aquarium Research 4 (2016) 139-146

Abstract. Acyclicity, conception failure, abortion, stillbirth, dystocia, infanticide and neonatal mortality have all been reported as causes of reproductive failure in zoo elephants. These events are often reported as single case reports or in specific studies focused on a particular stage in the reproductive process. In North America wider surveys of reproduction in the zoo elephant population have been completed and repeated to provide data over a number of years. This study is the largest and most comprehensive study of reproduction in the European zoo elephant population to date. Two questionnaires collected data from throughout the reproductive process from assessing cyclicity to independence of the calf at 5 years old. Information was collected regarding 189 birth events. Many causative and contributing factors such as obesity, infectious disease, husbandry, facilities, stress, behaviour, herd size and social grouping have been proposed. The importance of these was assessed and where possible association identified using statistical analysis. In African elephants, this study found that age, obesity, reproductive pathology and dominance, identified as important risk factors for failure to conceive in the American zoo elephant population were of low importance. The most significant cause in Europe was lack of access to a compatible bull. In Asian elephants reproductive failure was much less common but when it did occur age and reproductive pathologies were significant factors as found in previous studies. Previous studies have found that age, obesity and infanticide were considered as the most important risk factors in the period from birth to rearing. In this survey it was found that herd stability and compatibility, allomothering or maternal experience and management at parturition can significantly influence reproductive success.

Elephant Endotheliotropic Herpes virus was confirmed as the biggest cause of calf mortality. This work provides evidence to support changes to elephant management in European zoos in order to encourage development of social and affiliative herd behaviours and improve reproductive success.

L.E. Highfill, J.M. Spencer, O. Fad & A.M. Arnold

Performance on a means end task by Asian elephants (*Elephas maximus*) in a positive reinforcement-based protected contact setting

International Journal of Comparative Psychology 29 (2016)

Abstract. The current study tested six Asian elephants (*Elephas maximus*) on a means-end behavioral task of pulling a support to retrieve a distant object; a systematic replication of the Irie-Sugimoto, Kobayashi, Sato, and Hasegawa (2008) study. The paradigm was somewhat modified from the original research to accommodate a protected-contact setting, reduce the total number of trials, and one condition was excluded. Each elephant was tested on three conditions of increasing difficulty. Specifically, subjects were asked to select from a choice of two trays where one intact tray was baited with a highly-valued produce item and the other was A) empty, B) baited adjacent to the tray, and C) baited on the far side of a break in the tray. Results indicated that the elephants met or exceeded the criteria established for conditions A and B, but performed at chance levels on condition C. These data are contrasted with those of the original study where one elephant met criteria for all three conditions. We discuss potentially relevant variables affecting performance including differences in visual access to the trays, motivation levels, and training style. © 2016 The Authors.

M.R. Holdgate, C.L. Meehan, J.N. Hogan, L.J. Miller, J. Rushen, A.M. de Passillé, J. Soltis, J. Andrews & D.J. Shepherdson

Recumbence behavior in zoo elephants: Determination of patterns and frequency of recumbent rest and associated environmental and social factors

PLoS ONE 11 (2016) e0153301

Abstract. Resting behaviors are an essential

component of animal welfare but have received little attention in zoological research. African savanna elephant (*Loxodonta africana*) and Asian elephant (*Elephas maximus*) rest includes recumbent postures, but no large-scale investigation of African and Asian zoo elephant recumbence has been previously conducted. We used anklets equipped with accelerometers to measure recumbence in 72 adult female African (n = 44) and Asian (n = 28) elephants housed in 40 North American zoos. We collected 344 days of data and determined associations between recumbence and social, housing, management, and demographic factors. African elephants were recumbent less (2.1 hours/day, S.D. = 1.1) than Asian elephants (3.2 hours/day, S.D. = 1.5; P < 0.001). Nearly one-third of elephants were non-recumbent on at least one night, suggesting this is a common behavior. Multi-variable regression models for each species showed that substrate, space, and social variables had the strongest associations with recumbence. In the African model, elephants who spent any amount of time housed on all-hard substrate were recumbent 0.6 hours less per day than those who were never on all-hard substrate, and elephants who experienced an additional acre of outdoor space at night increased their recumbence by 0.48 hours per day. In the Asian model, elephants who spent any amount of time housed on all-soft substrate were recumbent 1.1 hours more per day more than those who were never on all-soft substrate, and elephants who spent any amount of time housed alone were recumbent 0.77 hours more per day than elephants who were never housed alone. Our results draw attention to the significant interspecific difference in the amount of recumbent rest and in the factors affecting recumbence; however, in both species, the influence of flooring substrate is notably important to recumbent rest, and by extension, zoo elephant welfare. © 2016 The Authors.

M.R. Holdgate, C.L. Meehan, J.N. Hogan, L.J. Miller, J. Soltis, J. Andrews & D.J. Shepherdson
Walking behavior of zoo elephants: Associations between GPS-measured daily walking distances and environmental factors, social factors, and welfare indicators
PLoS ONE 11 (2016) e0150331

Abstract. Research with humans and other animals suggests that walking benefits physical health. Perhaps because these links have been demonstrated in other species, it has been suggested that walking is important to elephant welfare, and that zoo elephant exhibits should be designed to allow for more walking. Our study is the first to address this suggestion empirically by measuring the mean daily walking distance of elephants in North American zoos, determining the factors that are associated with variations in walking distance, and testing for associations between walking and welfare indicators. We used anklets equipped with GPS data loggers to measure outdoor daily walking distance in 56 adult female African (n = 33) and Asian (n = 23) elephants housed in 30 North American zoos. We collected 259 days of data and determined associations between distance walked and social, housing, management, and demographic factors. Elephants walked an average of 5.3 km/day with no significant difference between species. In our multivariable model, more diverse feeding regimens were correlated with increased walking, and elephants who were fed on a temporally unpredictable feeding schedule walked 1.29 km/day more than elephants fed on a predictable schedule. Distance walked was also positively correlated with an increase in the number of social groupings and negatively correlated with age. We found a small but significant negative correlation between distance walked and nighttime Space Experience, but no other associations between walking distances and exhibit size were found. Finally, distance walked was not related to health or behavioral outcomes including foot health, joint health, body condition, and the performance of stereotypic behavior, suggesting that more research is necessary to determine explicitly how differences in walking may impact elephant welfare. © 2016 The Authors.

Ritesh Joshi

Mammalian fauna of Rajaji National Park, India: A review on ecological observations and checklist

Check List 12 (2016) e1892

Abstract. Rajaji National Park, in the Gangetic Plains biogeographic zone, has a diverse and biogeographically important mammalian

assemblage. In the recent past, several studies on the herbivores, large carnivores and mega-herbivores have been carried out, but limited work has been done on the distribution of mammals in the park. This study illustrates the ecological observations and review of the mammals of the Rajaji National Park, based on field surveys, carried out during 2006–2008, using direct and indirect sampling methods. A total of 44 mammal species, belonging to nine orders and 20 families were recorded, which included one insectivore, six chiropterans, two primates, one pholidotan, 16 carnivores, one proboscidean, six artiodactyls, one lagomorph and 10 rodents. Of these, seven are classified as Endangered/Vulnerable in the IUCN Red List of Threatened Species; however, three species are Near Threatened, a lower risk category. © 2016 Check List and Author.

S. Kaye, N. Abou-Madi & D.J. Fletcher

Effect of ϵ -aminocaproic acid on fibrinolysis in plasma of Asian elephants (*Elephas maximus*)

J. of Zoo and Wildlife Med. 47 (2016) 397-404

Abstract. ϵ -Aminocaproic acid (EACA) is a lysine analogue antifibrinolytic drug used to treat bleeding disorders in humans and domestic animals. Use in zoological medicine is rare and dose recommendations are anecdotal, but EACA may be a valuable therapeutic option for bleeding disorders in exotic species, including Asian elephants (*Elephas maximus*). This study used an in vitro model of hyperfibrinolysis and a thromboelastograph-based assay to estimate the therapeutic plasma concentration of EACA in Asian elephants (61.5 $\mu\text{g/ml}$, 95% CI 1/4 34.6–88.5 $\mu\text{g/ml}$). Substantial but incomplete inhibition of lysis was seen at relatively low concentrations of EACA (40 $\mu\text{g/ml}$). Asian elephants appear sensitive to EACA-mediated inhibition of hyperfibrinolysis. Doses published for domestic animals, targeting higher plasma concentrations, may be inappropriate in this species. © 2016 American Association of Zoo Veterinarians.

R. Kendall, L. Howard, N. Masters & R. Grant

The impact of elephant endotheliotropic herpesvirus on the captive Asian elephant (*Elephas maximus*) population of the United

Kingdom and Ireland (1995-2013)

Journal of Zoo and Wildlife Medicine 47 (2016) 405-418

Abstract. Elephant endotheliotropic herpesvirus (EEHV) is one of the most devastating infections and causes of mortality in captive Asian elephant (*Elephas maximus*) populations. Eight confirmed fatal EEHV cases have occurred since 1995 within the captive Asian elephant population of the United Kingdom and Ireland. This report aims to review the impact of EEHV on the captive Asian elephant population in the United Kingdom and Ireland, document and compare fatal cases, and recommend a framework of monitoring within the United Kingdom and Ireland to increase the success of treatment of EEHV hemorrhagic disease (EEHV HD) in the future. Six zoologic institutions (which include zoos, safari parks, and wildlife parks) that currently house or have previously housed a captive Asian elephant group were included in this report. Medical records and postmortem results were collected from four of these institutions for each confirmed fatal case. EEHV HD was found to be responsible for 29.6% of fatalities in Asian elephants born in captivity in the United Kingdom and Ireland between 1995 and 2013. Following a review of all the cases, it is shown that although clinical signs may be associated with specific EEHV species, the swiftness of disease progression means that most body tissues are impacted 1–6 days following the presentation of visible clinical signs and treatment is less likely to succeed. Therefore, EEHV monitoring should consist of conducting regular polymerase chain reaction analysis of whole blood samples from at-risk, young Asian elephants aged 1–8 yr in order for subclinical viremia to be identified early and treatment to be started before the appearance of visible clinical signs. © 2016 American Association of Zoo Veterinarians.

T. Kitpipit, P. Thanakiatkrai, K. Penchart, K. Ouithavon, C. Satasook & A. Linacre

Ivory species identification using electrophoresis-based techniques

Electrophoresis 37 (2016) 3068-3075

Abstract. Despite continuous conservation efforts by national and international organizations, the populations of the three extant elephant

species are still dramatically declining due to the illegal trade in ivory leading to the killing of elephants. A requirement to aid investigations and prosecutions is the accurate identification of the elephant species from which the ivory was removed. We report on the development of the first fully validated multiplex PCR-electrophoresis assay for ivory DNA analysis that can be used as a screening or confirmatory test. SNPs from the NADH dehydrogenase 5 and cytochrome b gene loci were identified and used in the development of the assay. The three extant elephant species could be identified based on three peaks/bands. *Elephas maximus* exhibited two distinct PCR fragments at approximate 129 and 381 bp; *Loxodonta cyclotis* showed two PCR fragments at 89 and 129 bp; and *Loxodonta africana* showed a single fragment of 129 bp. The assay correctly identified the elephant species using all 113 ivory and blood samples used in this report. We also report on the high sensitivity and specificity of the assay. All single-blinded samples were correctly classified, which demonstrated the assay's ability to be used for real casework. In addition, the assay could be used in conjunction with the technique of direct amplification. We propose that the test will benefit wildlife forensic laboratories and aid in the transition to the criminal justice system. © 2016 Wiley-VCH Verlag GmbH & Co.

R.K. Koirala, D. Raubenheimer, A. Aryal, M.L. Pathak & W. Ji

Feeding preferences of the Asian elephant (*Elephas maximus*) in Nepal

BMC Ecology 16 (2016) e54

Abstract. Nepal provides habitat for approximately 100–125 wild Asian elephants (*Elephas maximus*). Although a small proportion of the world population of this species, this group is important for maintaining the genetic diversity of elephants and conservation of biodiversity in this region. Knowledge of foraging patterns of these animals, which is important for understanding their habitat requirements and for assessing their habitat condition, is lacking for the main areas populated by elephants in Nepal. This study investigates the feeding preferences of the Asian elephant in Parsa Wildlife Reserve (PWR) and Chitwan National Park (CNP), Nepal. Fifty-

seven species of plants in 28 families were found to be eaten by Asian elephants, including 13 species of grasses, five shrubs, two climbers, one herb and 36 species of trees. The species that contributed the greatest proportion of the elephant's diet were *Spatholobus parviflorus* (20.2%), *Saccharum spontaneum* (7.1%), *Shorea robusta* (6.3), *Mallotus philippensis* (5.7%), *Garuga pinnata* (4.3%). *Saccharum bengalensis* (4.2%), *Cymbopogon* spp (3.7%), *Litsea monopetala* (3.6) and *Phoenix humilis* (2.9%). The preference index (PI) showed that browsed species were preferred during the dry season, while browsed species and grasses were both important food sources during the rainy season. Elephants targeted leaves and twigs more than other parts of plants ($P < 0.05$). This study presents useful information on foraging patterns and baseline data for elephant habitat management in the PWR and CNP in the south central region of Nepal. © 2016 The Authors.

Helen Kopnina

Wild animals and justice: The case of the dead elephant in the room

Journal of International Wildlife Law & Policy 19 (2016) 219-235

Abstract. none.

N. Kraiwong, P. Sanyathitiseree, K. Boonprasert, P. Diskul, P. Charoenphan, W. Pintawong & A. Thayananuphat

Anterior ocular abnormalities of captive Asian elephants (*Elephas maximus indicus*) in Thailand

Veterinary Ophthalmology 19 (2016) 269-274

Abstract. Objective: To survey and classify anterior ocular abnormalities in 1478 captive Asian elephants (*Elephas maximus indicus*) in six regions of Thailand. Methods: Anterior ocular examination was performed in both eyes ($n = 2956$) of 1478 elephants selected from the annual health check program involving 2958 animals within six regions of Thailand from January to November 2013. Lesions were described and compared between age and gender. Results: A total of 17.83% (527/2956) of examined eyes from 24.97% (369/1478) of examined elephants had anterior ocular abnormalities. The most common lesions in these examined eyes

were frothy ocular discharge (5.85%), corneal edema (5.31%), and conjunctivitis (5.18%). In addition, epiphora, phthisis bulbi, other corneal abnormalities, anterior uveitis, and lens abnormalities were noted. Almost all lesions increased in frequency with age ($P < 0.01$). Conclusions: Regular ophthalmic examination in elephants should be included in their annual health check program. Early detection and treatment of any ocular abnormality may avoid the development of subsequent irreversible ocular pathology. © 2015 American College of Veterinary Ophthalmologists.

M. Lahdenperä, K.U. Mar & V. Lummaa

Nearby grandmother enhances calf survival and reproduction in Asian elephants

Scientific Report 6 (2016) e27213

Abstract. Usually animals reproduce into old age, but a few species such as humans and killer whales can live decades after their last reproduction. The grandmother hypothesis proposes that such life-history evolved through older females switching to invest in their existing (grand)offspring, thereby increasing their inclusive fitness and selection for post-reproductive lifespan. However, positive grandmother effects are also found in non-menopausal taxa, but evidence of their associated fitness effects is rare and only a few tests of the hypothesis in such species exist. Here we investigate the grandmother effects in Asian elephants. Using a multigenerational demographic dataset on semi-captive elephants in Myanmar, we found that grandcalves from young mothers (<20 years) had 8 times lower mortality risk if the grandmother resided with her grandcalf compared to grandmothers residing elsewhere. Resident grandmothers also decreased their daughters' inter-birth intervals by one year. In contrast to the hypothesis predictions, the grandmother's own reproductive status did not modify such grandmother benefits. That elephant grandmothers increased their inclusive fitness by enhancing their daughter's reproductive rate and success irrespective of their own reproductive status suggests that fitness-enhancing grandmaternal effects are widespread, and challenge the view that grandmother effects alone select for menopause coupled with long post-reproductive lifespan.

P.D. Ling, S.Y. Long, A. Fuery, R.-S. Peng, S.Y. Heaggans, X. Qin, K.C. Worley, S. Dugan & G.S. Hayward

Complete genome sequence of elephant endotheliotropic herpesvirus 4, the first example of a GC-rich branch proboscivirus

mSphere 1 (2016) e00081-15

Abstract. A novel group of mammalian DNA viruses called elephant endotheliotropic herpesviruses (EEHVs) belonging to the Proboscivirus genus has been associated with nearly 100 cases of highly lethal acute hemorrhagic disease in young Asian elephants worldwide. The complete 180-kb genomes of prototype strains from three AT-rich branch viruses, EEHV1A, EEHV1B, and EEHV5, have been published. However, less than 6 kb of DNA sequence each from EEHV3, EEHV4, and EEHV7 showed them to be a hugely diverged second major branch with GC-rich characteristics. Here, we determined the complete 206-kb genome of EEHV4(Baylor) directly from trunk wash DNA by next-generation sequencing and de novo assembly procedures. Among a total of 119 genes with an overall colinear organization similar to those of the AT-rich EEHVs, major features of EEHV4 include a family of 26 paralogous 7xTM and vGPCR-like genes plus 25 novel or missing genes. The genome also contains an unusual distribution of tracts of 5 to 11 successive A or T nucleotides in intergenic domains between the mostly much higher GC content protein coding regions. Furthermore, an extremely high GC-rich bias in the third wobble position of codons clearly delineates the coding regions for many but not all proteins. There are also two novel captured cellular genes, including a C-type lectin (vECTL) and an O-linked acetylglucosamine transferase (vOGT), as well as an unusually large and complex Ori-Lyt dyad symmetry domain. Finally, 30 kb from a second strain proved to include three small chimeric domains, indicating the existence of distinct EEHV4A and EEHV4B subtypes. © 2016 The Authors.

C. Lowe & U. Münster

The viral creep. Elephants and herpes in times of extinction

Environmental Humanities 8 (2016) 118-142

Abstract. Across the world, elephant endo-

theliotropic herpesvirus is increasingly killing elephant calves and threatening the long-term survival of the Asian elephant, a species that is currently facing extinction. This article presents three open-ended stories of elephant care in times of death and loss: at places of confinement and elephant suffering like the zoos in Seattle and Zürich as well as in the conflict-ridden landscapes of South India, where the country's last free-ranging elephants live. Our stories of deadly viral-elephant-human becomings remind us that neither human care, love, and attentiveness nor techniques of control and creative management are sufficient to fully secure elephant survival. The article introduces the concept of "viral creep" to explore the ability of a creeping, only partially knowable virus to rearrange relations among people, animals, and objects despite multiple experimental human regimes of elephant care, governance, and organization. The viral creep exceeds the physical and intellectual contexts of human interpretation and control. It reminds us that uncertainty and modes of imaging are always involved when we make sense of the world around us. © 2016 The Authors.

K. Manoj, R. Raghavan & B. Allwin
Assessment of the distribution of herbivores in the elephant corridors, Mettupalayam Forest Range, Tamil Nadu, India
Poultry, Fisheries & Wildlife Sciences 4 (2016) e165

Abstract. Mettupalayam is located at 11.3000°N 76.9500°E. It has an average elevation of 314 metres (MSL). Mettupalayam is situated on the bank of Bhavani River at the foot of the Nilgiri mountains. Population density, distribution pattern of herbivores is very important for conservation as the presence of herbivore population represents the carnivores' activity of that particular habitat. Both herbivores and carnivore population density are important for management and conserving a particular habitat especially the biodiversity hot spots that sustain the existence of wild animals having a qualified and balanced habitat meeting out the pyramidal quotients that are required for the effective functioning of the bio-system and the flow of energy between the tiers. The line transects and distance sampling methodology was used to estimate population densities of both

the carnivores and herbivores in Mettupalayam Forest Range especially in the three elephant corridors, The Jaccanari-Vedar Colony corridor, Kallar-Jaccanari corridor, Kallar-Nellithurai corridor. Hence, considering the potentiality of long term conservation value and existing and growing human population in the Mettupalayam Forest Range it is essential to know the status and distribution pattern of herbivores for conservation management. The aim of this paper was to identify the major herbivore population in the elephant corridors so as to get the overview of the bearing effect of these species, the co-existing interactions and its habitat utilization. © 2016 The Authors.

C.L. Meehan, J.N. Hogan, M.K. Bonaparte-Saller & J.A. Mench

Housing and social environments of African (*Loxodonta africana*) and Asian (*Elephas maximus*) elephants in North American zoos

PLoS ONE 11 (2016) e0146703

Abstract. We evaluated 255 African (*Loxodonta africana*) and Asian (*Elephas maximus*) elephants living in 68 North American zoos over one year to quantify housing and social variables. All parameters were quantified for the both the day and the night and comparisons were made across these time periods as well as by species and sex. To assess housing, we evaluated not only total exhibit size, but also individual animals' experiences based on the time they spent in the unique environments into which the exhibits were subdivided. Variables developed to assess housing included measurements of area as a function of time (Total Space Experience), environment type (Indoor, Outdoor, In/Out Choice) and time spent on hard and soft flooring. Over the year, Total Space Experience values ranged from 1,273 square feet to 169,692 square feet, with Day values significantly greater than Night values ($p < 0.001$). Elephants spent an average of 55.1% of their time outdoors, 28.9% indoors, and 16% in areas with a choice between being in or out. Time spent on hard flooring substrate ranged from 0% to 66.7%, with Night values significantly greater than Day ($p < 0.001$). Social factors included number of animals functionally housed together (Social Experience) and social group characteristics such as time

spent with juveniles and in mixed-sex groups. Overall Social Experience scores ranged from 1 to 11.2 and were significantly greater during the Day than at Night ($p < 0.001$). There were few significant social or housing differences between African ($N = 138$) and Asian ($N = 117$) species or between males ($N = 54$) and females ($N = 201$). The most notable exception was Total Space Experience, with African and male elephants having larger Total Space Experience than Asian and female elephants, respectively ($P\text{-value} < 0.05$). The housing and social variables evaluated herein have been used in a series of subsequent epidemiological analyses relating to various elephant welfare outcomes. © 2016 The Authors.

C.L. Meehan, J.A. Mench, K. Carlstead & J.N. Hogan

Determining connections between the daily lives of zoo elephants and their welfare: An epidemiological approach

PLoS ONE 11 (2016) e0158124

Abstract. Concerns about animal welfare increasingly shape people's views about the acceptability of keeping animals for food production, biomedical research, and in zoos. The field of animal welfare science has developed over the past 50 years as a method of investigating these concerns via research that assesses how living in human-controlled environments influences the behavior, health and affective states of animals. Initially, animal welfare research focused on animals in agricultural settings, but the field has expanded to zoos because good animal welfare is essential to zoos' mission of promoting connections between animals and visitors and raising awareness of conservation issues. A particular challenge for zoos is ensuring good animal welfare for long-lived, highly social species like elephants. Our main goal in conducting an epidemiological study of African (*Loxodonta africana*) and Asian (*Elephas maximus*) elephant welfare in 68 accredited North American zoos was to understand the prevalence of welfare indicators in the population and determine the aspects of an elephant's zoo environment, social life and management that are most important to prevent and reduce a variety of welfare problems. In this overview, we provide a

summary of the findings of the nine papers in the collection titled: Epidemiological Investigations of North American Zoo Elephant Welfare with a focus on the life history, social, housing, and management factors found to be associated with particular aspects of elephant welfare, including the performance of abnormal behavior, foot and joint problems, recumbence, walking rates, and reproductive health issues. Social and management factors were found to be important for multiple indicators of welfare, while exhibit space was found to be less influential than expected. This body of work results from the largest prospective zoo-based animal welfare study conducted to date and sets in motion the process of using science-based welfare benchmarks to optimize care of zoo elephants. © 2016 The Authors.

M.A. Miller, J.N. Hogan & C.L. Meehan

Housing and demographic risk factors impacting foot and musculoskeletal health in African elephants [*Loxodonta africana*] and Asian elephants [*Elephas maximus*] in North American zoos

PLoS ONE 11 (2016) e0155223

Abstract. For more than three decades, foot and musculoskeletal conditions have been documented among both Asian (*Elephas maximus*) and African (*Loxodonta africana*) elephants in zoos. Although environmental factors have been hypothesized to play a contributing role in the development of foot and musculoskeletal pathology, there is a paucity of evidence-based research assessing risk. We investigated the associations between foot and musculoskeletal health conditions with demographic characteristics, space, flooring, exercise, enrichment, and body condition for elephants housed in North American zoos during 2012. Clinical examinations and medical records were used to assess health indicators and provide scores to quantitate conditions. Using multivariable regression models, associations were found between foot health and age (P value = 0.076; Odds Ratio = 1.018), time spent on hard substrates (P value = 0.022; Odds Ratio = 1.014), space experienced during the night (P value = 0.041; Odds Ratio = 1.008), and percent of time spent in indoor/outdoor exhibits during the day (P

value <0.001; Odds Ratio = 1.003). Similarly, the main risk factors for musculoskeletal disorders included time on hard substrate (P value = 0.002; Odds Ratio = 1.050) and space experienced in indoor/outdoor exhibits (P value = 0.039; Odds Ratio = 1.037). These results suggest that facility and management changes that decrease time spent on hard substrates will improve elephant welfare through better foot and musculoskeletal health. © 2016 The Authors.

K.A. Morfeld, C.L. Meehan, J.N. Hogan & J.L. Brown

Assessment of body condition in African (*Loxodonta africana*) and Asian (*Elephas maximus*) elephants in North American zoos and management practices associated with high body condition scores

PLoS ONE 11 (2016) e0155146

Abstract. Obesity has a negative effect on health and welfare of many species, and has been speculated to be a problem for zoo elephants. To address this concern, we assessed the body condition of 240 elephants housed in North American zoos based on a set of standardized photographs using a 5-point Body Condition Score index (1 = thinnest; 5 = fattest). A multi-variable regression analysis was then used to determine how demographic, management, housing, and social factors were associated with an elevated body condition score in 132 African (*Loxodonta africana*) and 108 Asian (*Elephas maximus*) elephants. The highest BCS of 5, suggestive of obesity, was observed in 34% of zoo elephants. In both species, the majority of elephants had elevated BCS, with 74% in the BCS 4 (40%) and 5 (34%) categories. Only 22% of elephants had BCS 3, and less than 5% of the population was assigned the lowest BCS categories (BCS 1 and 2). The strongest multi-variable model demonstrated that staff-directed walking exercise of 14 hours or more per week and highly unpredictable feeding schedules were associated with decreased risk of BCS 4 or 5, while increased diversity in feeding methods and being female was associated with increased risk of BCS 4 or 5. Our data suggest that high body condition is prevalent among North American zoo elephants, and management strategies that help prevent and mitigate obesity may lead to

improvements in welfare of zoo elephants. © 2016 The Authors.

A.M. Moßbrucker, C.H. Fleming, M.A. Imron, S. Pudyatmoko & Sumardi

AKDE_C home range size and habitat selection of Sumatran elephants

Wildlife Research 43 (2016) 566-575

Abstract. Context. Understanding ranging behaviour and habitat selection of threatened species is crucial for the development of conservation strategies and the design of conservation areas. Our understanding of the actual needs of the critically endangered Sumatran elephant in this context is insufficient. Aims. Provide reliable subspecies-specific information on home range size and habitat selection of Sumatran elephants. Methods. Using both the new area-corrected autocorrelated kernel density estimation (AKDE_C) and two commonly applied conventional methods, the home range sizes of nine Sumatran elephants were estimated. Elephant habitat selection was studied using Manly's selection ratios. Key results. AKDE_C home ranges of adults ranged from 275 km² to 1352 km². Estimates obtained using conventional KDE and minimum convex polygon (MCP) ranged between 156 km² and 997 km². Overall habitat selection was significant for both slope and land-cover type, whereas individual preferences varied to some extent. On the basis of global selection ratios, we found natural forest, pulpwood plantations and gentle slopes ($\leq 4^\circ$) to be significantly selected, whereas most areas affected by human activities and steeper slopes were avoided by the majority of animals included in the study. Conclusions. As expected, AKDE_C estimates were much larger than those obtained using conventional methods because conventional methods have a tendency to underestimate home range size when confronted with autocorrelated movement data and produce estimates that refer to the limited study period only, whereas AKDE_C estimates include the predicted animal's long-term space use. The extremely large AKDE_C estimate obtained for a subadult male most likely represents a combination of population dispersal range and temporary home range rather than its final adult home range. Regardless, it appears that Sumatran elephants roam over much larger

areas than previously assumed. Natural forests and relatively flat areas are of great importance for Sumatran elephants. The observed intensive use of pulpwood plantations by one individual is likely because of limited availability of alternative suitable habitats. Implications. A landscape-wide approach to elephant conservation that takes large home ranges into account, is required, and should include forest protection and restoration and elephant friendly management of existing pulpwood concessions, with special focus on areas with relatively gentle slopes. © 2016 With permission from CSIRO Publishing.

A.M. Moßbrucker, M.A. Imron, S. Pudyatmoko, P.-H. Pratje & Sumardi

Modeling the fate of Sumatran elephants in Bukit Tigapuluh Indonesia: Research needs & implications for population management

Jurnal Ilmu Kehutanan 10 (2016) 5-18

Abstract. The critically endangered Sumatran elephant persists in mainly small and isolated populations that may require intensive management to be viable in the long term. Population Viability Analysis (PVA) provides the opportunity to evaluate conservation strategies and objectives prior to implementation, which can be very valuable for site managers by supporting their decision making process. This study applies PVA to a local population of Sumatran elephants roaming the Bukit Tigapuluh landscape, Sumatra, with the main goal to explore the impact of pre-selected conservation measures and population scenarios on both population growth rate and extinction probability. Sensitivity testing revealed considerable parameter uncertainties that should be addressed by targeted research projects in order to improve the predictive power of the baseline population model. Given that further habitat destruction can be prevented, containing illegal killings appears to be of highest priority among the tested conservation measures and represents a mandatory pre-condition for activities addressing inbreeding depression such as elephant translocation or the establishment of a conservation corridor.

C.M.-C. Oelrichs, D.J. Lloyd & L. Christidis

Strategies for mitigating forest arson and elephant conflict in Way Kambas National

Park, Sumatra, Indonesia

Tropical Conservation Science 9 (2016) 565-583

Abstract. Forests in Indonesia are disappearing at an alarming rate, because the large population of poor rural people require land for agriculture. In Indonesia, forest fire is used to clear land and for protest, indirectly increasing opportunities for human-elephant interaction. Human-elephant conflict is a problem for elephant conservation and human wellbeing in all areas where elephants and humans compete for space, and is most severe in Asia. This paper presents a case study of poor rural people living near Way Kambas National Park, on the island of Sumatra. The park is valued for its critically endangered and endangered mega-fauna, but is a hotspot for both forest arson and human-elephant conflict. We describe the multifactorial conflict happening in the park, which involves arson, poaching, police brutality, and violation of elephants. Workshops with villagers and park stakeholders reveal villager-park interaction, and expose multiple levels of resentment and vicious retribution. Villagers resent the park for a multitude of reasons and take direct action, burning the park and killing elephants. We conclude that saving Way Kambas National Park will ultimately require construction of a barrier preventing human and elephant movement in and out of the park. However in the immediate term, successful conservation must understand and address villager-park conflict, respond to threats of arson, and help villagers protect farms from elephants. © 2016 The Authors.

S. Paudel, M.A. Villanueva, S.K. Mikota, C. Nakajima, K.P. Gairhe, S. Subedi, N. Rayamajhi, M. Sashika, M. Shimosuru, T. Matsuba, Y. Suzuki & T. Tsubota

Development and evaluation of an interferon- γ release assay in Asian elephants (*Elephas maximus*)

Journal of Veterinary Medical Science 78 (2016) 1117-1121

Abstract. We developed an interferon- γ release assay (IGRA) specific for Asian elephants (*Elephas maximus*). Whole blood collected from forty captive Asian elephants was stimulated with three different mitogens i.e., phytohemagglutinin (PHA), pokweed mitogen (PWM) and phorbol

myristate acetate/ionomycin (PMA/I). A sandwich ELISA that was able to recognize the recombinant elephant interferon- γ (rEIFN- γ) as well as native interferon- γ from the Asian elephants was performed using anti-elephant IFN- γ rabbit polyclonal antibodies as capture antibodies and biotinylated anti-elephant IFN- γ rabbit polyclonal antibodies as detection antibodies. PMA/I was the best mitogen to use as a positive control for an Asian elephant IGRA. The development of an Asian elephant-specific IGRA that detects native IFN- γ in elephant whole blood provides promising results for its application as a potential diagnostic tool for diseases, such as tuberculosis (TB) in Asian elephants. © 2016 Japanese Society of Veterinary Science.

D.M. Powell & C. Vitale

Behavioral changes in female Asian elephants when given access to an outdoor yard overnight
Zoo Biology 35 (2016) 298–303

Abstract. A study was conducted at the Bronx Zoo to determine whether providing elephants with access to an outdoor corral at night had any significant effects on behavior, use of space, and use of a sand corral. Activity budgets for three female Asian elephants were compared when the subjects were housed indoors overnight and when they were given access to an outdoor yard overnight. Observations were recorded via infrared video cameras between the hours of 1900 and 0700 during the months of July–September. Two of the three elephants showed a significant preference for spending time outdoors, whereas, the third elephant spent most of her time indoors. Standing and play behavior increased when the elephants had outdoor access while lying down and feeding behavior decreased. Swaying behavior decreased significantly when the elephants had access to the outdoor yard. The elephants made very little use of a sand-floor stall regardless of whether or not they had access to outdoors. The results of this study, suggest that having access to alternate areas overnight can promote well-being by reducing repetitive behavior and allowing animals to express their preferences for different locations. The relative importance of choice alone vs. the behavioral opportunities provided by choice options for zoo animals is discussed. © 2016 Wiley Periodicals.

N.A. Prado-Oviedo, M.K. Bonaparte-Saller, E.J. Malloy, C.L. Meehan, J.A. Mench, K. Carlstead & J.L. Brown

Evaluation of demographics and social life events of Asian (*Elephas maximus*) and African elephants (*Loxodonta africana*) in North American zoos

PLoS ONE 11 (2016) e0154750

Abstract. This study quantified social life events hypothesized to affect the welfare of zoo African and Asian elephants, focusing on animals that were part of a large multi-disciplinary, multi-institutional elephant welfare study in North America. Age was calculated based on recorded birth dates and an age-based account of life event data for each elephant was compiled. These event histories included facility transfers, births and deaths of offspring, and births and deaths of non-offspring herd mates. Each event was evaluated as a total number of events per elephant, lifetime rate of event exposure, and age at first event exposure. These were then compared across three categories: species (African vs. Asian); sex (male vs. female); and origin (imported vs. captive-born). Mean age distributions differed ($p < 0.05$) between the categories: African elephants were 6 years younger than Asian elephants, males were 12 years younger than females, and captive-born elephants were 20 years younger than imported elephants. Overall, the number of transfers ranged from 0 to 10, with a 33% higher age-adjusted transfer rate for imported African than imported Asian elephants, and 37% lower rate for imported females than males ($p < 0.05$). Other differences ($p < 0.05$) included a 96% higher rate of offspring births for captive-born females than those imported from range countries, a 159% higher rate of birthing event exposures for captive-born males than for their imported counterparts, and Asian elephant females being 4 years younger than African females when they produced their first calf. In summarizing demographic and social life events of elephants in North American zoos, we found both qualitative and quantitative differences in the early lives of imported versus captive-born elephants that could have long-term welfare implications. © 2016 The Authors.

T. Pursell, J. Tan, R.S. Peng & P.D. Ling

Generation and validation of new quantitative

real time PCR assays to detect elephant endotheliotropic herpesviruses 1A, 1B, and 4

J. of Virological Methods 237 (2016) 138-142

Abstract. Elephant endotheliotropic herpesviruses (EEHVs) can cause fatal hemorrhagic disease in Asian and African elephants. There are quantitative real time PCR (qPCR) tests that can detect seven known EEHVs (1A, 1B, 2–6) in mucosal secretions, tissue isolates, and blood samples. However, current qPCR tests are unable to distinguish between EEHV 1A and 1B or 3 and 4. To address these inadequacies, new qPCR assays were generated and validated to specifically detect EEHV 1A, 1B, and 4. Each assay demonstrated robust efficiency, a broad linear range, and low intra- and inter-assay variability. Each also proved to be specific for its EEHV target when tested against known banked samples from past EEHV cases. The EEHV1A and 1B assays were then used to characterize an eight-week, low level EEHV1 viremic event in a young Asian elephant. These new tests will allow veterinarians and researchers to pinpoint the specific species causing infection more rapidly. They will also allow veterinarians and elephant keepers to better characterize the EEHV status of each animal within their herd leading to more informed management strategies. © 2016 Reprinted with permission from Elsevier.

P.G.A. Pushpakumara, R.C. Rajapakse, B.M.A.O. Perera & J.L. Brown

Reproductive performance of the largest captive Asian elephant (*Elephas maximus*) population in Sri Lanka

Animal Reproduction Science 174 (2016) 93-99

Abstract. The Pinnawela Elephant Orphanage (PEO) in Sri Lanka maintains one of the largest captive Asian elephant (*Elephas maximus maximus*) populations in the world, with a total of 79 animals (45 females and 34 males) at present. It was established in 1975 as an orphanage for rescued wild calves, and commenced natural breeding under controlled conditions when they reached breeding age. This study summarizes reproductive data of 65 live births from 38 years of records at PEO. The age at first calving (n = 31) was 14.6 ± 0.7 years, and the numbers of females giving birth two, three, four and five times were 21, 8, 4 and 2, with corresponding inter-birth

intervals (IBI) of 4.9 ± 0.3 , 4.8 ± 0.5 , 7.9 ± 1.9 and 5.7 ± 0.5 years, respectively. Females giving birth to males (5.7 ± 2.2 years) had longer IBIs compared to birthing female calves (4.7 ± 1.1 years). The average gestation for 18 pregnancies with known conception dates was 667 ± 11 days. The average birth weight was similar for male (83.1 ± 4.6 kg; n = 14) and female (82.8 ± 8.4 kg; n = 6) calves. Sex ratio for live births was 36 male : 29 female and not different from 1:1; however, more males (10/14) were born after a second parity. Calf mortality and stillbirth rates were low: 7.6% and 4.4%, respectively. This study highlights the successful breeding program at the PEO, providing baseline reproductive data that can aid in improving breeding of other elephants managed under captive conditions. © 2016 Reprinted with permission from Elsevier.

J.-P. Puyravaud & P. Davidar

Culling of Asian elephants and overextension of population modelling

Biological Conservation 201 (2016) 423

Abstract. none.

X. Qiao, J. Hu, D. Wu, L. Wei, Y. Yang, J. Chen, B. Mi & S.Q. Yang

Isolation and identification of *Microsporium canis* from Asian elephants (*Elephas maximus*) in the Chongqing Zoo, China

Journal of Zoo and Wildlife Medicine 47 (2016) 844-845

Abstract. Skin diseases affect millions of people and animals worldwide, including Asian elephants. This study sought to determine the pathogen of skin diseases that occurred in Asian elephants in Chongqing Zoo, China. The isolated fungus was identified through its cultural characteristics, morphology, and polymerase chain reaction (PCR) amplification. The PCR amplification using common fungal primers (ITS1 and ITS4) determined that the pathogen was 99.7% homologous to *Microsporium canis*. This is the first report on elephants infected with *Microsporium canis* in China. © 2016 American Association of Zoo Veterinarians.

R.M.W. Rathnayake

Pricing the enjoyment of 'elephant watching' at the Minneriya National Park in Sri Lanka:

An analysis using CVM

Tourism Management Perspectives 18 (2016) 26-33

Abstract. The Minneriya National Park (MNP) is noted among elephant conservation areas in Sri Lanka for the excellent elephant (*Elephas maximus*) viewing opportunities that it provides to both domestic and foreign tourists. Given its high reputation, the present study estimates the optimum entrance fee that could be charged from visitors for 'observing elephants' at the Park. The Contingent Valuation Method (CVM) was used to determine the appropriate entrance fee. The study interviewed 407 visitors to MNP, using a closed-ended questionnaire. The estimated mean willingness to pay (WTP) per domestic visitor was SLR 172.00 (USD 1.30). If this park fee is implemented, the revenue of the Park would increase up to SLR 6.81 million per year, which would be a 49% increase in revenue and a 48% decrease in visitors compared to current values. The study recommends introducing a pricing policy for observing elephants at the Park. © 2016 Reprinted with permission from Elsevier.

D.J. Richmond, M.-H.S. Sinding & M.T.P. Gilbert

The potential and pitfalls of de-extinction

Zoologica Scripta 45 (2016) 22-36

Abstract. 'De-extinction' is the nascent discipline that aims to one day literally revive now-extinct species from the dead. Although we have yet to see any successful attempts to truly resurrect an extinct species, several technologies are now in place that might one day provide a plausible solution. Thus, the area is receiving increased attention from both scientists and the general public. However, how far does present technology place us from the ultimate goal? We address the state of the art of several prominent de-extinction methods: back-breeding, cloning, synthetic genomics and genome editing, and discuss some of the major outstanding challenges for each. We also discuss some of the wider challenges facing de-extinction, including both what might constitute the definition of success and what might be needed to successfully take a recreated animal and confer on it the ability to establish itself back in the wild. © 2016 The Authors.

C.K. Rohini, T. Aravindan, P.A. Vinayan, M. Ashokkumar & K.S. Anoop Das

An assessment of human-elephant conflict and associated ecological and demographic factors in Nilambur, Western Ghats of Kerala, southern India

Journal of Threatened Taxa 8 (2016) 8970-8976

Abstract. Elephant conservation carries cost in the form of human-elephant conflict and affects the wellbeing of people living near ecologically important areas. Conflicts impart serious challenges towards the survival of Asian Elephants, which are categorized as Endangered in the IUCN Red List of Threatened Species. Issues of wildlife conservation are least addressed in areas with less restricted categories of protection. Hence an attempt was made to evaluate the intensity of elephant conflict and factors associated with its occurrence in villages with forest fringes of North and South Forest Divisions of Nilambur, Kerala, southern India. It was hypothesized that variables such as number of houses, area of village, livestock population, forest frontage, and presence of water source along the forest boundary abutting the village to be the underlying correlates of conflict. Field studies were conducted fortnightly from June 2014 to May 2015, by visiting farms and households of 17 selected forest fringe villages. Observational methods, questionnaire surveys and secondary data collection were employed for this purpose. A total of 277 incidents of crop depredation, 12 incidents of property damage, three human injuries, and one human death due to conflict were recorded during this period. Crop raiding was highest during post monsoon season and it was low during pre-monsoon and monsoon seasons. Multiple linear regression results suggest that forest frontage and livestock population were significant predictors of conflict incidence. Information regarding the prime causes of conflict will be helpful for planning strategies for the establishment of appropriate mitigation methods. The present study serves as baseline information which will be helpful for formulating prospective management plans. © 2016 The Authors.

K. Seilern-Moy, M.F. Bertelsen, P.S. Leifsson, K.L. Perrin, J. Haycock & A. Dastjerdi

Fatal elephant endotheliotropic herpesvirus-1 and 4 co-infection in a juvenile Asian elephant in Europe

JMM Case Reports (2015)

Abstract. Introduction: Elephant Endotheliotropic Herpesvirus-1 (EEHV-1) is one of the major causes of fatality in juvenile Asian elephants (*Elephas maximus*). On occasions, other EEHV genotypes, EEHV-3, 4 and 5 have also been reported as the cause of Asian elephant deaths. In this case report we describe the investigation into a juvenile Asian elephant fatality in a European zoo. Case Presentation: A fatal case of haemorrhagic disease in a juvenile Asian elephant from a European zoo was diagnosed with co-infection of EEHV-1 and 4. EEHV-4 had a wider organ distribution and a higher viral load; both viruses presented the highest load in the mesenteric lymph nodes. Conclusion: Detection of EEHV-4 in this fatal case in Europe underlines the importance of inclusion of all known Asian elephant endotheliotropic herpesviruses in routine blood monitoring to facilitate early therapeutic intervention. © 2016 The Authors.

M. Songer, M. Aung, T.D. Allendorf, J.M. Calabrese & P. Leimgruber

Drivers of change in Myanmar's wild elephant distribution

Tropical Conservation Science (2016) Oct-Dec

Abstract. Myanmar is considered as a stronghold for wild elephants, though past estimates varied widely from 3000 to 10,000. Results of a 2004 expert workshop showed estimates between 1430 and 2065. Building on surveys from 1990 to 1992, we conducted new expert interviews in townships throughout the range, with questions focusing on numbers of elephants living in townships and threats to and from elephants. We used general linear models to analyze characteristics of townships with and without elephants and to understand factors influencing changes in elephant presence. Our results show a major decrease in the geographic distribution of wild elephants in Myanmar between 1992 and 2006 with deforestation being the major driver. While forest cover is important for elephant presence, continuity with other elephant populations had a stronger influence on elephant persistence between surveys.

Fragmentation of elephant populations is also a major driver of decline. Increases in forest cover increased elephant presence, while increases in edge and human population had the reverse effect. Deforestation and fragmentation lead to increased human-elephant conflict in some areas, sometimes concluding with the capture of elephants for timber operations and further draining wild populations. A national elephant action plan that includes monitoring of elephant status and threats is urgently needed and critical for Myanmar's wild elephants, particularly as more than 50 years of political isolation are rapidly ending and pressure on the country's natural resources is increasing exponentially. © 2016 The Authors.

S. Sripiboon, B. Jackson, W. Ditcham, C. Holyoake, I. Robertson, C. Thitaram, P. Tankaw, P. Letwatcharasarakul & K. Warren

Molecular characterisation and genetic variation of elephant endotheliotropic herpesvirus infection in captive young Asian elephants in Thailand

Infection, Genetics and Evol. 44 (2016) 487-494

Abstract. Elephant Endotheliotropic Herpesvirus (EEHV) is emerging as a new threat for elephant conservation, since being identified as the cause of severe, often fatal, haemorrhagic disease in young Asian elephants. To describe positive cases and the molecular relatedness of virus detected in elephants in Thailand, we re-examined all available of EEHV samples occurring in young elephants in Thailand between 2006 and 2014 (n = 24). Results indicated 75% (18/24) of suspected cases were positive for EEHV by semi-nested PCR. Further gene analysis identified these positive cases as EEHV1A (72%, 13/18 cases), EEHV1B (11%, 2/18) and EEHV4 (17%, 3/18). This study is the first to phylogenetically analyse and provide an overview of most of the known EEHV cases that have occurred in Thailand. Positive individuals ranged in age from one to nine years, with no sex association detected, and occurred across geographical locations throughout the country. All individuals, except one, were captive-born. No history of direct contact among the cases was recorded, and this together with the fact that various subtype clusters of virus were found, implied that none

of the positive cases were epidemiologically related. These results concur with the hypothesis that EEHV1 is likely to be an ancient endogenous pathogen in Asian elephants. It is recommended that active surveillance and routine monitoring for EEHV should be undertaken in all elephant range countries, to gain a better understanding of the epidemiology, transmission and prevention of this disease. © 2016 Reprinted with permission from Elsevier.

R. Srivastava & R. Tyagi

Wildlife corridors in India: Viable legal tools for species conservation?

Environmental Law Review 18 (2016) 205-223

Abstract. Wildlife corridors, used by various species to migrate, breed and feed, are increasingly becoming relevant as essential tools for wildlife conservation. Rapid increase in industrial and infrastructural development, especially around forests, has resulted in widespread habitat fragmentation and isolation. Added to this, the growing development (for tourism, linear infrastructure etc.) around protected areas, and the altered de facto boundaries of these, have exacerbated this need. There is, however, no 'hard' statutory recognition afforded in India to wildlife corridors in spite of their established relevance in ecological conservation. Nor is there a strict prohibition on development within, and around important corridors in India. Even so, wildlife corridors have found passing mention in certain conservation law and guidelines framed thereunder, which seek to protect wildlife habitat and reduce human-wildlife conflict. These extant legal spaces have largely proved ineffective in the protection and conservation of corridors, and corridor protection and management continues to be a dormant legal space in India. This paper seeks to analyse the various barriers to corridor conservation and management, and whether the existing legal measures are underutilised in providing legal protection to wildlife corridors, without the need of a parallel institutional framework. Through an understanding of the criticality of corridors to wildlife conservation, the adequacy of existing legal structures has been examined by the authors, and recommendations made for augmenting the current legal framework with more concrete strategies. © 2016 The Authors.

Raman Sukumar

Iconic fauna of heritage significance in India *Indian Journal of History of Science 51 (2016) 369-379*

Abstract. There are many reasons why an animal becomes iconic in human cultures – admiration for certain qualities of the animal, its mere presence in or association with our environment, its utility to our endeavours, and fear of the creature that may even result in its worship. Given the equal status to all forms of life in ancient Indian religions, it is not surprising that “iconic fauna of heritage significance” in the country include not just the largest or fiercest animals (elephant, tiger and lion), but also a number of birds (peacock, eagle, vulture, sarus crane) and even insects (ant, honey bee, praying mantis). This essay traces the possible reasons for the iconic status and heritage significance of a representative set of mammals, birds, reptiles, fish, and insects. As this volume is devoted to a genomic view of India's heritage species, I also provide a brief introduction to the evolutionary history and phylogenetics of most of these faunal taxa described here. © 2016 Indian National Science Academy.

M. Sulak, L. Fong, K. Mika, S. Chigurupati, L. Yon, N.P. Mongan, R.D. Emes & V.J. Lynch

TP53 copy number expansion is associated with the evolution of increased body size and an enhanced DNA damage response in elephants

eLife 5 (2016) e11994

Abstract. A major constraint on the evolution of large body sizes in animals is an increased risk of developing cancer. There is no correlation, however, between body size and cancer risk. This lack of correlation is often referred to as 'Peto's Paradox'. Here, we show that the elephant genome encodes 20 copies of the tumor suppressor gene TP53 and that the increase in TP53 copy number occurred coincident with the evolution of large body sizes, the evolution of extreme sensitivity to genotoxic stress, and a hyperactive TP53 signaling pathway in the elephant (Proboscidean) lineage. Furthermore, we show that several of the TP53 retrogenes (TP53RTGs) are transcribed and likely translated. While TP53RTGs do not appear to directly function as transcription factors, they

do contribute to the enhanced sensitivity of elephant cells to DNA damage and the induction of apoptosis by regulating activity of the TP53 signaling pathway. These results suggest that an increase in the copy number of TP53 may have played a direct role in the evolution of very large body sizes and the resolution of Peto's paradox in Proboscideans. © 2016 The Authors.

N. Thongtip, B. Lorsunyaluck, M. Sukmak, S. Chaichanathong, & P. Sunyathiseree

Urethral rupture and leakage following prolonged surgical removal of urethral and bladder stones by episiotomy and urethrotomy in female Asian elephant (*Elephas Maximus*): A case report

Thai Journal of Veterinary Medicine 46 (2016) 325-329

A 46-year-old female Asian elephant (*Elephas maximus*) with an abnormal ballottement mass in the perineal area was presented. The elephant was unable to urinate via the normal tract. Previously, this elephant was treated for urethral and bladder obstruction caused by stones by episiotomy and urethrotomy. Eight months later, post-operative care was completed. At this point, the incision wound completely closed and the elephant could urinate through the normal tract. However, the elephant was then mated with an adult male elephant. Three weeks later, the female showed signs of the perineal ballottement mass and was unable to urinate. Episiotomy and urethrotomy were performed following the previous incision line. After resectioning through the urethra, urine from the urinary bladder flowed through the incision wound and urine scalding was found. Then, daily wound cleaning was conducted for two months. Finally, the surgical wound completely closed and a new urinated tract behind the vulva opening was completely formed. © 2016 The Thai Journal of Veterinary Medicine.

V. Varadharajan, T. Krishnamoorthy & B. Nagarajan

Prevalence of stereotypies and its possible causes among captive Asian elephants (*Elephas maximus*) in Tamil Nadu, India

Applied Animal Behaviour Science 174 (2016) 137-146

Abstract. Animals in captivity are often confined in small barren enclosures, preventing adequate exercise, and socialization with conspecifics. Captivity is also known for depriving young individuals' association with maternal relatives by weaning away from their mothers' earlier than what their peers experience in free-living populations. Such husbandry practices often lead to various welfare problems among captive animals. In India, Asian elephants are managed in captivity under various systems, for various purposes. To understand the effect of husbandry practices on the welfare of elephants, this study first time from a range country examined the prevalence of stereotypies and its possible causes among 144 captive Asian elephants managed under three captive systems—Private, Hindu Temple and Forest Department—in southern India. Occurrence of stereotypies and its possible influences by factors like age, sex, housing type and its size, duration of chaining and access to conspecific socialization were obtained by direct observations on each elephant and from registers maintained at each facility. Among the systems, the number of elephants with stereotypies was the highest in temple system (49%) followed by private (25%) and the lowest in the forest department (7%). None of the elephants that born in or brought from the wild and managed only at the timber camps was stereotyped. But those transferred from the timber camps to the temple, private and zoo and from the zoo to the timber camps showed stereotypies. Consistent with the prevalence of stereotypies among the three systems, number of elephants managed only at the indoor enclosure and duration of chaining were the highest in temple followed by private and the least in forest department system. The proportion of elephants displaying stereotypies and the proportion of time spent on stereotypies decreased significantly with age, indicating a greater vulnerability of young individuals to stereotypies. Further, logistic regression on prevalence of stereotypies with demographic and welfare parameters revealed that stereotypies decreased significantly with age and free access to conspecific association until juvenile stage, indicating again the juveniles without conspecific association are more susceptible to develop stereotypies. Multiple regression on extent of

stereotypes and various daily routines revealed that the extent increased significantly with daily rituals, resting, and marginally with feeding implying that prolonged daily rituals and resting promote its extent. It is argued that deprivation of association with maternal relatives and isolation from conspecifics result in the appearance of stereotypes among elephants in captivity, with younger individuals being more susceptible, perhaps the most active phase of their life being confined by chaining.

T.N.C. Vidya

Evolutionary history and population genetic structure of Asian elephants in India

Indian J. of History of Science 51 (2016) 391-405

Abstract. The Asian elephant (*Elephas maximus*), which has shared a long and rich cultural relationship with humans in India, is endangered in the country today, largely because of habitat loss. There are an estimated 41,400-52,300 Asian elephants worldwide, of which over half range in India. I describe studies that examined the evolutionary history of the Asian elephant, uncovering a surprising coexistence of divergent clades of mitochondrial DNA (mtDNA) within the species, often within populations. Several hypotheses were proposed to explain this coexistence of divergent clades, but it required extensive sampling of elephants from India (because of its large populations of elephants), along with samples from other countries, to gain an understanding of Asian elephant phylogeography, which was found to be largely shaped by Pleistocene climatic oscillations. I also describe studies of the genetic variability of the Indian populations based on mtDNA and nuclear microsatellite DNA and discuss reasons for the patterns seen. Examination of population genetic structure within India, and the geographic barriers that gave rise to such structuring are also described. I end with possibilities for future research, such as addressing the possibility of subspecies within the Asian elephant, understanding the low levels of genetic diversity in southern India, and explaining patterns of population genetic differentiation and breaks in gene flow in elephants and other animals in southern and northeastern India. © 2016 Indian National Science Academy.

Geoffrey Wandesforde-Smith

Looking for law in all the wrong places? Dying elephants, evolving treaties, and empty threats

Journal of International Wildlife Law & Policy 19 (2016) 365-381

Abstract. none

K.A. Weston-Ford, M.L. Moseley, L.J. Hall, N.P. Marsh, R.M. Morgan & L.P. Barron

The retrieval of fingerprint friction ridge detail from elephant ivory using reduced-scale magnetic and non-magnetic powdering materials

Science & Justice 56 (2016) 1-8

Abstract. An evaluation of reduced-size particle powdering methods for the recovery of usable fingerprint ridge detail from elephant ivory is presented herein for the first time as a practical and cost-effective tool in forensic analysis. Of two reduced-size powder material types tested, powders with particle sizes $\leq 40 \mu\text{m}$ offered better chances of recovering ridge detail from unpolished ivory in comparison to a conventional powder material. The quality of developed ridge detail of these powders was also assessed for comparison and automated search suitability. Powder materials and the enhanced ridge detail on ivory were analysed by scanning electron microscopy and energy dispersive X-ray spectroscopy and interactions between their constituents and the ivory discussed. The effect of ageing on the quality of ridge detail recovered showed that the best quality was obtained within 1 week. However, some ridge detail could still be developed up to 28 days after deposition. Cyanoacrylate and fluorescently-labelled cyanoacrylate fuming of ridge detail on ivory was explored and was less effective than reduced-scale powdering in general. This research contributes to the understanding and potential application of smaller scale powdering materials for the development of ridge detail on hard, semi-porous biological material typically seized in wildlife-related crimes. © 2015 The Chartered Society of Forensic Sciences. Reprinted with permission from Elsevier.

M.P.B. Wijayagunawardane, R.V. Short, T.S. Samarakone, K.B.M. Nishany, H. Harrington, B.V.P. Perera, R. Rassool & E.P. Bittner

The use of audio playback to deter crop-raiding Asian elephants

Wildlife Society Bulletin 40 (2016) 375-379

Abstract. Human–elephant conflict (HEC) and poaching are the foremost threats to the survival of elephants (African, *Loxodonta africana*; Asian, *Elephas maximus*) in their natural environments. Reducing HEC has the potential to save hundreds of elephant and human lives annually across Asia and Africa. Lone adult male elephants are the principal crop raiders; therefore, we investigated the effectiveness of a variety of audio playbacks at deterring 22 wild adult male Asian elephants from food sources in a wildlife reserve in southern Sri Lanka in January, 2011. Food was provided ad libitum, and the reactions of the elephants in response to various stimuli were recorded and analyzed. Vocalizations from a wild Asian elephant matriarchal group resulted in a flight response in 65% of trials conducted, in contrast to a control sound, a chainsaw, which produced no flight responses from any adult male. We demonstrated that audio playbacks could be used as a short-term deterrent to wild adult male Asian elephants from crop raiding; thus, providing a simple, natural, cost-effective, and humane way of mitigating HEC. © 2016 The Wildlife Society.

E.P. Wong, L. Yon, R. Purcell, S.L. Walker, N. Othman, S. Saaban & A. Campos-Arceiz

Concentrations of faecal glucocorticoid metabolites in Asian elephant's dung are stable for up to 8 h in a tropical environment

Conservation Physiology 4 (2016) cow070

Abstract. The use of faecal glucocorticoid metabolites (fGCMs) has facilitated the development of non-invasive methods to study physiological conditions of endangered wildlife populations. One limitation is that fGCM concentrations are known to change over time and to vary according to different environmental conditions. The aim of this study was to perform a controlled dung decay experiment to understand the impact of time (since defecation) and two common environmental variables (exposure to water and direct sunlight) on fGCM concentrations of Asian elephants (*Elephas maximus*). Eighty dung piles from 10 Malaysian elephants were randomly exposed to a 2 × 2 combination of

treatments (wet–shade, dry–shade, wet–sun and dry–sun) and repeatedly subsampled from the time of defecation through to 2 days post-defecation (n = 685 faecal subsamples). Overall, the mean concentration of fGCMs was stable in samples of up to 8 h old from defecation time, regardless of environmental treatment (water or direct sunlight); thereafter, the overall mean fGCM concentrations increased, peaking 1 day after defecation (31.8% higher than at defecation time), and subsequently decreased (reaching values 9.2% below defecation time on the second day). Overall, the treatment of sun exposure resulted in higher fGCM concentration compared with shade, whereas water exposure (compared with no water exposure) had no impact on fGCM concentrations. Hence, in field studies we recommend collecting dung samples <8 h old and recording shade conditions (e.g. sun vs. shade) as a covariate for the subsequent interpretation of fGCM measurements. This study has helped to identify the optimal window for sampling in which we can have a higher confidence in interpreting the results as being a genuine reflection of glucocorticoid status in the elephant. © 2016 The Authors.

Y. Yakubu, B.L. Ong, Z. Zakaria, L. Hassan, A.R. Mutalib, Y.F. Ngeow, K. Verasahib & M.F.A.A. Razak

Evidence and potential risk factors of tuberculosis among captive Asian elephants and wildlife staff in Peninsular Malaysia

Preventive Veterinary Medicine 125 (2016) 147-153

Abstract. Elephant tuberculosis (TB) caused by *Mycobacterium tuberculosis* is an important re-emerging zoonosis with considerable conservation and public health risk. We conducted prospective cohort and cross-sectional studies in elephants and wildlife staff respectively in order to identify potential risk factors associated with TB in captive Asian elephants and their handlers in Peninsular Malaysia. Sixty elephants in six different facilities were screened for TB longitudinally using the ElephantTB STAT-PAK and DPP VetTB assays from February 2012 to May 2014, and 149 wildlife staff were examined for tuberculosis infection using the QuantiFERON-TB Gold In-tube (QFT) assay

from January to April, 2012. Information on potential risk factors associated with infection in both elephants and staff were collected using questionnaires and facility records. The overall seroprevalence of TB amongst the elephants was 23.3% (95% CI: 13.8–36.3) and the risk of seroconversion was significantly higher among elephants with assigned mahouts [$p = 0.022$, OR = 4.9 (95% CI: 1.3–18.2)]. The percentage of QFT responders among wildlife staff was 24.8% (95% CI: 18.3–32.7) and the risk of infection was observed to be significantly associated with being a zoo employee [$p = 0.018$, OR = 2.7 (95% CI: 1.2–6.3)] or elephant handler [$p = 0.035$, OR = 4.1 (95% CI: 1.1–15.5)]. These findings revealed a potential risk of TB infection in captive elephants and handlers in Malaysia, and emphasize the need for TB screening of newly acquired elephants, isolating sero-positive elephants and performing further diagnostic tests to determine their infection status, and screening elephant handlers for TB, pre- and post-employment. © 2016 Reprinted with permission from Elsevier.

S. Yamamoto-Ebina, S. Saaban, A. Campos-Arceiz & S. Takatsuki

Food habits of Asian elephants *Elephas maximus* in a rainforest of Northern Peninsular Malaysia

Mammal Study 41 (2016) 155-161

Abstract. Little is known about the food habits of Asian elephants (*Elephas maximus*) in tropical rainforests of Southeast Asia. In Peninsular Malaysia, elephant habitat has been extensively modified by human intervention in the past few decades. Most of the primary forest has been logged or given way to plantations, infrastructure, and human inhabitation. Here we compare the food habits of wild elephants in three habitats of Belum-Temengor Forest Complex (BTFC): (1) primary forest, (2) selectively-logged forest, and (3) by the side of a road that bisects the forest complex. We used microhistological fecal analysis to describe elephants' diet. Elephant dung in the primary forest was mainly composed of non-grass monocotyledonous leaves (22%), woody debris (32%), and woody fiber (20%).

Those in the logged forest were similar; non-grass monocotyledonous leaves accounted for 33%, woody debris for 24%, and fiber for 26%. At the roadside, elephant dung was dominated by grasses (47%). We conclude that by the road elephants shift their diet into grasses, suggesting that the road acts like a large forest gap, promoting the availability of grasses and other early succession plants. Elephant feeding by the road poses potential conservation conflicts by means of road accidents and increased contact with people. © 2016 Mammal Society of Japan.

A. Zlot, J. Vines, L. Nystrom, L. Lane, H. Behm, J. Denny, M. Finnegan, T. Hostetler, G. Matthews, T. Storms & E. DeBess

Diagnosis of tuberculosis in three zoo elephants and a human contact – Oregon, 2013

Morbidity and Mortality Weekly Report 64 (2016) 1398-1402

Abstract. In North America, approximately 5% of captive Asian elephants are infected with *Mycobacterium tuberculosis*. Bidirectional spread of *M. tuberculosis* between elephants and humans has been documented. Investigation of a tuberculosis (TB) outbreak among three elephants at an Oregon zoo identified multiple close, casual, and spectator contacts. One hundred and eighteen contacts were identified, 96 of these contacts were screened, and seven close contacts (six recent conversions and one earlier positive test) were found to have latent, noninfectious TB. Whole-genome sequencing revealed that one elephant's *M. tuberculosis* isolate identically matched the isolate of a person with pleural TB who attended a zoo orientation in 2012. The lack of guidance about how to manage captive, TB-infected elephants complicated the decision-making process for protection of zoo contacts, other animals at the zoo, and the general public. Collaboration between public health, veterinary medicine, and occupational health experts could lead to better understanding about associated risks, and could help prevent zoonotic transmission of *M. tuberculosis*. The development of improved TB screening methods for elephants is needed to prevent exposure to humans with close and prolonged contact.