Gajah 44 (2016) 50-67

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 (2016) publications on Asian elephants.

L.M. Abegglen, A.F. Caulin, A. Chan, K. Lee, R. Robinson, M.S. Campbell, W.K. Kiso, D.L. Schmitt, P.J. Waddell, S. Bhaskara, S.T. Jensen, C.C. Maley & J.D. Schiffman
Potential mechanisms for cancer resistance in elephants and comparative cellular response to DNA damage in humans
JAMA 314 (2015) 1850-1860
Abstract. No permission to print abstract free of charge.

Y. Aihara, T. Hosaka, M. Yasuda, M. Hashim & S. Numata
Mammalian wildlife tourism in south-east Asian tropical rainforest: The case of Endau Rompin National Park, Malaysia
J. of Tropical Forest Science 28 (2016) 167-181
Abstract. Wildlife tourism is for the purpose of watching and/or encountering wildlife. In South-east Asia, mammalian wildlife tourism is less popular than in Africa. This is because mammalian wildlife tourism in South-East Asia is generally targeted at terrestrial national parks with forest fauna, as it is difficult to observe mammals in dense rainforest. To assess the potential of a South-East Asian national park for mammalian wildlife tourism, a mixed methods approach was used, 1) mammalian wildlife-based tourist attractions and 2) park use and visitor attitudes towards wildlife in Endau Rompin National Park, Peninsular Malaysia. There are potentially 149 mammalian species, including 24 threatened species, in Endau Rompin National Park. Camera trap data indicated that small and medium sized mammals do occur in these areas frequented by tourists. Footprints, nests, scratches and disturbance traces of various mammals were also observed. However, most visitors did not have high expectations regarding wildlife encounters, nor did many actually see wildlife during their stay. These results implied that animal signs and devices for indirect observation of elusive and/or rare animals were important at sites of mammalian wildlife-based tourism. Additionally, elephants could be a strong attraction for wildlife tourists, but there was concern about conflict between local people and elephants. © 2016 Forest Research Institute Malaysia.

I. Aroch, N. Larian & N. Avni-Magen
Concentrations of free (ionized) and total calcium and magnesium in healthy captive Asian elephants (*Elephas maximus*) and effects of sample type and pH on measured free calcium and magnesium concentrations
Israel J. of Veterinary Medicine 71 (2016) 24-32
Abstract. The Asian elephant (*Elephas maximus*) is an endangered species, with an overall low reproduction rate in captivity, and a long, 22-month gestation, mostly with a single calve. Calcium and magnesium are important for the normal progression of gestation and parturition. This study measured blood total and ionized calcium (tCa and iCa, respectively) and total and ionized magnesium (tMg and iMg, respectively) in four healthy, captive Asian elephant cows in the Tisch Family Zoological Gardens, Jerusalem, every alternative month, over a 1-year period, to establish their reference intervals and examine sample pH and sample type effects on measured iCa and iMg concentrations. iCa and iMg were measured using an ion-selective electrode electrolyte analyzer. Calcium and magnesium levels in diet samples were measured. The iCa:tCa and iMg:tMg ratios were 0.44 and 0.73,

respectively. Mean iMg concentrations in whole-blood, heparinized plasma and serum were 0.58, 0.65 and 0.66 mmol/L, respectively. iCa and iMg concentrations in the three sample types were highly correlated, with no sample type effect on measured iCa concentration, but significant effect on iMg concentration, with significantly lower whole-blood levels vs. serum and plasma. Serum albumin and both tCa and tMg concentrations positively correlated. Sample pH had no effect on measured iCa or iMg levels. This study is the first to measure iMg in Asian elephants, and assess the effects of sample type and pH on the results. It was concluded that different iMg reference intervals should be established for each sample type.

N. Chai, J.L. Pouchelon, J. Bouvard, L.C. Sillero, M. Huynh, V. Segalini, L. Point, V. Croce, G. Rigaux, J. Highwood & V. Chetboul

Proposed simple method for electrocardiogram recording in free-ranging Asian elephants (*Elephas maximus*)

J. of Zoo and Wildlife Medicine 47 (2016) 6-11

Abstract. Electrocardiography represents a relevant diagnostic tool for detecting cardiac disease in animals. Elephants can present various congenital and acquired cardiovascular diseases. However, few electrophysiologic studies have been reported in captive elephants, mainly due to challenging technical difficulties in obtaining good-quality electrocardiogram (ECG) tracings, and no data are currently available for free-ranging Asian elephants (*Elephas maximus*). The purpose of this pilot prospective study was to evaluate the feasibility of using a simple method for recording ECG tracings in wild, apparently healthy, unsedated Asian elephants (n = 7) in the standing position. Successful six-lead recordings (I, II, III, aVR, aVL, and aVF) were obtained, with the aVL lead providing the best-quality tracings in most animals. Variables measured in the aVL lead included heart rate, amplitudes and duration of the P waves, QRS complexes, T and U waves, and duration of the PR, QT, and QU intervals. A negative deflection following positive P waves, representative of an atrial repolarization wave (Ta wave), was observed for five out of the seven elephants. © 2016 American Association of Zoo Veterinarians.

S.N. Chapman, H.S Mumby, J.A.H. Crawley, K.U. Mar, W. Htut, A.T. Soe, H.H. Aung & V. Lummaa

How big is it really? Assessing the efficacy of indirect estimates of body size in Asian elephants

PLoS ONE 11 (2016) e0150533

Abstract. Information on an organism's body size is pivotal in understanding its life history and fitness, as well as helping inform conservation measures. However, for many species, particularly large-bodied wild animals, taking accurate body size measurements can be a challenge. Various means to estimate body size have been employed, from more direct methods such as using photogrammetry to obtain height or length measurements, to indirect prediction of weight using other body morphometrics or even the size of dung boli. It is often unclear how accurate these measures are because they cannot be compared to objective measures. Here, we investigate how well existing estimation equations predict the actual body weight of Asian elephants *Elephas maximus*, using body measurements (height, chest girth, length, foot circumference and neck circumference) taken directly from a large population of semi-captive animals in Myanmar (n = 404). We then define new and better fitting formulas to predict body weight in Myanmar elephants from these readily available measures. We also investigate whether the important parameters height and chest girth can be estimated from photographs (n = 151). Our results show considerable variation in the ability of existing estimation equations to predict weight, and that the equations proposed in this paper predict weight better in almost all circumstances. We also find that measurements from standardised photographs reflect body height and chest girth after applying minor adjustments. Our results have implications for size estimation of large wild animals in the field, as well as for management in captive settings. © 2016 The Authors.

N. Ding, Y. Jiang, L. Han, X. Chen, J. Ma, X. Qu, Y. Mu, J. Liu, L. Li, C. Jiang & X. Huang

Bafilomycins and odoriferous sesquiterpenoids from *Streptomyces albolongus* isolated from *Elephas maximus* feces

Journal of Natural Products 79 (2016) 799-805

Abstract. From a fermentation broth of *Streptomyces albolongus* obtained from *Elephas maximus* feces, nine bafilomycins (1–9) and seven odoriferous sesquiterpenoids (10–16) were isolated. The structures of the new compounds, including three bafilomycins, 19-methoxybafilomycin C1 amide (1), 21-deoxybafilomycin A1 (2), and 21-deoxybafilomycin A2 (3), and two sesquiterpenoid degradation products, (1β,4β,4aβ,8aα)-4,8a-dimethyloctahydro-naphthalene-1,4a(2H)-diol (10) and (1β,4β,4aβ,7α,8aα)-4,8a-dimethyloctahydronaphthalene-1,4a,7(2H)-triol (11), were elucidated by comprehensive spectroscopic data analysis. The cytotoxicity activity against four human cancer cell lines and antimicrobial activities against a panel of bacteria and fungi of all compounds isolated were evaluated. Compounds 1, 7, and 8 were cytotoxic, with IC50 values ranging from 0.54 to 5.02 μM. Compounds 2, 7, 8, and 10 showed strong antifungal activity against *Candida parapsilosis*, with MIC values of 3.13, 1.56, 1.56, and 3.13 μg/mL respectively. © 2016 The American Chemical Society and American Society of Pharmacognosy.

K.L. Edwards, J. Trotter, M. Jones, J.L. Brown, H.W. Steinmetz & S.L. Walkera

Investigating temporary acyclicity in a captive group of Asian elephants (*Elephas maximus*): Relationship between management, adrenal activity and social factors

General and Comparative Endocrinology 225 (2016) 104-116

Abstract. Routine faecal steroid monitoring has been used to aid the management of five captive Asian elephant (*Elephas maximus*) females at Chester Zoo, UK, since 2007. Progestagen analysis initially revealed synchronized oestrous cycles among all females. However, a 14- to 20-week period of temporary acyclicity subsequently occurred in three females, following several management changes (increased training, foot-care and intermittent matriarch removal for health reasons) and the initiation of pregnancy in another female. The aim of this study was to retrospectively investigate whether these management changes were related to increased adrenal activity and disruption of ovarian activity, or whether social factors may have been involved in the temporary cessation of cyclicity. Faecal samples collected every other day were analysed to investigate whether glucocorticoid metabolites were related to reproductive status (pregnant, cycling, acyclic) or management (training, foot-care, matriarch presence). Routine training and foot-care were not associated with adrenal activity; however, intensive foot-care to treat an abscess in one female was associated with increased glucocorticoid concentration. Matriarch presence influenced adrenal activity in three females, being lower when the matriarch was separated from the group at night compared to being always present. However, in the females that exhibited temporary acyclicity, there was no consistent relationship between glucocorticoids and cyclicity state. Although the results of this study do not fully explain this occurrence, the highly synchronized nature of oestrous cycles within this group, and the concurrent acyclicity in three females, raises the question of whether social factors could have been involved in the temporary disruption of ovarian activity. © 2015 Reprinted with permission from Elsevier.

P. Fernando

Managing elephants in Sri Lanka: Where we are and where we need to be

Ceylon J. of Science (Bio. Sci.) 44 (2015) 1-11

Abstract. Asian elephants are 'endangered' but come into significant conflict with humans. Sri Lanka holds an important position in relation to Asian elephants, both in terms of species conservation and human-elephant conflict (HEC) mitigation. Historical aspects of the two main conservation agencies and lack of coordination between them has prevented a landscape level holistic approach to conservation in general and elephants in particular. The primary objective of elephant management is HEC mitigation and secondarily elephant conservation. Many HEC mitigation activities are ineffective and in some cases cause its escalation and wider spread. Others are extremely detrimental to elephant conservation. Effective human-elephant conflict mitigation and elephant conservation requires a paradigm change. Elephant management needs to be based on science and evidence rather than outdated beliefs and false assumptions. Unless

immediate and effective remedial measures are taken, HEC will continue to escalate and the elephant population continue to decline.

A. Fuery, G.R. Browning, J. Tan, S. Long, G.S. Hayward, S.K. Cox, J.P. Flanagan, M.E. Tocidlowski, L.L. Howard & P.D. Ling

Clinical infection of captive Asian elephants (*Elephas maximus*) with elephant endotheliotropic herpesvirus 4

Journal of Zoo and Wildlife Medicine 47 (2016) 311-318

Abstract. Elephant endotheliotropic herpesvirus (EEHV) can cause lethal hemorrhagic disease in juvenile Asian elephants. A number of EEHV types and subtypes exist, where most deaths have been caused by EEHV1A and EEHV1B. EEHV4 has been attributed to two deaths, but as both diagnoses were made postmortem, EEHV4 disease has not yet been observed and recorded clinically. In this brief communication, two cases of EEHV4 infection in juvenile elephants at the Houston Zoo are described, where both cases were resolved following intensive treatment and administration of famciclovir. A quantitative real-time polymerase chain reaction detected EEHV4 viremia that correlated with clinical signs. High levels of EEHV4 shedding from trunk wash secretions of the first viremic elephant correlated with subsequent infection of the second elephant with EEHV4. It is hoped that the observations made in these cases—and the successful treatment regimen used—will help other institutions identify and treat EEHV4 infection in the future. © 2016 American Association of Zoo Veterinarians.

A. Fuery, J. Tan, R. Peng, J.P. Flanagan, M.E. Tocidlowski, L.L. Howard & P.D. Ling

Clinical infection of two captive Asian elephants (*Elephas maximus*) with elephant endotheliotropic herpesvirus 1B

Journal of Zoo and Wildlife Medicine 47 (2016) 319-324

Abstract. The ability of prior infection from one elephant endotheliotropic herpesvirus (EEHV) type to protect against clinical or lethal infection from others remains an important question. This report describes viremia and subsequent shedding of EEHV1B in two juvenile 4-yr-old Asian elephants within 3 wk or 2 mo following significant infections caused by the rarely seen EEHV4. High levels of EEHV1B shedding were detected in the first elephant prior to emergence of infection and viremia in the second animal. The EEHV1B virus associated with both infections was identical to the strain causing infection in two herd mates previously. High EEHV viremia correlated with leukopenia and thrombocytopenia, which was followed by leukocytosis and thrombocytosis when clinical signs started to resolve. The observations from these cases should be beneficial for helping other institutions monitor and treat elephants infected with EEHV1, the most common virus associated with lethal hemorrhagic disease. © 2016 American Association of Zoo Veterinarians.

B. Goossens, R. Sharma, N. Othman, C. Kun-Rodrigues, R. Sakong, M. Ancrenaz, L.N. Ambu, N.K. Jue, R.J. O'Neill, M.W. Bruford & L. Chikhi

Habitat fragmentation and genetic diversity in natural populations of the Bornean elephant: Implications for conservation

Biological Conservation 196 (2016) 80-92

Abstract. The Bornean elephant population in Sabah, with only 2000 individuals, is currently mainly restricted to a limited number of forest reserves. The main threats to the species' survival are population fragmentation and isolation of the existing herds. To support and help monitor future conservation and management measures, we assessed the genetic diversity and population structure of Bornean elephants using mitochondrial DNA, microsatellites and single nucleotide polymorphisms. Our results confirmed a previously reported lack of mitochondrial control region diversity, characterized by a single widespread haplotype. However, we found low but significant degree of genetic differentiation among populations and marked variation in genetic diversity with the other two types of markers among Bornean elephants. Microsatellite data showed that Bornean elephants from the Lower Kinabatangan and North Kinabatangan ranges are differentiated and perhaps isolated from the main elephant populations located in the Central Forest and Tabin Wildlife Reserve. The pairwise FST values between these sites ranged from 0.08 to 0.14 ($p < 0.001$). Data from these

markers also indicate that the Bornean elephant populations from Lower Kinabatangan Wildlife Sanctuary and North Kinabatangan (Deramakot Forest Reserve) possess higher levels of genetic variation compared to the elephant populations from other areas. Our results suggest that (i) Bornean elephants probably derive from a very small female population, (ii) they rarely disperse across current human-dominated landscapes that separate forest fragments, and (iii) forest fragments are predominantly comprised of populations that are already undergoing genetic drift. To maintain the current levels of genetic diversity in fragmented habitats, conservation of the Bornean elephants should aim at securing connectivity between spatially distinct populations. © 2016 Reprinted with permission from Elsevier.

M. Gunji, A. Takai & H. Endo
Deformations of the cervical and cranial thoracic vertebrae in a bedridden Asian elephant
Japanese Journal of Zoo and Wildlife Medicine 19 (2014) 79-86
Abstract. The present study reports an abnormality of the neck in a bedridden Asian elephant. When 1 year old, the elephant lost the ability to stand and grew up under the bedridden condition for 3.5 years. Our observations from CT scan revealed that the articular facets of the cervical and first 3 thoracic vertebrae possessed intricately rough surfaces and that the anterior articular processes of C4, C5 and C6 intruded to the adjacent processes. The articular processes were partly fused to the contiguous processes in the C5/C6 and T1/T2 zygapophyseal joints and the processes of C6 were completely coalesced with those of C7. The neck of the bedridden elephant was dorsally bent at 30.4 degrees more than that of a hyperostotic elephant. Under the bedridden condition, the nuchal ligament is contracted without the gravitational load of the head weight. This induces the dorsiflexion of the neck, and then generates a compressive force between adjacent vertebrae. The compressive force might cause the inflammation and bony destruction between the articular processes, and prompt the abnormal ossifications in the articulations through the repairing process. The abnormalities of the articular processes were identified in the attachment site of the nuchal ligament, and the vertebral fusions were distributed intensively on where the compressive force should be converged. This study concludes that a long-term lying posture under the bedridden condition might cause the over-dorsalization of the neck and the deformations of the articular processes in large mammals. © 2014 Japanese Society of Zoo and Wildlife Medicine.

A. Houssaye, K. Waskow, S. Hayashi, R. Cornette, A.H. Lee & J.R. Hutchinson
Biomechanical evolution of solid bones in large animals: A microanatomical investigation
Biological Journal of the Linnean Society 117 (2016) 350-371
Abstract. Graviportal taxa show an allometric increase of the cross-sectional area of supportive bones and are assumed to display microanatomical changes associated with an increase in bone mass. This evokes osteosclerosis (i.e. an increase in bone compactness observed in some aquatic amniotes). The present study investigates the changes in bones' microanatomical organization associated with graviportality and how comparable they are with aquatically acquired osteosclerosis aiming to better understand the adaptation of bone to the different associated functional requirements. Bones of graviportal taxa show microanatomical changes that are not solely attributable to allometry. They display a thicker cortex and a proportionally smaller medullary cavity, with a wider transition zone between these domains. This inner cancellous structure may enable to better enhance energy absorption and marrow support. Moreover, the cross-sectional geometric parameters indicate increased resistance to stresses engendered by bending and torsion, as well as compression. Adaptation to a graviportal posture should be taken into consideration when analyzing possibly amphibious taxa with a terrestrial-like morphology. This is particularly important for palaeoecological inferences about large extinct tetrapods that might have been amphibious and, more generally, for the study of early stages of adaptation to an aquatic life in amniotes. © 2015 The Linnean Society of London.

A.S. Jacob, E.J. Busby, A.D. Levy, N. Komm & C.G. Clark

Expanding the *Entamoeba* universe: New hosts yield novel ribosomal lineages†

J. of Eukaryotic Microbiology 63 (2016) 69-78

Abstract. Removing the requirement for cell culture has led to a substantial increase in the number of lineages of *Entamoeba* recognized as distinct. Surveying the range of potential host species for this parasite genus has barely been started and it is clear that additional sampling of the same host in different locations often identifies additional diversity. In this study, using small subunit ribosomal RNA gene sequencing, we identify four new lineages of *Entamoeba*, including the first report of *Entamoeba* from an elephant, and extend the host range of some previously described lineages. In addition, examination of microbiome data from a number of host animals suggests that substantial *Entamoeba* diversity remains to be uncovered. © 2015 The Authors © 2015 International Society of Protistologists.

K.K. Karanth

Wildlife in the matrix: Spatio-temporal patterns of herbivore occurrence in Karnataka, India

Environmental Management 57 (2016) 189-206

Abstract. Wildlife reserves are becoming increasingly isolated from the surrounding human-dominated landscapes particularly in Asia. It is imperative to understand how species are distributed spatially and temporally in and outside reserves, and what factors influence their occurrence. This study surveyed 7500 km^2 landscape surrounding five reserves in the Western Ghats to examine patterns of occurrence of five herbivores: elephant, gaur, sambar, chital, and pig. Species distributions are modeled spatio-temporally using an occupancy approach. Trained field teams conducted 3860 interview-based occupancy surveys in a 10-km buffer surrounding these five reserves in 2012. I found gaur and wild pig to be the least and most wide-ranging species, respectively. Elephant and chital exhibit seasonal differences in spatial distribution unlike the other three species. As predicted, distance to reserve, the reserve itself, and forest cover were associated with higher occupancy of all species, and higher densities of people negatively influenced occurrence of all species. Park management, species protection, and conflict mitigation efforts in this landscape need to incorporate temporal and spatial understanding of species distributions. All species are known crop raiders and conflict prone locations with resources (such as water and forage) have to be monitored and managed carefully. Wildlife reserves and adjacent areas are critical for long-term persistence and habitat use for all five herbivores and must be monitored to ensure wildlife can move freely. Such a large-scale approach to map and monitor species distributions can be adapted to other landscapes to identify and monitor critical habitats shared by people and wildlife. © 2015 Springer Science+Business Media. With permission of Springer.

P. Keerthipriya, R. Tewari & T.N.C. Vidya

Lateralization in trunk and forefoot movements in a population of free-ranging Asian elephants (*Elephas maximus*)

Journal of Comparative Psychology 129 (2015) 377-387

Abstract. We examined side preferences in trunk and forefoot movement during feeding in a wild population of Asian elephants. Trunk sweeping movements to pluck/uproot/gather vegetation and forefoot scuffing movements to uproot vegetation were scored in 206 individuals. We found a much stronger side preference in trunk use than in forefoot use, supporting a modified task complexity hypothesis. The forefoot and trunk appeared to be coordinated while feeding and, among individuals that had significant forefoot preferences, the proportion of right forefoot use was higher among right trunkers than left trunkers. Trunk and forefoot preferences were not dependent on individuals' social associates, and trunk preferences were also not dependent on feeding associates. There was a significant effect of individual identity on forefoot preference strength but no population-level side preference in trunk or forefoot movement, suggesting no dominant eye control over the task, which might be true of feeding-related foot movement in other herbivores also. There was no effect of age or sex on trunk or forefoot side preference or strength.

The onset of trunk side preference, however, was very early compared with that observed in other species studied and calls for a comparison of the ontogeny of side preferences in precocial and altricial species. Based on 57 mother-offspring pairs, we found that offspring trunk side preferences were independent of their mothers' preferences, suggesting that these preferences are not maternally inherited. © 2015 APA.

C. Kevrekidis & D. Mol
A new partial skeleton of *Elephas* (*Palaeoloxodon*) *antiquus* Falconer and Cautley, 1847 (Proboscidea, Elephantidae) from Amyntaio, Macedonia, Greece
Quaternary International 406 (2016) 35-56
Abstract. *Elephas* (*Palaeoloxodon*) *antiquus* is a well-known elephant species of the Middle and Late Pleistocene of Europe, but few skeletons so far have been described in detail. Here we present a detailed account of a partial skeleton in good condition from the alluvial sands of the Amyntaio coalmines, Macedonia, Greece. It represents a large male aged in its forties. Based on extant and extinct elephant specimens, the Amyntaio's elephant estimated height at the shoulder is 3.5 m and its weight close to 9 tonnes. A CT scan was performed on the deformed fifth metacarpal, which was diagnosed with osteomyelitis, probably rendering the animal lame. No signs of further biologically induced ante- or post-mortem modifications were detected. From that skeleton the first known basihyoid bone of *E. antiquus* is recovered; comparisons with homologous bones of other elephantid taxa show it has a very distinct morphology and can be used in phylogenetic studies of the Elephantidae family. © 2015 Elsevier Ltd and INQUA.

R.K. Koirala, W. Ji, A. Aryal, J. Rothman & D. Raubenheimer
Dispersal and ranging patterns of the Asian elephant (*Elephas maximus*) in relation to their interactions with humans in Nepal
Ethology Ecology & Evolution 28 (2016) 221-31
Abstract. none.

J. Kottwitz, M. Boothe, R. Harmon, S.B. Citino, J.R. Zuba, & D.M. Boothe
Results of the megavertebrate analgesia survey: Elephants and rhino
Journal of Zoo and Wildlife Medicine 47 (2016) 301-310
Abstract. An online survey utilizing Survey Monkey linked through the American Association of Zoo Veterinarians listserve examined current practices in megavertebrate analgesia. Data collected included drugs administered, dosing regimens, ease of administration, efficacy, and adverse events. Fifty-nine facilities (38 housing elephants, 33 housing rhinoceroses) responded. All facilities administered nonsteroidal anti-inflammatory drugs (NSAIDs), with phenylbutazone (0.25–10 mg/kg) and flunixin meglumine (0.2–4 mg/kg) being most common. Efficacy was reported as "good" to "excellent" for these medications. Opioids were administered to elephants (11 of 38) and rhinoceroses (7 of 33), with tramadol (0.5–3.0 mg/kg) and butorphanol (0.05–1.0 mg/kg) being most common. Tramadol efficacy scores were highly variable in both elephants and rhinoceroses. While drug choices were similar among institutions, substantial variability in dosing regimens and reported efficacy between and within facilities indicates the need for pharmacokinetic studies and standardized methods of analyzing response to treatment to establish dosing regimens and clinical trials to establish efficacy and safety. © 2016 American Association of Zoo Veterinarians.

M. Lahdenperä, K.U. Mar & V. Lummaa
Short-term and delayed effects of mother death on calf mortality in Asian elephants
Behavioral Ecology 27 (2016) 166-174
Abstract. Long-lived, highly social species with prolonged offspring dependency can show long postreproductive periods. The Mother hypothesis proposes that a need for extended maternal care of offspring together with increased maternal mortality risk associated with old age select for such postreproductive survival, but tests in species with long postreproductive periods, other than humans and marine mammals, are lacking. Here, we investigate the Mother hypothesis with longitudinal data on Asian elephants from timber camps of Myanmar 1) to determine the costs of reproduction on female age-specific mortality risk within 1 year after calving and 2) to quantify the effects of mother loss on calf

survival across development. We found that older females did not show an increased immediate mortality risk after calving. Calves had a 10-fold higher mortality risk in their first year if they lost their mother, but this decreased with age to only a 1.1-fold higher risk in the fifth year. We also detected delayed effects of maternal death: calves losing their mother during early ages still suffered from increased mortality risk at ages 3–4 and during adolescence but such effects were weaker in magnitude. Consequently, the Mother hypothesis could account for the first 5 years of postreproductive survival, but there were no costs of continued reproduction on the immediate maternal mortality risk. However, the observed postreproductive lifespan of females surviving to old age commonly exceeds 5 years in Asian elephants, and further studies are thus needed to determine selection for (postreproductive) lifespan in elephants and other comparably long-lived species. © 2015 The Authors.

N. Lakshminarayanan, K.K. Karanth, V.R. Goswami, S. Vaidyanathan & K.U. Karanth
Determinants of dry season habitat use by Asian elephants in the Western Ghats of India
Journal of Zoology 298 (2016) 169-177
Abstract. Large herbivores respond to seasonal changes in resource availability through habitat selection. Understanding variations in habitat choice is crucial for targeting conservation efforts, particularly for endangered, wide-ranging species, such as the Asian elephant. We assessed patterns and determinants of elephant habitat use during the dry season, a period of resource limitation in tropical deciduous forests, in the Western Ghats of Karnataka, India. We collected detection/non-detection data on elephant signs under an occupancy sampling framework, using spatially replicated surveys on foot along forest trails to estimate probabilities of habitat use by elephants. Each of our 97 sites (sampling units) was a grid cell of 11.75 km^2 area. Data were analysed using an occupancy model, which estimated detection probabilities for signs, while explicitly addressing the potential spatial dependence between sign detections on adjacent replicates. Using covariates that are likely to influence resource use, we made ecological predictions about dry season habitat use by elephants across the study area of 1850 km^2. The site-level probabilities of habitat use by elephants ranged from inline image The estimated replicate level detection probability was inline image We found that distance to rivers was the best predictor of elephant habitat use, in dry season, demonstrating the overarching importance of riparian habitats in the landscape for the species. Artificial water holes established by wildlife managers do not appear to influence elephant habitat use, which is likely a result of abundant and near-uniform distribution of such water holes across the study area. The sign survey-based occupancy modelling approach provides a basis for reliable cost-effective assessment of spatial distribution and habitat use by elephants and other large herbivores. Such assessments are essential for effective conservation management of large herbivores. © 2015 The Zoological Society of London.

J. Lassausaie, A. Bret, X Bouapao, V. Chanthavong, J. Castonguay-Vanier, F. Quet, S.K. Mikota, C. Théorêt, Y. Buisson & B. Bouchard
Tuberculosis in Laos, who is at risk: The mahouts or their elephants?
Epidemiology and Infection 143 (2015) 922-931
Abstract. Tuberculosis (TB) in elephants has the potential to infect humans and is an increasing public health concern. Lao PDR is one of the last countries where elephants are still used for timber extraction and where they live in close contact with their mahouts. There are 500 animals at work in the country, some interacting with wild herds. Although human TB prevalence is known to be high in Laos, studies on elephant TB had yet to be undertaken. From January to July 2012, screening was performed using the ElephantTB Stat-Pak assay on 80 elephants working around the Nam Pouy National Park in Sayaboury Province. This represents more than 18% of the total registered national working elephant population. Here we report that 36% of the elephants were seroreactive to the test. Of these, 31% had contacts with wild individuals, which suggests potential transmission of mycobacteria to the local wild herds. Clinical examination, chest X-rays, sputum microscopy and culture were performed on their 142 mahouts or owners. Despite high TB seroreactivity in elephants,

no participant was smear- or culture-positive for *Mycobacterium tuberculosis* or *M. bovis*, although atypical mycobacteria were isolated from 4% of participants. © 2014 Cambridge University Press.

M. Lev & R. Barkai

Elephants are people, people are elephants: Human–proboscideans similarities as a case for cross cultural animal humanization in recent and Paleolithic times

Quaternary International 406 (2016) 239-245

Abstract. Human and elephants shared habitats and interacted from Paleolithic times to the present day. It appears that pre-historic hunter–gatherers were wise enough to understand that elephants are cohabiters of the human race and not a product to be exploited in an uncontrolled way. The understanding of the long tradition of human and elephant relationship and kinship may change the mind-set of modern humans to lead to carry on the important relationship between man and elephant in particular, and man and nature in general, and prevent future extinctions of all species involved. This study is conducted in the spirit of the newly developed multidisciplinary study field of 'Ethnoelephantology' that studies human and elephant relationships and strives to protect the endangered species. In order to have better understanding of this unique relationship we will explore it through the study of food taboos in modern hunter–gatherers societies. More so, in this study we detected multiple striking similarities between elephant and man in several fields, such as physical, behavioral/social and conceptual. The importance of this study is in providing a new and better perspective about human and animal relationship, specifically elephants. We suggest that the physical and social uniqueness of the elephant, and its unique resemblance to man in so many aspects, alongside its pivotal role as a major food source, is what makes it appropriate for serving as a cosmological and conceptual beacon, mostly conceived in recent hunter–gatherers societies by the concept of taboo. Although detecting food taboos in the deep past are not possible, we believe that the archaeological evidence presented in this paper could indicate that human–elephant interactions in the past were complex, and were not based solely on human perception of the elephant as a food and raw material source. © 2015 Elsevier Ltd and INQUA.

P. Liu, H. Wen, L. Lin, J. Liu & L. Zhang

Habitat evaluation for Asian elephants (*Elephas maximus*) in Lincang: Conservation planning for an extremely small population of elephants in China

Biological Conservation 198 (2016) 113-121

Abstract. Fewer than 250 Asian elephants remain in China, occupying fragmented habitats of Yunnan Province. One such fragmented population of 18–23 individuals occupies the Nangunhe Nature Reserve Area in Lincang City, Yunnan Province, China. The greatest threat to the survival of this population is the loss and fragmentation of habitat. In this study, we applied an ecological niche factor analysis (ENFA) model to evaluate the habitat suitability of Lincang City for Asian elephants based on geographical factors, vegetation type, and human disturbance. Optimal, relatively suitable, and marginal habitat accounted for 0.16% (38.45 km^2), 0.61% (150.00 km^2), and 3.34% (817.26 km^2) of the total study area, whereas non-suitable habitat accounted for 95.89% (23,463.29 km^2) of this area. The marginality of Asian elephant habitat in Lincang was 1.954, indicating nonrandom selection of various eco-geographical variables in the environment. The primary factor affecting Asian elephant habitat quality was vegetation type, followed by geographical factors and human disturbance. A habitat quality map for the total distribution of Asian elephants remaining in China (i.e., Yunnan Province: Xishuangbanna, Lincang, and Pu'er) based on our current and previous study showed that just 1400.57 km^2 and 2689.62 km^2 relatively suitable and optimal habitat is available, owing to significant deforestation. In addition to reintroduction programs, conservation strategies should focus on improving the quality of marginal habitats for elephants, in parallel to placing ecological corridors through non-suitable habitat to connect all suitable habitats for this and other extremely small elephant populations in China to reduce genetic isolation and secure long-term survival for the species. © 2016 Reprinted with permission from Elsevier.

S.Y. Long, E.M. Latimer & G.S. Hayward

Review of elephant endotheliotropic herpesviruses and acute hemorrhagic disease

ILAR Journal 56 (2015) 283-296

Abstract. More than 100 young captive and wild Asian elephants are known to have died from a rapid-onset, acute hemorrhagic disease caused primarily by multiple distinct strains of two closely related chimeric variants of a novel herpesvirus species designated elephant endotheliotropic herpesvirus (EEHV1A and EEHV1B). These and two other species of Probosciviruses (EEHV4 and EEHV5) are evidently ancient and likely nearly ubiquitous asymptomatic infections of adult Asian elephants worldwide that are occasionally shed in trunk wash secretions. Although only a handful of similar cases have been observed in African elephants, they also have proved to harbor their own multiple and distinct species of Probosciviruses—EEHV2, EEHV3, EEHV6, and EEHV7—found in lung and skin nodules or saliva. For reasons that are not yet understood, approximately 20% of Asian elephant calves appear to be susceptible to the disease when primary infections are not controlled by normal innate cellular and humoral immune responses. Sensitive specific polymerase chain reaction (PCR) DNA blood tests have been developed, routine monitoring has been established, the complete large DNA genomes of each of the four Asian EEHV species have now been sequenced, and PCR gene subtyping has provided unambiguous evidence that this is a sporadic rather than epidemic disease that it is not being spread among zoos or other elephant housing facilities. Nevertheless, researchers have not yet been able to propagate EEHV in cell culture, determine whether or not human antiherpesvirus drugs are effective inhibitors, or develop serology assays that can distinguish between antibodies against the multiple different EEHV species.

Elephant scratching at Yala NP (Sri Lanka)

D.E. Lukacs, M. Poulin, H. Besenthal, O.C. Fad, S.P. Miller, J.L. Atkinson & E.J. Finegan

Diurnal and nocturnal activity time budgets of Asian elephants (*Elephas maximus*) in a zoological park

Animal Behavior and Cognition 3 (2016) 63-77

Abstract. The diurnal and nocturnal activity time budgets of five adult female Asian elephants (*Elephas maximus*) were studied in a zoological park for two 24-hour, five 14-hour, and one 9-hour observation periods between May and June 2011. Relatively few studies have looked at detailed daytime and nighttime activity time budgets in captive Asian elephants. Continuous observation was used to measure the activity time budgets of at least one focal animal per observation period. The activity time budgets varied between animals and observation periods. The elephants spent 17-49% of the day (daylight hours) standing, 1-9% of the day walking, 19-44% of the day eating, and 1-20% of the day using enrichment items. At night, the elephants spent 29-87% of the observation period standing, 1-19% of the night eating, and 0.1-10% of the night using enrichment items. At night, elephants spent 0-45% of the observation period lying down. Variations in activity time budgets between elephants and observation periods have been observed in other studies of captive and wild elephants. Results of this observational study allow comparison between groups of captive elephants and between captive and wild elephants. Furthermore, results of this study can inform management strategies.

K. Mizuno, N. Irie, M. Hiraiwa-Hasegawa & N. Kutsukake

Asian elephants acquire inaccessible food by blowing

Animal Cognition 19 (2016) 215-222

Abstract. Many animals acquire otherwise

inaccessible food with the aid of sticks and occasionally water. As an exception, some reports suggest that elephants manipulate breathing through their trunks to acquire inaccessible food. Here, we report on two female Asian elephants (*Elephas maximus*) in Kamine Zoo, Japan, who regularly blew to drive food within their reach. We experimentally investigated this behaviour by placing foods in inaccessible places. The elephants blew the food until it came within accessible range. Once the food was within range, the elephants were increasingly less likely to blow as the distance to the food became shorter. One subject manipulated her blowing duration based on food distance: longer when the food was distant. These results suggest that the elephants used their breath to achieve goals: that is, they used it not only to retrieve the food but also to fine-tune the food position for easy grasping. We also observed individual differences in the elephants' aptitude for this technique, which altered the efficiency of food acquisition. Thus, we added a new example of spontaneous behaviour for achieving a goal in animals. The use of breath to drive food is probably unique to elephants, with their dexterous trunks and familiarity with manipulating the act of blowing, which is commonly employed for self-comfort and acoustic communication.

U. Münster

Working for the forest: The ambivalent intimacies of human–elephant collaboration in South Indian wildlife conservation

Ethnos: J. of Anthropology 81 (2016) 425-447

Abstract. This paper explores the collaboration of humans and elephants in South Indian wildlife conservation. Drawing on ethnography within the Indian forest department and among elephant handlers in Wayanad, Kerala, it highlights the largely invisible work relationship between indigenous forest labourers and captive elephants, and their essential contribution to wildlife management. Extending ethnographic attention beyond an exclusively human realm, I show that human and elephant relations have been co-constituted while working together for the forest department. Their working partnership, situated in the historical nature-cultures of logging, teak extraction, and conservation, has created ambivalent intimacies between humans and elephants, containing both mutual violence and affect. By highlighting the importance of work relationships, history, and questions of power for multi-species studies, this article argues that human–animal relations are not only shaped by individual intimacies, but also by danger, risk, and aggression, situated within a region's larger political ecology. © 2014 Taylor & Francis.

K. Nganvongpanit, J.L. Brown, K. Buddhachat, C. Somgird & C. Thitaram

Elemental analysis of Asian elephant (*Elephas maximus*) teeth using X-ray fluorescence and a comparison to other species

Biol. Trace Element Research 170 (2016) 94-105

Abstract. Elemental composition in bone of the different species has variation depending on genetic and environmental factors especially their food habitat. The aims of this study were to conduct an elemental analysis of Asian elephant teeth, both deciduous (first molar, second molar, and tusk) and permanent (molar and tusk), and compare the elemental composition of permanent teeth among 15 species, mostly mammalian. These teeth were analyzed using X-ray fluorescence at two voltages: 15 and 50 kV. In Asian elephants, deciduous tusk showed a lower Ca/Zn ratio compared to permanent tusk, because of the lack of Zn in permanent molars. Ca/Fe ratio was higher in deciduous than permanent molars. For permanent teeth, elephant molars presented a high Ca/Pb ratio but no Ca/Zn, Ca/Sr, and Zn/Fe ratios because of the lack of Zn and Sr in the samples tested. The key elemental ratios for differentiating elephant deciduous and permanent tusk were Ca/P and Ca/Zn. The considerable variation in elemental ratio data across 15 species was observed. All tooth samples contained Ca and P, which was not surprising; however, Pb also was present in all samples and Cd in a large majority, suggesting exposure to environmental contaminants. From discriminant analysis, the combination of Ca/P+Ca/Zn+Ca/Pb+Ca/Fe+Ca/Sr+Zn/Fe can generate two equations that successfully classified six (dog, pig, goat, tapir, monkey, and elephant) out of 15 species at 100 % specificity. In conclusion, determining the elemental profile

of teeth may serve as a tool to identify the tooth "type" of elephants and to potentially classify other species. © 2016 With permission of Springer.

K. Nganvongpanit, K. Buddhachat, S. Klinhom, P. Kaewmong, C. Thitaram & P. Mahakkanukrauh
Determining comparative elemental profile using handheld X-ray fluorescence in humans, elephants, dogs, and dolphins: Preliminary study for species identification
Forensic Science Internat. 263 (2016) 101-106
Abstract. Species identification is a crucial step in forensic anthropological studies. The aim of this study was to determine elemental profiles in bones from four mammal species, to be used for species discrimination. Human, elephant, dog, and dolphin bones were scanned by X-ray fluorescence (XRF); the differences in elemental profiles between species were determined using discriminant analysis. Dogs had the greatest number of elements (23), followed by humans (22) and elephants (20). Dolphins had the lowest number of elements (16). The accuracy rate of species identification in humans, elephants, dogs, and dolphins was 98.7%, 100%, 94.9%, and 92.3%, respectively. We conclude that element profiles of bones based on XRF analyses can serve as a tool for determining species. © 2016 Reprinted with permission from Elsevier.

O. Phuphisut, W. Maipanich, S. Pubampen, M. Yindee, N. Kosoltanapiwat, S. Nuamtanong, A. Ponlawat & P. Adisakwattana
Molecular identification of the strongyloid nematode Oesophagostomum aculeatum in the Asian wild elephant *Elephas maximus*
Journal of Helminthology 90 (2016) 434-440
Abstract. The transmission of zoonoses by wildlife, including elephants, is a growing global concern. In this study, we screened for helminth infections among Asian wild elephants (*Elephas maximus*) of the Salakpra Wildlife Sanctuary, Kanchanaburi, Thailand. Elephant faecal samples (45) were collected from the sanctuary grounds during January through November 2013 and assayed individually using the tetranucleotide microsatellite technique. Microscopic examination indicated a high prevalence of strongylids (93.0%) and low prevalences of trichurids (2.3%) and ascarids (2.3%). To identify the strongylid species, small subunit (SSU) rDNA sequences were amplified from copro-DNA and compared with sequences in GenBank. The generated SSU-rDNA sequences comprised five distinct haplotypes that were closely related to *Oesophagostomum aculeatum*. A phylogenetic analysis that incorporated related nematodes yielded a tree separated into two main clades, one containing our samples and human and domestic animal hookworms and the other consisting of Strongyloides. The present results indicate that *O. aculeatum* in local elephants is a potential source of helminthiasis in human and domestic animals in this wild-elephant irrupted area. © 2015 Cambridge University Press.

T. Ramesh, R. Kalle, K. Sankar & Q. Qureshi
Role of body size in activity budgets of mammals in the Western Ghats of India
Journal of Tropical Ecology 31 (2015) 315-323
Abstract. Body size in animals is an important trait affecting species niche differentiation and restricting similarity. Using camera-trap data over 2008–2010, we used photo-captures from 50 cameras spread throughout Mudumalai Tiger Reserve (Western Ghats, India) to assess the activity budgets of 21 mammal species ranging in body size from 1 kg to 2088 kg. Large carnivores were mostly cathemeral whereas small cat and civet species were purely nocturnal. Mongoose species were mainly diurnal possibly due to their terrestrial feeding habits and reduce competition with other sympatric small carnivores. All large and small-bodied herbivores were cathemeral and nocturnal respectively, whereas medium-sized herbivores were active during the day. Overall, small mammals tended to be mostly nocturnal, whereas large mammals were cathemeral mainly due to energy requirements and other ecological constraints. Body size showed significant negative relationship with mean vector length (clustering of activity in time) thus implying that the daily amount of time being active increased with body size. The shorter activity time (12 h) in small mammals resulted in higher mean vector length probably to utilize the available time to fulfil energy needs. The observed cathemeral activity in large mammals may be associated with travel over larger areas to acquire large

quantities of food therefore they are active for a longer duration. Our results clearly support the allometric relationship between body size and activity budgets in mammals and its association with niche differentiation. © 2015 Cambridge University Press.

S.J. Sander, J.L. Siegal-Willott, J. Ziegler, E. Lee, L. Tell & S. Murray

Pharmacokinetics of a single dose of metronidazole after rectal administration in captive Asian elephants (*Elephas maximus*)

J. of Zoo and Wildlife Medicine 47 (2016) 1-5

Abstract. Metronidazole is a nitroimidazole antibacterial and antiprotozoal drug with bacteriocidal activity against a broad range of anaerobic bacteria. It is a recognized treatment for elephants diagnosed with anaerobic bacterial infection or protozoal disease or exhibiting signs of colonic impaction, diarrhea, and colic. This study evaluated the pharmacokinetics of rectally administered metronidazole (15 mg/kg) in five adult female Asian elephants (*Elephas maximus*). Serum samples were collected from each animal for 96 hr after rectal administration of metronidazole. Serum concentrations of metronidazole and its primary metabolite, hydroxymetronidazole, were measured via ultraperformance liquid chromatography. Data were analyzed via a noncompartmental pharmacokinetic approach. Results indicated that serum levels of metronidazole were quantifiable at the 0.25 hr time point and absent in all elephants by the 96 hr time point. The serum peak concentration (mean ± SD, 13.15 ± 2.59 μg/ml) and area under the curve from time 0 to infinity (mean ± SD, 108.79 ± 24.77 hr × μg/ml) were higher than that reported in domestic horses after similar usage. Concurrently, the time of maximum serum concentration (mean ± SD, 1.2 ± 0.45 hr) and terminal elimination half-life (harmonic mean ± pseudo-SD, 7.85 ± 0.93 hr) were longer when compared to equine reports. Rectal administration of metronidazole was well tolerated and rapidly absorbed in all study elephants. Based on the findings in this study, metronidazole administered at a single dose of 15 mg/kg per rectum in the Asian elephant is likely to result in serum concentrations above 4 μg/ml for 8 hr and above 2 μg/ml for 24 hr after treatment is administered. Dosing recommendations should reflect the mean inhibitory concentration of metronidazole for each pathogen. © 2016 American Association of Zoo Veterinarians.

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

Distribution and load of elephant endotheliotropic herpesviruses in tissues from associated fatalities of Asian elephants

Virus Research 220 (2016) 91-96

Abstract. Elephant Endotheliotropic Herpesviruses (EEHVs) are the cause of a highly fatal haemorrhagic disease in elephants primarily affecting young Asian elephants (*Elephas maximus*) in both captivity and in the wild. The viruses have emerged as a significant threat to Asian elephant conservation, critically affecting overall sustainability of their population. So far insight into the pathogenesis of EEHV infections has been restricted to examination of EEHV-infected tissues. However, little is known about distribution and burden of the viruses within the organs of fatal cases, crucial elements in the understanding of the virus pathogenesis. This study was therefore undertaken to assess the extent of organ and cell involvement in fatal cases of EEHV-1A, 1B and 5 using a quantitative real-time PCR. EEHV-1 and 5 DNA were detectable in all the tissues examined, albeit with substantial differences in the viral DNA load. The highest EEHV-1A DNA load was observed in the liver, followed by the heart, thymus and tongue. EEHV-1B and 5 showed the highest DNA load in the heart, followed by tongue and liver. This study provides new insights into EEHV pathogenicity and has implications in choice of sample type for disease investigation and virus isolation. © 2016 Reprinted with permission from Elsevier.

N. Sekar, X. Giam, N.P. Sharma & R. Sukumar

How much *Dillenia indica* seed predation occurs from Asian elephant dung?

Acta Oecologica 70 (2016) 53-59

Abstract. Elephants are thought to be effective seed dispersers, but research on whether elephant dung effectively protects seeds from seed predation is lacking. Quantifying rates of seed predation from elephant dung will facilitate comparisons between elephants and

alternative dispersers, helping us understand the functional role of megaherbivores in ecosystems. We conducted an experiment to quantify the predation of *Dillenia indica* seeds from elephant dung in Buxa Reserve, India from December 2012 to April 2013. Using dung boluses from the same dung pile, we compared the number of seeds in boluses that are a) opened immediately upon detection (control boluses), b) made available only to small seed predators (<3 mm wide) for 1-4 months, and c) made available to all seed predators and secondary dispersers for 1-4 months. Using a model built on this experiment, we estimated that seed predation by small seed predators (most likely ants and termites) destroys between 82.9% and 96.4% of seeds in elephant dung between the time of defecation and the median germination date for *D. indica*. Exposure to larger seed predators and secondary dispersers did not lead to a significant additional reduction in the number of seeds per dung bolus. Our findings suggest that post-dispersal seed predation by small insects (<3 mm) substantially reduces but does not eliminate the success of elephants as dispersers of *D. indica* in a tropical moist forest habitat.

N. Sekar & R. Sukumar

The Asian elephant is amongst the top three frugivores of two tree species with easily edible fruit

Journal of Tropical Ecology 31 (2015) 385-394

Abstract. Large animal species are prone to local extirpation, but ecologists cannot yet predict how the loss of megaherbivores affects ecosystem processes such as seed dispersal. Few studies have compared the quantity and quality of seed dispersal by megaherbivores versus alternative frugivores in the wild, particularly for plant species with fruit easily consumed by many frugivorous species. In a disturbed tropical moist forest in India, we examine whether megaherbivores are a major frugivore of two tree species with easily edible, mammal-dispersed fruit. We quantify the relative fruit removal rates of Artocarpus chaplasha and Careya arborea, by the Asian elephant (*Elephas maximus*) and alternative dispersers. Through focal watches and camera trapping, we found the elephant to be amongst the top three frugivores for each tree species. Furthermore, seed transects under *A. chaplasha* show that arboreal frugivores discard seeds only a short distance from the parental tree, underscoring the elephant's role as a long-distance disperser. Our data provide unprecedented support for an old notion: megaherbivores may be key dispersers for a broad set of mammal-dispersed fruiting species, and not just fruit inaccessible to smaller frugivores. As such, the elephant may be particularly important for the functional ecology of the disturbed forests it still inhabits across tropical Asia. © 2015 Cambridge University Press.

P. Sinphithakkul, N. Klangkaew, P. Sanyathitiseree, M. Giorgi, S. Kumagai, A. Poapolathep & S. Poapolathep

Pharmacokinetics of amoxicillin trihydrate in male Asian elephants (*Elephas maximus*) following intramuscular administration

Journal of Veterinary Pharmacology and Therapeutics 39 (2016) 287-291

Abstract. The purpose of this study was to investigate the pharmacokinetic characteristics of amoxicillin (AMX) trihydrate in male Asian elephants, *Elephas maximus*, following intramuscular administration at two dosages of 5.5 and 11 mg/kg body weight (b.w.). Blood samples were collected from 0.5 up to 72 h. The concentration of AMX in elephant plasma was measured using liquid chromatography electrospray ionization mass spectrometry. AMX was measurable up to 24 h after administration at two dosages. Peak plasma concentration (C_{max}) was 1.20 ± 0.39 μg/ml after i.m. administration at a dosage of 5.5 mg/kg b.w., whereas it was 3.40 ± 0.63 μg/ml at a dosage of 11 mg/kg b.w. A noncompartment model was developed to describe the disposition of AMX in Asian elephants. Based on the preliminary findings found in this research, the dosage of 5.5 and 11 mg/kg b.w. produced drug plasma concentrations higher than 0.25 mg/ml for 24 h after i.m. administration. Thereafter, i.m. administration with AMX at a dosage of 5.5 mg/kg b.w. appeared a more suitable dose than 11 mg/kg b.w. However, more studies are needed to determine AMX clinical effectiveness in elephants. © 2015 John Wiley & Sons Ltd.

C. Somgird, P. Homkong, S. Sripiboon, J.L. Brown, T.A.E. Stout, B. Colenbrander, S. Mahasawangkul & C. Thitaram

Potential of a gonadotropin-releasing hormone vaccine to suppress musth in captive male Asian elephants (*Elephas maximus*)

Animal Reproduction Science 164 (2016) 111-20

Abstract. Musth in adult bull elephants is a period of increased androgen concentrations ranging from a few weeks to several months. For captive elephant bull management, musth presents a serious challenge because of the aggressive behavior of musth bulls toward people and other elephants. Commercially available GnRH vaccines have been shown to suppress testicular function by interrupting the hypothalamo-pituitary-gonadal (HPG) axis in many species. The aim of this study was to test the efficacy of a GnRH vaccine in elephant bulls for suppressing the HPG axis and mitigating musth-related aggressive behavior. Five adult Asian elephant bulls (22–55 years old) were immunized with a GnRH vaccine starting with an initial injection 2–4 months before the predicted musth period, and followed by three boosters at approximately 4-week intervals. Blood samples were collected twice weekly for hormone and antibody titer analysis. An increase in GnRH antibody titers was observed in all bulls after the second or third booster, and titers remained elevated for 2–3 months after the final booster. Musth was attenuated and shortened in three bulls and postponed completely in two. We conclude that GnRH vaccination is capable of suppressing symptoms of musth in adult bull elephants. With appropriate timing, GnRH vaccination could be used to control or manage musth and aggressive behavior in captive elephant bulls. However, more work is needed to identify an optimal dose, booster interval, and vaccination schedule for complete suppression of testicular steroidogenesis.

C. Somgird, S. Sripiboon, S. Mahasawangkul, K. Boonprasert, J.L. Brown, T.A.E. Stout, B. Colenbrander & C. Thitaram

Differential testosterone response to GnRH-induced LH release before and after musth in adult Asian elephant (*Elephas maximus*) bulls

Theriogenology 85 (2016) 1225-1232

Abstract. Bull elephants exhibit marked increases in testosterone secretion during musth, and studies have shown a heightened sensitivity of the testis to GnRH-stimulated testosterone production in musth compared to nonmusth males. However, activity of the hypothalamo-pituitary-gonadal axis before or soon after musth has not been studied in detail. The aim of this study was to evaluate LH and testosterone responses to GnRH challenge in nine adult Asian elephant (*Elephas maximus*) bulls during three periods relative to musth: premusth, postmusth, and nonmusth. Bulls were administered 80 μg of a GnRH agonist, and blood was collected before and after injection to monitor serum hormone concentrations. The same bulls were injected with saline 2 weeks before each GnRH challenge and monitored using the same blood collection protocol. All bulls responded to GnRH, but not saline, with an increase in LH and testosterone during all three periods. The mean peak LH (1.76 ± 0.19 ng/mL; $P < 0.001$) and testosterone (6.71 ± 1.62 ng/mL; $P = 0.019$) concentrations after GnRH were higher than the respective baselines (0.57 ± 0.07 ng/mL, 3.05 ± 0.60 ng/mL). Although basal- and GnRH-induced LH secretion were similar across the stages, evaluation of the area under the curve in GnRH-treated bulls indicated that the testosterone response was greatest during premusth (2.84 ± 0.76 area units; $P = 0.019$) compared to postmusth (2.02 ± 0.63 area units), and nonmusth (2.01 ± 0.46 area units). This confirms earlier reports that GnRH stimulates LH release and subsequent testosterone production in bull elephants. Furthermore, although the hypothalamo-pituitary-gonadal axis is active throughout the year, the testis appears to be more responsive to LH in terms of testosterone production in the period leading up to musth, compared to the nonmusth and postmusth periods. This heightened sensitivity, perhaps as a result of LH receptor up-regulation, may prime the testis for maximal testosterone production, leading to the physiological and behavioral changes associated with musth.

S.K. Swami, A. Vijay, G. Nagarajan, R. Kaur & M. Srivastava

Molecular characterization of pro-inflammatory cytokines interleukin-1β and interleukin-8 in Asian elephant (*Elephas maximus*)

Animal Biotechnology 27 (2016) 66-76

Abstract. Interleukin (IL)-1β and IL-8 are pro-inflammatory cytokines produced primarily by monocytes and macrophages in response to a variety of microbial and nonmicrobial agents. As yet, no molecular data have been reported for IL-1β and IL-8 of the Asian elephant. In the present study, we have cloned and sequenced the cDNA encoding IL-1β and IL-8 of the Asian elephant. The open reading frame (ORF) of Asian elephant IL-1β is 789 bp in length, encoded a propeptide of 263 amino acid polypeptide. The predicted protein revealed the presence of IL-1 family signature motif and an ICE cut site. Whereas, IL-8 contained 321 bp of open reading frame. Interestingly, the predicted protein sequence of 106 aa, contains an ELR motif immediately upstream of the CQC residues, common in all vertebrate IL-8 molecules. Identity levels of the nucleic acid and deduced amino acid sequences of Asian elephant IL-1β ranged from 68.48 (squirrel monkey) to 98.57% (African elephant), and 57.78 (sheep) to 98.47% (African elephant), respectively, whereas that of IL-8 ranged from 72.9% (human) to 87.8% (African elephant), and 63.2 (human, gorilla, chimpanzee) to 74.5% (African elephant, buffalo), respectively. The phylogenetic analysis based on deduced amino acid sequenced showed that the Asian elephant IL-1β and IL-8 were most closely related to African elephant. Molecular characterization of these two cytokines, IL-1β and IL-8, in Asian elephant provides fundamental information necessary to progress the study of functional immune responses in this animal and gives the potential to use them to manipulate the immune response as recombinant proteins.

V. Thuppil & R.G. Coss

Playback of felid growls mitigates crop-raiding by elephants *Elephas maximus* in southern India

Oryx 50 (2016) 329-335

Abstract. We attempted to deter crop-raiding elephants *Elephas maximus* by using playbacks of threatening vocalizations such as felid growls and human shouts. For this purpose, we tested two sound-playback systems in southern India: a wireless, active infrared beam-triggered system to explore the effects of night-time uncertainty in elephants' assessment of predatory threats, and a passive infrared motion detector-triggered system for closer-range playbacks. Using the first system, we deterred 90% of crop-raiding attempts using tiger *Panthera tigris* growls, 72.7% using leopard *Panthera pardus* growls, and 57.1% using human shouts, with no statistically significant difference among the three sounds. Using the second system, playbacks of tiger and lion *Panthera leo* growls deterred 100 and 83.3% of crop-raiding attempts, respectively, with no statistically reliable difference between the two, although video evidence indicated that elephants were more fearful of tiger growls. Our results indicate that playbacks of threatening sounds can be effective in mitigating human–elephant conflict, particularly in bolstering existing deterrent methods.

V. Vanitha, K. Thiyagesan & N. Baskaran

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 stereotypies 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 stereotypies among elephants in captivity, with younger individuals being more susceptible, perhaps the most active phase of their life being confined by chaining.

R. Vézina-Audette, C. Herry, P. Burns, M. Frasch, E. Chave & C. Theoret

Heart rate variability in relation to stress in the Asian elephant (*Elephas maximus*)

Canadian Veterinary Journal 57 (2016) 289-292

Abstract. This study describes a safe, reliable, and accessible means to measure heart rate (HR) and HR variability (HRV) and evaluates the use of HRV as a physiological correlate of stress in the Asian elephant. A probabilistic model indicates that HRV measurements may adequately distinguish between stressed and non-stressed elephants.

S. Wilson, T.E. Davies, N. Hazarika & A. Zimmermann

Understanding spatial and temporal patterns of human–elephant conflict in Assam, India

Oryx 49 (2015) 140-149

Abstract. Large-scale forest encroachment in Assam, India, has led to increasing levels of human–elephant conflict. Conflict mitigation is a priority for the survival of Asian elephants *Elephas maximus* throughout Asia. We analysed a 3-year dataset of elephant occurrence and related instances of human–elephant conflict, from two sites in Assam, and explored the relationships between the various effects of elephants on human communities and factors influencing the spatial and temporal occurrence of these effects (proximity to water, refuge areas and villages, and human and crop density). The landscapes at both study sites have been transformed by forest loss, with large areas converted to agriculture. Remaining forest patches, which are mostly small, disconnected and degraded, as well as tea plantations, provide refuge areas for elephants as they move through the region. We found that crop depredation and property damage caused by elephants showed well-defined seasonal trends. They also showed a clear diurnal pattern, mostly occurring between 18:00 and 22:00. Small communities within 700 m of a refuge were most affected. In the management of human–elephant

Collared female "Dushya" in Yala (Sri Lanka)

conflict in Assam we need to consider the refuge patches used by elephants as they move through the region, the peripheries of which are likely to be conflict hotspots. Small villages on the edges of refuges should be a priority for conflict mitigation assistance, with strategies taking into account seasonal and diurnal variation in elephant behaviour, as well as the socio-economic and cultural composition of communities. © 2013 Fauna & Flora International.

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 Med. 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.

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Towards understanding isotope variability in elephant ivory to establish isotopic profiling and source-area determination

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Abstract. We present here new isotopic data ($\delta^{13}C$, $\delta^{15}N$, $\delta^{18}O$, $\delta^{2}H$, and $\delta^{34}S$) from pulverised ivory powder, measured by continuous flow isotope ratio mass spectrometry from an unprecedented large dataset of 507 ivory samples, derived from 28 African and six Asian elephant range states. The aim of this study is to assess the accuracy of isotopic fingerprinting and to evaluate its forensic potential and limitations to predict the provenance of ivory of unknown origin. We constructed a nominal assignment framework for the African reference samples, consisting of 208 different sites and applied the weighted k-Nearest Neighbor Classifier with reference site as classifier and inferred the accuracy of the assignments of samples from the African elephant species to their correct provenance. Our results show that isotopic profiling of African elephant ivory works on regional scales and we were able to assign 50% of all samples within 381 km, and the majority of the remaining samples within 1154 km. Source area determination is hampered by the fact that within-site and within-individual variation in ivory is immense because elephants as ecological generalists use a wide diversity of plant resources. We propose that forest elephant diets differ more between individuals (i.e. dietary niche partitioning is more significant) than in savanna elephants where individual diets overlap more. Increasing sampling effort in order to decrease median distance of the nominal assignment framework and to better understand within-site variance of the studied isotopic systems are imperative to establish isotopic profiling in the context of law enforcement and wildlife forensics.