Recent Publications on Asian Elephants

Compiled by Jennifer Pastorini

Anthropologisches Institut, Universität Zürich, Zürich, Switzerland
Centre for Conservation and Research, Tissamaharama, Sri Lanka
E-mail: jenny@aim.uzh.ch

If you need additional information on any of the articles, please feel free to contact me. You can also let me know about new (2018) publications on Asian elephants.

N. Abeysekara, R.P.V.J. Rajapakse & R.S. Rajakaruna
Comparative cross-sectional survey on gastrointestinal parasites of captive, semi-captive, and wild elephants of Sri Lanka
J. of Threatened Taxa 10 (2018) 11583-11594
Abstract. Parasites can influence the fitness of individuals particularly of small populations of endangered species. An island-wide, cross sectional, coprological survey was carried out from 03 January to 30 October 2015, to determine the gastrointestinal (GI) parasites of the Sri Lankan elephant *Elephas maximus maximus*. Fresh fecal samples from wild, captive and semi-captive elephants were collected and analyzed using a modified salt floatation, Sheather's sucrose floatation, direct iodine smears, and sedimentation methods. Species identification was done morphologically. Intensity of parasite infections was determined using McMaster technique. A total of 85 fecal samples (wild = 45, semi-captive = 20, captive = 20) were analysed; 58 (68.2%) samples were positive for GI parasites. Overall, helminth infections (60.0%) were more common than protozoan (37.6%) infections (Chi square test, $\chi^2 = 8.499$; $p < 0.001$). In the captive elephants, however, more protozoan infections were observed than helminthes, which could be due to anthelminthic treatment. A significantly higher prevalence of infection was observed in the wild elephants (93.3%) compared to semi-captive elephants (55.0%; $\chi^2 = 13.516$; $p < 0.001$) and captive elephants (25.0%; $\chi^2 = 32.289$; $p < 0.001$) but there was no significant difference in the prevalence between captive and semi-captive elephants ($\chi^2 = 3.750$; $p = 0.053$). Ten types of GI parasites were observed, nine of which were recorded in wild elephants. Among them the most common infection was strongyles (34.1%) with high intensity (440.1±295.2 EPG). Semi-captive elephants harbored five types of GI parasites, while captive elephants had only three types. One captive elephant at the Temple of the Tooth was infected with the tapeworm Anoplocephala sp. at low intensity of 50 EPG. Some of the GI parasites recorded are highly pathogenic while others are incidental. © 2018 The Authors.

R. Amin, H.S. Baral, B.R. Lamichhane, L.P. Poudyal, S. Lee, S.R. Jnawali, K.P. Acharya, G.P. Upadhyaya, M.B. Pandey, R. Shrestha, D. Joshi, J. Griffiths, A.P. Khatiwada & N. Subedi
The status of Nepal's mammals
J. of Threatened Taxa 10 (2018) 11361-11378
Abstract. The main objectives of the Nepal National Mammal Red Data Book (RDB) were to provide comprehensive and up-to-date accounts of 212 mammal species recorded in Nepal, assess their status applying the IUCN Guidelines at Regional Levels, identify threats and recommend the most practical measures for their conservation. It is hoped that the Mammal RDB will help Nepal achieve the Convention on Biological Diversity target of preventing the extinction of known threatened species and improving their conservation status. Of the 212 mammal species assessed, 49 species (23%) were listed as nationally threatened. These comprise nine (18%) Critically Endangered species, 26 (53%) Endangered species and 14 (29%) Vulnerable species. One species was considered regionally Extinct. A total of seven species (3%) were considered Near Threatened and 83 species (39%) were Data Deficient. Over sixty percent of Nepal's ungulates are threatened and

almost half of Nepal's carnivores face extinction (45% threatened). Bats and small mammals are the least known groups with 60 species being Data Deficient. Habitat loss, degradation and fragmentation are the most significant threats. Other significant threats include illegal hunting, small and fragmented populations, reduction of prey base, human wildlife conflict and persecution, climate change, invasive species, disease and inadequate knowledge and research. Adequate measures to address these threats are described. It was also concluded that re-assessments of the status of certain mammal groups be carried out every five years and the setting up of a national online species database and mapping system would also greatly help in land-use planning and policies. © 2018 The Authors.

James J. Anderson

The relationship of mammal survivorship and body mass modeled by metabolic and vitality theories

Abstract. A model describes the relationship between mammal body mass and survivorship by combining replicative senescence theory postulating a cellular basis of aging, metabolic theory relating metabolism to body mass, and vitality theory relating survival to vitality loss and extrinsic mortality. In the combined framework, intrinsic mortality results from replicative senescence of the hematopoietic stem cells and extrinsic mortality results from environmental challenges. Because the model expresses the intrinsic and extrinsic rates with different powers of body mass, across the spectrum of mammals, survivorship changes from Type I to Type II curve shapes with decreasing body mass. Fitting the model to body mass and maximum lifespan data of 494 nonvolant mammals yields allometric relationships of body mass to the vitality parameters, from which full survivor- ship pro les were generated from body mass alone. Because maximum lifespan data is predominantly derived from captive populations, the generated survivorship curves were dominated by intrinsic mortality. Comparison of the mass-derived and observed survivorship curves provides insights into how specific populations deviate from the aggregate of populations observed under captivity. © 2018 Society of Population Ecology and Springer Nature.

A. Aryal, C.G. Morley & I.G. McLean

Conserving elephants depend on a total ban of ivory trade globally

Abstract. Despite the Convention on International Trade in Endangered Species (CITES) 1989 ban on trading ivory internationally, poaching for ivory has intensified in both Africa and Asia. Populations of African elephant (*Loxodonta* spp.) and Asian elephant (*Elephas maximus*) have declined drastically. In response to the rapid decline, the USA and some other CITES countries have banned commercial ivory trading in ivory. The country with the highest ivory consumption, the People's Republic of China, recently shut down its legal ivory trade at the end of 2017. Nepal has turned the tide of elephant poaching, with no loss of elephants in the last 4 years. This remarkable success has been achieved by imposing a total ban on trade in ivory, supported by strict national legislation that includes significant fines and incarceration for poachers, traders and officials. Elsewhere, elephant poaching continues to increase despite the numerous disincentives already in place. Thus, we propose a global ban on trade in ivory as the only realistic solution to the current unsustainable rate of loss of elephants. The ban should be extended to trade in all products from endangered wildlife. © 2018 Springer Nature.

W. Azab, A.M. Damiani, A. Ochs & N. Osterrieder

Subclinical infection of a young captive Asian elephant with elephant endotheliotropic herpesvirus 1

Abstract. Elephant endotheliotropic herpes-viruses (EEHVs) are a continuous threat for young Asian elephants. We report a laboratory-confirmed infection of a 5-year-old female Asian elephant (AZ_2016) in the Berlin Zoologischer Garten. Initially, high EEHV-1 loads were detected in trunk swabs obtained from the young elephant during routine screening. The animal showed no clinical signs except for slight irritability. EEHV-1 was continuously shed for

almost one year, with fluctuations in viral load from time to time. Our investigations highlight the continuous threat of EEHV-1 to young captive Asian elephants and stress the importance of routine monitoring of captive elephants to allow early detection of infection. © 2018 Reprinted with permission from Springer-Verlag.

M. Bonaparte-Saller & J.A. Mench
Assessing the dyadic social relationships of female African (*Loxodonta africana*) and Asian (*Elephas maximus*) zoo elephants using proximity, tactile contact, and keeper surveys
Applied Animal Behaviour Science 199 (2018) 45-51
Abstract. Understanding the affiliative social relationships, or bonds, between zoo elephants has implications for both their welfare and management, yet there is limited work assessing and describing these bonds. Consequently, there is a need for the development of a reliable assessment tool. We used multiple metrics of proximity and tactile contact, as well as keeper surveys, to assess the social bond strength of 41 elephant dyads from 22 different zoos. Survey descriptions of social bond strength were based on previous research and included proximity and separation-reunion behaviors between individuals in a dyad. Approximately half of the elephant dyads in our study were rated as having a "strong" or "strongest" bond by keepers, who showed excellent agreement in their ratings of elephant bond strength (ICC(1,k) = 0.82). Elephant dyads that spent more time in proximity (within two elephant body lengths), and those that were more consistent in this behavior across time had an increased predicted probability of being rated as having a "strong or strongest bond" by keepers (p < 0.001; p = 0.002; respectively). Affiliative tactile contact within dyads, described using duration, diversity, symmetry, and variability metrics, was not significantly related to keeper assessments of dyad bond strength. On average, proximity within dyads occurred more often and was less variable than dyads' tactile behaviors. Our results suggest that tactile contact may play a more limited role in the maintenance of zoo elephant social bonds than proximity; however, additional research is needed to confirm this. Additionally, this study suggests that keepers are accurately assessing the proximity behavior of their elephants, highlighting the potential of this survey tool to reliably measure the social bond strength of zoo elephant dyads. © 2017 Reprinted with permission from Elsevier.

K. Boonsri, C. Somgird, P. Noinafai, K. Pringproa, T. Janyamethakul, T. Angkawanish, J.L. Brown, P. Tankaew, S. Srivorakul & C. Thitaram
Elephant endotheliotropic herpesvirus associated with *Clostridium perfringens* infection in two Asian elephant (*Elephas maximus*) calves
Journal of Zoo and Wildlife Medicine 49 (2018) 178-182
Abstract. Elephant endotheliotropic herpesvirus (EEHV) is an infection associated with fatal hemorrhagic disease in young Asian elephants (*Elephas maximus*). This brief communication describes the postmortem evaluation of two Asian elephant calves diagnosed with EEHV4 and EEHV1A in conjunction with *Clostridium perfringens* infection. Case 1 was a 7-mo-old, male captive-born Asian elephant that developed diarrhea and died 2 days after clinical presentation. Examination of the heart, lungs, liver, and spleen revealed predominantly basophilic intranuclear inclusion bodies in the endothelial cells of the blood vessels. Case 2 was a 3-mo-old, female wild-born Asian elephant that showed signs of lethargy, anorexia, and convulsions and died 6 hr after clinical presentation. No intranuclear inclusion bodies were observed. The heart, lung, liver, and spleen of both calves tested positive for EEHV by polymerase chain reaction. Phylogenetic analysis identified EEHV4 and EEHV1A in Case 1 and 2, respectively. Additionally, liver, spleen, and hemorrhagic intestinal tissue samples tested positive for $C.perfringens$ α, β, and ε toxins. This is the first reported case to describe coinfection of EEHV and *C. perfringens* in Asian elephant calves. © 2018 American Association of Zoo Veterinarians.

Janine L. Brown
Comparative ovarian function and reproductive monitoring of endangered mammals
Theriogenology 109 (2018) 2-13
Abstract. The ability to track gonadal function is facilitated by the use of endocrine and ultrasound techniques, both of which are important tools

for optimizing reproduction and ensuring sustainability of fragile populations. With so many species now endangered, captive breeding is increasingly viewed as a means to sustain important insurance populations. As reproduction is key to species survival, understanding how to control and monitor ovarian function is vital. Through decades of study, we now have a greater understanding of the diversity, and plasticity, of reproductive mechanisms across taxa. Even within related species, there are marked differences in seasonal, environmental and social influences on ovarian cycle dynamics, ovulatory mechanisms, and responses to assisted reproductive/ovulation induction protocols. For most wildlife species, endocrine function is assessed noninvasively through analyses of hormones or their metabolites excreted in urine or feces. Perhaps it should not be surprising then, that major differences in metabolism and routes of excretion exist, not only between species, but also among hormone types within a species. This means that a species by species, and sometimes hormone by hormone, approach is essential for developing effective reproductive monitoring and control strategies. Over the past 30 years, our laboratory has developed and validated a number of reproductive assay techniques, which has led to our amassing a database of ovarian cycle dynamics on over 100 species. This paper presents an overview of ovarian physiology, and summarizes comparative ovarian function research on some of our most well-studied species: felids, elephants, rhinos, tapirs and the giant panda, and how that information has been used to aid ex situ management. Each of these species represents a range of reproductive strategies, from the highly seasonal, monestrus giant panda to the aseasonal, polyestrus elephant. Some species exhibit spontaneous ovulations, while others are induced ovulators or both, with variations in ovarian cycle lengths that range from a few days to several months. These differences reinforce the need for studies of species basic biology to optimize breeding strategies. © 2017 Reprinted with permission from Elsevier.

M. Camoin, A. Kocher, P. Chalermwong, S. Yangtarra, N. Thongtip, S. Jittapalapong & M. Desquesnes

Adaptation and evaluation of an ELISA for *Trypanosoma evansi* infection (surra) in elephants and its application to a serological survey in Thailand

Abstract. *Trypanosoma evansi*, the causative agent of surra, is widespread in domestic livestock and wildlife in South East Asia. Surra can affect cattle, buffaloes, horses and also Asian elephants (*Elephas maximus*). Despite the 'threatened to extinction' CITES status of elephant, surra's impact has not been thoroughly assessed yet in this species. This work offers to adapt an antibody enzyme-linked immunosorbent assay (ELISA) protocol, to detect *Trypanosoma evansi* antibodies in elephant serum. The test was validated with 365 negative-reference samples, which allowed the determination of a 16% positive threshold. The test was applied to a serological survey including 375 individuals. The estimated global seroprevalence was 2.1% (95% CI 1.1–4.2%). Therefore, surra does not appear to be endemic in Thai domestic elephants, but occasional outbreaks were reported to our laboratory during the survey period. These outbreaks seemed to be linked to close proximity to cattle or buffaloes, and led to severe clinical signs in elephants. Frequent relapses were observed after treatment with diminazene aceturate, the only trypanocide drug currently available in Thailand. Therefore, care should be taken to keep elephants away from bovine reservoirs, and to monitor the disease in this endangered species. ELISA proved to be reliable for screening purposes as well as for post-treatment monitoring. © 2017 Cambridge University Press.

S. Chaichanathong, K. Taya, G. Watanabe, K. Nagaoka, W. Wajjwalku, A. Sudsukh & N. Thongtip

Immunohistochemical localization of inhibin/activin subunits in adult Asian elephant (*Elephas maximus*) testes

Abstract. Immunolocalization of inhibin-α and inhibin/activin βA and βB subunits in the testes of Asian elephant was determined. Testicular sections were immunostained with polyclonal antisera against inhibin subunit-α

and inhibin/activin βA and βB using the avidin-biotin-peroxidase complex method. Positive immunostaining against inhibin-α subunit was strongly present in Sertoli cells, and positive immunostaining for the inhibin/activin βA and βB subunits was observed in both Sertoli and Leydig cells. These results indicated that while Sertoli cells are the predominant source of inhibin and activin secretions in the testes of adult male Asian elephant, Leydig cells are a source of activin but not inhibin. © 2018 Japanese Society of Veterinary Science.

W.G.D. Chathuranga & K.B. Ranawana

A preliminary investigation of seed dispersal by elephants (*Elephas maximus maximus*) in Kumaragala Forest Reserve, Matale District, Sri Lanka

Abstract. Elephants are capable of dispersing seeds in the wild and hence, have the potential to affect the vegetation dynamics of forests. Only few studies have been conducted in Sri Lanka to study the seed dispersal capability of wild elephants. Thus, this study was initiated to determine the diversity of plant species that are dispersed by the elephants in Kumaragala forest reserve, Central Sri Lanka. Dung piles were searched twice a month and three dung boli were collected randomly from each dung pile. Visible seeds were identified by comparing with a reference seed collection. A total of 84 dung piles were recorded from September 2014 to February 2015. Fifty three dung piles out of 84 (63.1%) contained seeds or seedlings of one or more plant species. Most of the dung piles were found in relatively undisturbed areas of the study site. Twenty two plant species; 15 cultivated (68.2%) and seven non-cultivated (31.8%) plants belonging to nine families were identified from dung boli. *Careya arborea*, *Megathyrsus maximus* and *Mimosa pudica* were the most commonly noted seedlings. The findings of this study prove that elephants assist in dispersing seeds of some plant species in Kumaragala forest reserve area.

S. Debata & K.K. Swain

Estimating mammalian diversity and relative abundance using camera traps in a tropical deciduous forest of Kuldiha Wildlife Sanctuary, eastern India

Abstract. Information on the status and distribution of species within a geographical region is vital for designing effective conservation plans. We assessed the diversity and abundance of medium to large sized mammals in Kuldiha Wildlife Sanctuary, eastern India by using remotely triggered camera traps from January 2013 to August 2013. A total 916 camera trap days at 65 trap stations were deployed. We recorded 912 independent photographs and identified 20 species of mammals. Based on photographic rate of each mammalian species, the small Indian civet *Viverricula indica* represented high relative abundance (RAI = 2.07) among the carnivore while the Asian elephant *Elephas maximus* among the herbivores (RAI = 9.72) and the sloth bear *Melursus ursinus* among the omnivores (RAI = 2.51). Large carnivores like the leopard *Panthera pardus* (RAI = 0.55) and the Asiatic wild dog *Cuon alpinus* (RAI = 0.11) were represented by a relatively low abundance. Frequency of various anthropogenic activities from movement of livestock, feral dogs and human traffic accounted for maximum photo capture (combined RAI = 30.7) and found to be negatively correlated with mammalian relative abundance. So an effective intervention incorporating the social and ecological components is desirable for wildlife conservation in Kuldiha Wildlife Sanctuary. © 2018 Mammal Society of Japan.

L.J. Evans, G.P. Asner & B. Goossens

Protected area management priorities crucial for the future of Bornean elephants

Abstract. Tropical protected area management strategies have traditionally been heavily skewed towards high carbon, primary forests. This focus can result in areas, such as heavily logged forests, being viewed as low quality and thus offered up for conversion. We assessed the importance of intact to heavily logged forests for the Bornean elephant in the Malaysian state of Sabah. By modelling distributions of elephants throughout Sabah based on GPS telemetry tracking of 29 individuals and airborne three-dimensional forest mapping, we present the most wide-scale

analysis of forest use by Bornean elephants to date. Forests of 13 m in stature were found to be of highest suitability for elephants, especially when these areas were flat and low lying. Forest statures of this order are consistent with degraded landscapes, often viewed as suitable for oil palm conversion. Less than a quarter of fully protected intact forests in Sabah were of suitable stature for elephants, whereas disturbed commercial forest reserves were found to be highly suitable. We suggest that the importance of degraded landscapes for the future of elephants is currently underestimated, and thus, the need for the preservation of such habitats is not seen as a priority. The loss of these landscapes to large-scale agriculture could prove detrimental to the longevity of the species in Borneo. © 2018 The Authors. Reprinted with permission from Elsevier.

F. French, C. Mancini & H. Sharp
High tech cognitive and acoustic enrichment for captive elephants
Abstract. This paper investigates the potential for using technology to support the development of sensory and cognitive enrichment activities for captive elephants. It explores the usefulness of applying conceptual frameworks from interaction design and game design to the problem of developing species-specific smart toys that promote natural behaviours and provide stimulation. We adopted a Research through Design approach, and describe how scientific inquiry supported our design process, while the creation of artefacts guided our investigations into possible future solutions. Our fieldwork resulted in the development of an interactive prototype of an acoustic toy that elephants are able to control using interface elements constructed from a range of natural materials. © 2017 Reprinted with permission from Elsevier.

Herve Fritz
Long-term field studies of elephants: Understanding the ecology and conservation of a long-lived ecosystem engineer
Abstract. No permission to print abstract.

L. Girdland-Flink, E. Albayrak & A.M. Lister
Genetic insight into an extinct population of Asian elephants (*Elephas maximus*) in the Near East
Abstract. The current range of the Asian elephant is fragmented and restricted to southern Asia. Its historical range was far wider and extended from Anatolia and the Levant to Central China. The fossil record from these peripheral populations is scant and we know little of their relationship to modern Asian elephants. To gain a first insight to the genetic affinity of an *E. maximus* population that once inhabited Turkey we sequenced ca. 570 bp mtDNA from four individuals dating to ~3500 cal. BP. We show that these elephants carried a rare haplotype previously only observed in one modern elephant from Thailand. These results clarify the taxonomic identity of specimens with indeterminate morphologies and show that this ancient population groups within extant genetic variation. By placing the age of the common ancestor of this haplotype in the interval 3.7–58.7 kya (mean = 23.5 kya) we show that range-wide connectivity occurred at some time or times since the start of MIS 3, ~57 kya, probably reflecting range and population expansion during a favourable climatic episode. The genetic data do not distinguish natural versus anthropogenic origin of the Near Eastern Bronze Age population, but together with archaeological and paleoclimatic data they allow the possibility of a natural westward expansion around that time. © 2018 The Authors.

T.N.E. Gray, A.C. Hughes, W.F. Laurance, B. Long, A.J. Lynam, H. O'Kelly, W.J. Ripple, T. Seng, L. Scotson & N.M. Wilkinson
The wildlife snaring crisis: An insidious and pervasive threat to biodiversity in Southeast Asia
Abstract. Southeast Asia, a region supporting more threatened species than any other comparable continental area, is in the midst of a conservation crisis. Hunting constitutes the greatest current threat to the region's threatened vertebrates and has resulted in many areas of largely intact forest losing much of their former vertebrate diversity and abundance. Though numerous hunting

methods are used, capture with homemade snares is a major driver of this defaunation. Snares are cheaply constructed and easy to set but can be difficult to detect and are highly damaging to vertebrate populations due to their indiscriminate and wasteful nature. The primary response to snaring is the removal of snares by patrol teams: more than 200,000 snares were removed from just five of the region's protected areas between 2010 and 2015. However due to the low opportunity costs of replacing snares, removal alone is largely ineffective. Without the proactive search, arrest and prosecution of snare-setters, along with incentives not to hunt, snares will continue to be replaced. Legislative reform that criminalises the possession of snares, and the materials used for their construction, inside and immediately adjacent to protected areas is also required. Consistent enforcement of such legislation is essential. This must be combined with longer-term demand reduction activities aimed at changing cultural attitudes and behaviors related to the consumption of wildlife products in Southeast Asia. © 2017 Reprinted by permission from Springer Science+Business Media.

E.M. Gross, B.P. Lahkar, N. Subedi, V.R. Nyirenda, L.L. Lichtenfeld & O. Jakoby
Seasonality, crop type and crop phenology influence crop damage by wildlife herbivores in Africa and Asia
Abstract. Wildlife species damaging crops can cause substantial losses to farmers and at the same time create negative attitudes against wildlife and conservation efforts that may result in negative interactions against wildlife and lead to human-wildlife conflicts (HWCs). For the analysis of negative interactions between humans and terrestrial wildlife species, a globally applicable scheme for monitoring was developed and applied over 6 years in study areas of two Asian (Nepal and India) and two African (Zambia and Tanzania) countries. Factors influencing crop consumption by eight different groups of herbivores were monitored and analyzed using generalized linear models. Seasonality, crop availability, type and the phenological stage of the crop seem to play an important role in the crop damaging behavior of herbivores. Crop consumers such as elephants (*Loxodonta africana* and *Elephas maximus*), zebra (*Equus quagga* spp.) and boars/hogs (*Sus scrofa*, *Potamocherus larvatus* and *Phacochoerus africanus*) show preferences for harvested and/or maturing crops. Rhinos (*Rhinoceros unicornis*) and antelopes/deer (*Taurotragus oryx*, *Aepyceros melampus*, *Boselaphus tragocamelus* and *Axis axis*) damage the highest numbers of fields with crops at an intermediate growth stage. The findings of this study can inform management of HWCs in areas where people and wildlife coexist. Furthermore, this study demonstrates the benefits of standardized HWC assessments in order to compare data from different continents and between different species to be able to draw generalized conclusions for the management of HWC. © 2018 Reprinted by permission from Springer Nature.

R. Hermes, J. Saragusty, I. Moser, S. Holtze, J. Nieter, K. Sachse, T. Voracek, A. Bernhard, T. Bouts, F. Göritz & T.B. Hildebrandt
Bronchoalveolar lavage for diagnosis of tuberculosis infection in elephants
Abstract. Tuberculosis (TB) has been known to affect elephants for thousands of years. It was put into spotlight when few circus elephants were diagnosed carrying *Mycobacterium tuberculosis*. Because of the zoonotic risk and high susceptibility to *M. tuberculosis*, periodic testing was enacted since, in captive breeding programmes. Presently, trunk wash is the recommended diagnostic procedure for TB. Trunk wash, however, puts the operator at risk, has low sensitivity, and is prone to contamination. Here, bronchoalveolar lavage is described for the first time for TB diagnosis in elephants. Bronchial, trunk and mouth fluids were investigated using bacterial culture, *M. tuberculosis* complex (MTC)-specific real-time quantitative PCR (qPCR) and mycobacterial genus-specific qPCR for overall presence of mycobacteria or mycobacterial DNA including bacteria or DNA of closely related genera, respectively, in 14 elephants. Neither bacteria of the MTC nor their DNA were identified in any of the elephants. Yet, 25% of the cultures grew non-tuberculous mycobacteria (NTM) or closely related bacterial species. Furthermore, 85% of the samples contained DNA of NTM

or closely related bacterial genera. This finding might explain continued false-positive results from various serological tests. From a zoonotic point of view, bronchoalveolar lavage is safer for the testing personal, has higher probability of capturing MTC and, through PCR, identifies DNA NTM in elephants. Yet, necessary endoscopic equipment, animal sedation and access to a TB reference laboratory might pose challenging requirements in remote conditions in some elephant range countries. © 2018 Cambridge University Press.

K. Islam, M.F. Rahman & M. Jashimuddin
Modeling land use change using Cellular Automata and Artificial Neural Network: The case of Chunati Wildlife Sanctuary, Bangladesh
Abstract. Land use changes generally affect the integrity of an ecosystem. The effect of this change can be very severe if the conversion disrupts a crucial habitat of major plants and animals. The degraded Chunati Wildlife Sanctuary is one such area of Bangladesh, which is facing a serious problem of rapid land use change. In this study, the future trend of land use change of the area was modelled using Artificial Neural Network. Several driver variables were also incorporated to determine their effect on land use change. Binary logistic regression was used to assess the significance of the drivers of land use change for this region. The analysis shows that nearly 76% of the total land area (8258 ha) was covered by vegetation during 2005. After 2005, that was reduced to 61% (6637 ha) in 2015, a 15% decline from 2005. On the other hand, the coverage of vacant land increased from nearly 10% in 2005 to 22% in 2015. This is indeed a matter of real concern. The critical analysis suggests that Cellular Automata is not a good fit to simulate the future land uses as it misdirects the analysis both spatially and numerically. The incorporation of driver variables gives strength to the Artificial Neural Network to predict the future. The chi-square value for the prediction of land use of the area found from the neural network was 7.815, which was greater than the critical value (3.316). The neural network was found to be a good fit for future land use prediction. The kappa index of variation shows that the overall accuracy of the prediction using neural network was above 90%. Elevation, slope, and distance to the road were the three driver variables, which were found statistically significant while predicting the probability of forest land use change. The accuracy of the binary logistic regression was about 61%, which was quite satisfactory. The simulation result shows that almost 5732 ha of the total land will be in the forest category of land use during 2020 and it will be further decreased to 5128 ha in 2025. The vacant area will increase from 24% to 31% from 2020 to 2025. Based on the findings and simulated land use map of 2020–2025, the study will help the management authority of this critical habitat to take proper action before further degradation occurs. © 2018 Reprinted with permission from Elsevier.

G. Johnson, J. Smith, J. Peddie, L. Peddie, J. DeMarco & E. Wiedner
Use of glue-on shoes to improve conformational abnormalities in two Asian elephants (*Elephas maximus*)
Abstract. This report describes the use of custom-made, glue-on shoes for the front feet of two female adult Asian elephants (*Elephas maximus*) with conformational abnormalities. Both elephants had unequal leg lengths. The first elephant also had bilateral fetlock varus causing recurrent nail infections of the fourth digits of the front feet. The second elephant displayed weight shifting. Over several years, multiple shoe prototypes were tested. The current version is made of two types of shoe rubber, glued together and attached to the pad of the shorter leg with a liquid adhesive. The first elephant also has bilateral wedge pads to offload pressure from the fourth nails. The shoes are removed each month for foot care, then replaced. Within several months of wearing shoes, the first elephant's nail infections healed and the second elephant stopped weight shifting. Both elephants' gaits became smoother. This is the first description of corrective shoeing in elephants. © 2018 American Association of Zoo Veterinarians.

K. Karenina, A. Giljov, S. de Silva & Y. Malashichev

Social lateralization in wild Asian elephants: Visual preferences of mothers and offspring
Behavioral Ecology and Sociobiol. 72 (2018) e21

Abstract. Theoretical and empirical evidence suggest that socio-biological factors determine the expression of behavioural lateralization across species. One would expect the same association at the intraspecific level, that is, that the differences in social strategies of the two sexes entail the sex differences in the lateralized social processing. This study aimed to test whether this hypothesis applies to the lateralized behaviour of offspring towards a mother. The preferences in the use of the lateral visual field of the left and right eye were assessed in wild Asian elephant, *Elephas maximus* mothers and their young sons and daughters. The spatial positioning relative to a social partner during approach was used as a behavioural indicator of visual lateralization. At the population level, elephant mothers preferred to keep the young in their left visual field during slow travelling. In contrast, young did not display a one-sided bias for the whole sample. The lateralization, however, was pronounced in a sex-specific manner—sons preferentially kept their mothers in the right visual field, while daughters preferred to keep mothers in the left visual field. Intriguingly, both sons and daughters preferentially kept the familiar older young in the left visual field. Sons, thus, showed oppositely directed lateral preferences towards mother and non-mother companion. Presumably, sons aim to approach the mother from her left side (rather than to keep her in the right visual field) and benefit from optimized maternal perception, while daughters facilitate their own perception of the mother by keeping her in the left visual field. These sex-related differences in lateralized behaviour may result from strikingly different social strategies of two sexes. © 2018 Reprinted by permission from Springer-Verlag.

L. King, M. Pardo, S. Weerathunga, T.V. Kumara, N. Jayasena, J. Soltis & S. de Silva
Wild Sri Lankan elephants retreat from the sound of disturbed Asian honey bees
Current Biology 28 (2018) R51-R65

Abstract. Asian elephants (*Elephas maximus*) are threatened primarily by habitat loss and human–elephant conflict. In addition to establishing protected areas and corridors for wildlife, empowering farmers to protect their crops is crucial for Asian elephant conservation. Elephants can habituate to artificial deterrents, hence natural biological alternatives are of great interest. African elephants (*Loxodonta africana*) avoid African honey bees (*Apis mellifera scutellata*), inspiring 'beehive fences' as a successful means of small-scale crop protection. Here, we used a recording of a disturbed hive of cavity-dwelling Asian honey bees (*Apis cerana indica*) and conducted sound playbacks to 120 wild elephants in 28 different groups resting under trees in Uda Walawe National Park in Sri Lanka. Elephants responded by moving significantly further away from their resting site in bee playback trials compared to controls. Elephants also increased vocalization rates, as well as investigative and reassurance behaviours in response to bee sounds, but did not display dusting or headshaking behaviour. © 2018 Reprinted with permission from Elsevier.

V. Kochagul, S. Srivorakul, K. Boonsri, C. Somgird, N. Sthitmatee, C. Thitaram & K. Pringproa
Production of antibody against elephant endotheliotropic herpesvirus (EEHV) unveils tissue tropisms and routes of viral transmission in EEHV-infected Asian elephants
Scientific Reports 8 (2018) e4675

Abstract. Elephant endotheliotropic herpesvirus (EEHV) is one of the most devastating viral infectious diseases in elephants worldwide. To date, it remains unclear how elephants get infected by the virus, where the virus persists, and what mechanisms drive the pathogenesis of the disease. The present study was aimed to develop an antibody against glycoprotein B (gB) of EEHV, investigate the EEHV tissue tropisms, and provide the possible routes of EEHV transmission in Asian elephants. Samples from elephant organs that had died from EEHV1A and EEHV4 infections, peripheral blood mononuclear cells (PBMC) from EEHV4- and non-EEHV-infected calves were used in this study. The results of western immunoblotting indicated that the antibody can be used for detection of gB antigens in both EEHV1A- and EEHV4-infected samples. Immunohistochemical detection indicated that the EEHV gB antigens

were distributed mainly in the epithelial cells of the salivary glands, stomach and intestines. Immunofluorescence test of PBMC for EEHV gB in the EEHV4-infected calf indicated that the virus was observed predominantly in the mononuclear phagocytic cells. The findings in the present study unveil tissue tropisms in the EEHV1A- and EEHV4-infected calves and point out that saliva and intestinal content are likely sources for virus transmission in EEHV-infected Asian elephants. © 2018 The Authors.

C.A. LaDue, T.E. Goodwin & B.A. Schulte

Concentration-dependent chemosensory responses towards pheromones are influenced by receiver attributes in Asian elephants

Abstract. The physical structure of a signal is not sufficient to determine its meaning. For chemical signals between conspecifics, this concept is termed "pheromonal parsimony." The function of a compound depends not only on its molecular structure but also on its context, which can include signal concentration and various receiver at- tributes. We sought to investigate the contextual flexibility of chemosensory responses through bioassays with Asian elephant (*Elephas maximus*) sex pheromones of various concentrations (frontalin, from males, and (Z)-7-dodecenyl acetate [Z7-12:Ac], from females). We hypothesized that elephants would respond stronger to higher concentrations, especially towards the opposite-sex pheromone, and that receiver age and sexual experience would modify responses. We examined responses of 73 captive elephants to both compounds. Pheromone concentration impacted the rate of chemosensory response, which was further modified by the sex, age and/or sexual experience of the receiver. Response rates increased with concentration for each compound across both sexes. Experience shaped male responses with older, physiologically primed males responding more often. The interaction between experience and age affected female response to frontalin, but not to Z7-12:Ac. Furthermore, response thresholds were modified by sexual experience in most cases: experienced animals generally had lower thresholds than inexperienced animals. Elephants responded to each solution according to its perceived relevance, including concentration. These results also indicate that receiver attributes (e.g., sex, age and sexual experience) may modify seemingly fixed chemosensory responses and further emphasize the flexibility of vertebrate communication systems. © 2018 Blackwell Verlag GmbH.

Nicolas Lainé

Elephant tuberculosis as a reverse zoonosis

Abstract. In the last twenty years, a growing number of captive elephants have tested positive for tuberculosis (TB) in various institutions worldwide, causing public health concerns. This article discusses two localities where this concern has produced significant mobilizations to ask about the postcolonial resonances of this global response. The first case focuses on epidemiological studies of elephant TB in Laos launched by international organizations involved in conservation, and on the role of traditional elephant workers (mahouts) in the daily care for elephants. The second describes the finding by veterinarians of two elephants suspected of TB infection in a French zoo and the mobilization of animal rights activists against the euthanasia of the pachyderms. The article shows that while, in the recent past, in France elephants were considered markers of exoticism and in Laos as coworkers in the timber industry, they are now considered to be endangered subjects in need of care, compassion, and conservation. This analysis contributes to the anthropology of relations between humans and elephants through the study of a rare but fascinating zoonosis. © 2018 The Author.

B.R. Lamichhane, N. Subedi, C.P. Pokheral, M. Dhakal, K.P. Acharya, N.M.B. Pradhan, J.L.D. Smith, S. Malla, B.S. Thakuri & C.B. Yackulic

Using interviews and biological sign surveys to infer seasonal use of forested and agricultural portions of a human-dominated landscape by Asian elephants in Nepal

Abstract. Understanding how wide-ranging animals use landscapes in which human use is highly heterogeneous is important for determining patterns of human–wildlife conflict

and designing mitigation strategies. Here, we show how biological sign surveys in forested components of a human-dominated landscape can be combined with human interviews in agricultural portions of a landscape to provide a full picture of seasonal use of different landscape components by wide-ranging animals and resulting human–wildlife conflict. We selected Asian elephants (*Elephas maximus*) in Nepal to illustrate this approach. Asian elephants are threatened throughout their geographic range, and there are large gaps in our understanding of their landscape-scale habitat use. We identified all potential elephant habitat in Nepal and divided the potential habitat into sampling units based on a 10 km by 10 km grid. Forested areas within grids were surveyed for signs of elephant use, and local villagers were interviewed regarding elephant use of agricultural areas and instances of conflict. Data were analyzed using single-season and multi-season (dynamic) occupancy models. A single-season occupancy model applied to data from 139 partially or wholly forested grid cells estimated that 0.57 of grid cells were used by elephants. Dynamic occupancy models fit to data from interviews across 158 grid cells estimated that monthly use of non-forested, human-dominated areas over the preceding year varied between 0.43 and 0.82 with a minimum in February and maximum in October. Seasonal patterns of crop raiding by elephants coincided with monthly elephant use of human-dominated areas, and serious instances of human–wildlife conflict were common. Efforts to mitigate human–elephant conflict in Nepal are likely to be most effective if they are concentrated during August through December when elephant use of human-dominated landscapes and human–elephant conflict are most common. © 2017 Dipartimento di Biologia, Universita di Firenze, Italia.

L. Lin & L. Zhang

The impact on local forest ecosystem by elephants
Abstract. Current taxonomy recognizes three extant species of elephants (Elephantidae), the African bush elephant *Lodonta africana*, the African forest elephant *Loxodonta cyclotis* and the Asian elephant *Elephas maximus*. As large herbivores and an excellent keystone species, elephants can cause positive and / or negative impacts on their surrounding environments and these impacts can vary in both temporal and spatial scales. The positive impacts include: improved seed dispersal and germination; creating forest gaps and maintaining community diversity; and enriching food resources and habitat for other animals. The negative impacts include: causing biodiversity loss by reducing locally vulnerable species, and causing habitat degradation by transforming local plant communities from woodlands to shrub lands or grass lands. Population over-abundance by confinement to habitat islands due to habitat loss is mainly responsible for the negative impacts caused by elephants. Simply culling off elephants would not be an effective mitigation strategy to offset their negative impacts and is strongly discouraged. Rigorous scientific information on effective ways to evaluate and alleviate the negative impact of elephants and to guide proper management plans still is lacking. Local environmental conditions and site-specific objectives should be considered when developing management actions to curb the negative impact of elephants on woody vegetation. All elephant species, including African bush elephant, African forest elephant and Asian elephants, are currently facing severe population declines and habit loss. In order to save them from extinction, it is imperative to conduct more comprehensive research to better understand the relationship between elephants and the ecosystems in which they live. [MAIN TEXT IN CHINESE].

S. Liu, Y. Yin, J. Li, F. Cheng, S. Dong & Y. Zhang

Using cross-scale landscape connectivity indices to identify key habitat resource patches for Asian elephants in Xishuangbanna, China
Abstract. The landscape connectivity of natural habitats serves an important role in the migration and survival of animals. In southwestern China, the rapid decline of the Asian elephant (*Elephas maximus*) population has been attributed to habitat loss and fragmentation due to recent land-

use changes. Despite efforts to protect the Asian elephants' habitats, an analysis on the cross-scale landscape connectivity within and among these habitats has rarely been documented. In this study, we focused in Xishuangbanna, China and first identified the key patches for the Asian elephant in Xishuangbanna, China. We then evaluated the landscape connectivity and compared scenarios for eight dispersal distances of the resource patches. Levels of importance for each individual patch were evaluated by calculating the probability of connectivity (dPC) and betweenness centrality (dBC). Results showed that habitats with high suitability occupied 29% of the studied area. The distribution of patch importance levels was determined separately by dPC and dBC, and these two indices corresponded with each other via the connector fraction of dPC (dPC$_{connector}$) index. The final total area of the priority patches was 2478 km^2, or approximately 76% of the suitable habitat area. Our study indicated that the cross-scale landscape connectivity analysis is an effective approach to characterize the key patches, and the priority patches for Asian elephants can be selected by using both dBC and dPC in Xishuangbanna. © 2017 Reprinted with permission from Elsevier.

K.P. Lyashchenko, C. Gortázar, M.A. Miller & W.R. Waters

Spectrum of antibody profiles in tuberculous elephants, cervids, and cattle
Veterinary Microbiology 214 (2018) 89-92

Abstract. Using multi-antigen print immuno-assay and DPP® VetTB Assay approved in the United States for testing captive cervids and elephants, we analyzed antibody recognition of MPB83 and CFP10/ESAT-6 antigens in Asian elephants (*Elephas maximus*) infected with Mycobacterium tuberculosis and in white-tailed deer (*Odocoileus virginianus*), fallow deer (*Dama dama*), elk (*Cervus elaphus*), and cattle (*Bos taurus*) infected with *Mycobacterium bovis*. Serum IgG reactivity to MPB83 was found in the vast majority of tuberculous cattle and cervid species among which white-tailed deer and elk also showed significant CFP10/ESAT-6 recognition rates with added serodiagnostic value. In contrast, the infected elephants developed antibody responses mainly to CFP10/ESAT-6 with MPB83 reactivity being relatively low. The findings demonstrate distinct patterns of predominant antigen recognition by different animal hosts in tuberculosis. © 2017 Reprinted with permission from Elsevier.

S.S.B. Moo, G.Z.L. Froese & T.N.E. Gray

First structured camera-trap surveys in Karen State, Myanmar, reveal high diversity of globally threatened mammals
Oryx 52 (2018) 537-543

Abstract. The hill forests of Karen State, Myanmar, were previously inaccessible to biologists and conservationists for security and political reasons. We have, however, now been able to conduct six surveys across the area, using camera traps, for a total of 9,511 trap-nights, to ascertain the presence of threatened mammal species. We obtained 4,191 records of at least 31 mammal species, including 17 categorized as Near Threatened, Vulnerable or Endangered on the IUCN Red List. Carnivores were especially diverse, with 19 species recorded, indicating a globally significant community, including the tiger *Panthera tigris*, leopard *Panthera pardus* and dhole *Cuon alpinus*. Our methodology was not appropriate for estimating relative abundance or occupancy but the species richness of the mammal community, the number of records and the number of locations where species were detected suggest the area is important for the conservation of a globally threatened mammal community that is in decline across the majority of its range. Despite long-standing conservation efforts undertaken by the Karen people, their forests are threatened by hunting and habitat loss. These threats are likely to be exacerbated as political change brings rapid development. Urgent action is thus needed to assist the Karen people to protect one of South-east Asia's last intact rich and diverse ecosystems. © 2017 Fauna & Flora International.

S. Nandini, P. Keerthipriya & T.N.C. Vidya

Group size differences may mask underlying similarities in social structure: A comparison of female elephant societies
Behavioral Ecology 29 (2018) 145-159

Abstract. No permission to print abstract.

T. Nguyen & J.L. Frechette

The market for elephant ivory in Cambodia

Abstract. This study aimed to evaluate the potentially important and under- studied market for ivory in Cambodia. Market surveys were conducted in June 2015 and January 2016 to assess the number of ivory items for sale, the price of items, and the demographics of the customer base in three Cambodian cities (Phnom Penh, Siem Reap, Sihanoukville). Each city was systematically surveyed to identify ivory vendors. In 2015, 10 retail outlets in Phnom Penh and five retail outlets in Siem Reap were identified as selling elephant ivory, offering a total of 502 and 282 ivory items, respectively. Surveys in January 2016 showed that the number of shops offering ivory had increased to 16 (670 items) in Phnom Penh and eight shops (446 items) in Siem Reap. No elephant ivory was found during either survey in Sihanoukville. Vendors reported that the main consumers of ivory were foreign, particularly Chinese nationals. This study shows that there is a persistent market for ivory in Cambodia, which may be driven largely by foreign buyers from China.

A. Pérez-Manrique & A. Gomila

The comparative study of empathy: Sympathetic concern and empathic perspective-taking in non-human animals

Abstract. While empathy is a century-old psychological concept, its study in non-human animals has become the focus of much recent scientific interest, as it promises to provide the clues to understand the evolutionary origins of our social and moral nature. A review of the comparative study of empathy is thus timely to complement and constrain anthropocentric views, and to integrate current findings. However, this is not an easy task. The study of animal empathy has developed using different paradigms, different concepts of the phenomena involved, and the absence of a systematic program. Herein, we carry out a comprehensive review of the literature on complex forms of empathy in non-human animals: sympathetic concern and empathic perspective-taking. In particular, we focus on consolation and targeted helping, as the best examples of each category. In so doing, we try to shed light on the current debate concerning whether these phenomena are exclusively human traits. First, we try to clarify the terminology and taxonomy of forms of empathy, providing operative criteria for these phenomena that are applicable to both human and non-human animals. Second, we discuss whether the available evidence qualifies such behaviour as empathic. Third, we aim to provide an integrative view of the field, clarifying the challenges and conditions to satisfy. We also hope to highlight the importance of the study of these processes for elucidating the evolutionary history of this capacity across the animal kingdom. © 2017 The Authors.

K.L. Perrin, A.K. Krogh, M. Kjelgaard-Hansen, L. Howard, L. Bochsen, W.K. Kiso, D. Schmitt, A.T. Kristensen & M.F. Bertelsen

Thromboelastography in the healthy Asian elephant (*Elephas maximus*): Reference intervals and effects of storage

Abstract. Hemorrhagic disease associated with elephant endotheliotropic herpesvirus infection is the most-frequent cause of mortality in captive Asian elephants (*Elephas maximus*). Survival relies on intensive monitoring of hemostatic status. Thromboelastography (TEG) utilizes whole blood samples containing all the blood components of hemostasis and is therefore a sensitive indicator of the clinical status in the patient. This study was performed to assess the practicability of TEG in Asian elephants in a zoo environment. Citrated stabilized whole blood samples were obtained from 44 healthy Asian elephants. Kaolin-activated TEG was performed on whole blood at 60 min and 24 hr postsampling (to replicate shipment to an external laboratory) as well as on freeze–thawed plasma samples, 12–14 mo postsampling. Reference intervals were calculated for fresh whole blood and freeze–thawed plasma samples. In the 24-hr analysis, storage artifacts, likely due to cellular degeneration, resulted in a hypercoagulable thromboelastogram and thus reduced sensitivity for detecting coagulopathies. Therefore, delayed analysis of whole blood samples is not

recommended. © 2018 American Association of Zoo Veterinarians.

A. Pinyopummin, S. Mahasawangkul, G. Nunklang, K. Kornkaewrat, S. Laopiem, S. Koonjaenak & P. Wattananit

Supplemented stallion seminal plasma can improve impaired motility due to the dilution effect in chilled Asian elephant sperm

Abstract. The dilution effect and effect of restoring seminal plasma (SP) proportion in diluted semen were determined in chilled Asian elephant sperm. Semen was collected from eight males, and samples with ≥30% motile sperm were used in the study. Tris‑glucose‑egg yolk extender (TE) was used for cooled storage at 4°C for 48 hr. In experiment 1 (n = 18), semen was diluted to 1:1, 1:3, 1:7 and 1:15 with TE (volume per volume). There were no significant changes in sperm viability and sperm with normal acrosome integrity among dilutions, but sperm motility and motility velocities were greater (p < .05) in the 1:1 dilution than those of the 1:7 and 1:15 dilutions at 48 hr of storage. In experiment 2, supplemented SP was derived from elephants and stallions. In experiment 2.1, diluted semen (1:7 dilution) was restored with SP to obtain a 1:2 proportion (n = 8). Sperm motility, viability and sperm with normal acrosome integrity were similar among treatments, but motility velocities were greater (p < .05) with stallion SP at 48 hr of storage. In experiment 2.2, diluted semen (1:15 dilution) was restored with SP to obtain a 1:3 proportion (n = 10). Sperm viability and sperm with normal acrosome integrity were similar among treatments at 48 hr of storage. However, sperm motility and motility velocities were greater (p < .05) with stallion SP than those of others. In conclusion, elephant sperm motility was affected by a dilution effect and restoration of SP proportion with stallion SP, but not with elephant SP, could improve motility in chilled highly diluted sperm. © 2018 Blackwell Verlag.

J. Podani, A. Kun & A. Szilágyi

How fast does Darwin's elephant population grow?

Abstract. In "The Origin of Species," Darwin describes a hypothetical example illustrating that large, slowly reproducing mammals such as the elephant can reach very large numbers if population growth is not affected by regulating factors. The elephant example has since been cited in various forms in a wide variety of books, ranging from educational material to encyclopedias. However, Darwin's text was changed over the six editions of the book, although some errors in the mathematics persisted throughout. In addition, full details of the problem remained hidden in his correspondence with readers of the Origin. As a result, Darwin's example is very often misinterpreted, misunderstood or presented as if it were a fact. We show that the population growth of Darwin's elephant population can be modeled by the Leslie matrix method, which we generalize here to males as well. Darwin's most often cited figure, about 19 million elephants after 750 years is not a typical outcome, actually a very unlikely result under more realistic, although still hypothetical situations. We provide a recursion formula suggesting that Darwin's original model corresponds to a tribonacci series, a proof showing that sex ratio is constant over all age classes, and a derivation of a generating function of the sequence. © 2017 reprinted by permission from Springer Science+Business Media.

A.D.G. Ranjeewa, J. Pastorini, K. Isler, D.K. Weerakoon, H.D. Kottage & P. Fernando

Decreasing reservoir water levels improve habitat quality for Asian elephants

Population health and habitat quality are intimately related and seasonal changes in habitat quality are likely to be reflected in the body condition of animals. We studied seasonal variation of body condition in free ranging Asian elephants (*Elephas maximus*) in Udawalawe National Park, Sri Lanka based on visual scoring of individually identified elephants. We assessed the body condition of 218 adult females and 329 adult males from January 2008 to November 2012 and examined its relation to monthly rainfall and water level of the Udawalawe reservoir. Contrary to expectations, body condition of elephants was higher in the dry season, when primary

productivity decreases due to lack of rainfall. However, the body condition showed both a seasonal and inter-annual negative co-relation with reservoir water level. A possible explanation for improved body condition in the dry season is the greater availability of fresh grass due to the emergence of reservoir bed grasslands with the drawdown of water. Our results underscore the importance of water management of large irrigation reservoirs in elephant conservation in Sri Lanka. © 2017 Deutsche Gesellschaft für Säugetierkunde. Reprinted with permission from Elsevier.

C. Sampson, P. Leimgruber, D. Tonkyn, J. Pastorini, H.K. Janaka, E. Sotherden & P. Fernando
Effects of illegal grazing and invasive *Lantana camara* on Asian elephant habitat use
Abstract. Protected areas provide some of the last refuges for Asian elephants in the wild. Managing these areas for elephants will be critical for elephant conservation. Scientists know little about elephant habitat use in Asia and how invasive species or livestock grazing influence habitat use. We studied these issues in two protected areas in Sri Lanka, Udawalawe National Park and Hurulu Eco-Park. These areas contain some of Sri Lanka's largest remaining grasslands. These grasslands are threatened by the invasive and toxic shrub, *Lantana camara*, and are used for illegal livestock grazing. To measure habitat use by elephants and livestock, we conducted dung surveys along over 50 km of transects stratified across grassland, scrub, and forest. We surveyed 159 vegetation plots along these transects to assess plant composition, and mapped habitat types based on satellite images. We used mixed-effect models to determine the relative importance of habitats, livestock presence, and plant associations for elephant use. Elephant presence was greatest in scrub and grassland habitats, positively associated with both livestock presence and short graminoids, and unaffected by *L. camara*, which was widespread but at low densities. Given the importance of these areas to elephants, we recommend a precautionary management approach that focuses on curbing both illegal grazing and the spread of *L. camara*. © 2018 Reprinted with permission from Elsevier.

C. Sampson, J. McEvoy, Z.M. Oo, A.M. Chit, A.N. Chan, D. Tonkyn, P. Soe, M. Songer, A.C. Williams, K. Reisinger, G. Wittemyer & P. Leimgruber
New elephant crisis in Asia — Early warning signs from Myanmar
Abstract. In the southern Bago Yoma mountain range in Myanmar, Asian elephants are being killed at a disturbing rate. This emerging crisis was identified initially through a telemetry study when 7 of 19 of collared elephants were poached within a year of being fitted with a satellite-GPS collar. Subsequent follow up of ground teams confirmed the human caused death or disappearance of at least 19 elephants, including the seven collared individuals, within a 35 km2 area in less than two years. The carcasses of 40 additional elephants were found in areas located across south-central Myanmar once systematic surveys began by our team and collaborators. In addition to the extreme rate of loss, this study documents the targeting of elephants for their skin instead of the more common ivory, an increasing trend in Myanmar. Intensive research programs focused on other conservation problems identified this issue and are now encouraging local authorities to prioritize anti-poaching efforts and improve conservation policies within the country. Myanmar represents one of the last remaining countries in Asia with substantial wildlands suitable for elephants. Increasing rates of human-elephant conflict and poaching events in this country pose a dire threat to the global population.

C. Schiffmann, S. Hoby, C. Wenker, T. Hard, R. Scholz, M. Clauss & J.-M. Hatt
When elephants fall asleep: A literature review on elephant rest with case studies on elephant falling bouts, and practical solutions for zoo elephants
Abstract. Little attention has been paid to the resting and sleeping behavior of zoo elephants so far. An important concern is when elephants avoid lying down, due to degenerative joint

and foot disease, social structure, or stressful environmental changes. Inability or unwillingness to lie down for resting is an important welfare issue, as it may impair sleep. We emphasize the importance of satisfying rest in elephants by reviewing the literature on resting behavior in elephants (*Loxodonta africana* and *Elephas maximus*) as well as the documentation of four cases from European zoos and our own direct observations in a zoo group of four female African elephants during 12 entire days. The common denominator in the case reports is the occurrence of a falling bout out of a standing position subsequently to a cessation of lying rest for different periods of time. Although well-known in horses as "episodic collapse" or "excessive drowsiness," this syndrome has not been described in elephants before. To enable its detection, we recommend nocturnal video monitoring for elephant-keeping institutions. The literature evaluation as well as own observational data suggest an inverse relationship between lying rest and standing rest. Preventative measures consist of enclosure modifications that facilitate lying rest (e.g., sand hills) or standing rest in a leaning position as a substitute. Anecdotal observations suggest that the provision of appropriate horizontal environmental structures may encourage safe, sleep-conducive standing rest. We provide drawings on how to install such structures. Effects of providing such structures should be evaluated in the future. © 2018 Wiley Periodicals.

M.W. Seltmann, S. Helle, M.J. Adams, K.U Mar & M. Lahdenperä

Evaluating the personality structure of semi-captive Asian elephants living in their natural habitat

Abstract. Data on personality for long-lived, highly social wild mammals with high cognitive abilities are rare. We investigated the personality structure of Asian elephants (*Elephas maximus*) by using a large sample of semi-captive timber elephants in Myanmar. Data were collected during 2014–2017 using questionnaires, for which elephant riders (mahouts) rated 28 behavioural adjectives of elephants. Repeated questionnaires were obtained for each elephant from several raters whenever possible, resulting in 690 ratings of 150 female and 107 male elephants. We started by performing a confirmatory factor analysis to compare the fit of our data to a previously published captive elephant personality structure. Owing to a poor fit of this model to our data, we proceeded by performing explanatory factor analysis to determine the personality structure in our study population. This model suggested that personality in these elephants was manifested as three factors that we labelled as Attentiveness, Sociability and Aggressiveness. This structure did not differ between the sexes. These results provide the basis for future research on the link between personality and reproductive success in this endangered species and more generally, help to resolve the selective pressures on personalities in long-lived, highly social species. © 2018 The Authors.

R. Sharma, B. Goossens, R. Heller, R. Rasteiro, N. Othman, M.W. Bruford & L. Chikhi

Genetic analyses favour an ancient and natural origin of elephants on Borneo

Abstract. The origin of the elephant on the island of Borneo remains elusive. Research has suggested two alternative hypotheses: the Bornean elephant stems either from a recent introduction in the 17th century or from an ancient colonization several hundreds of thousands years ago. Lack of elephant fossils has been interpreted as evidence for a very recent introduction, whereas mtDNA divergence from other Asian elephants has been argued to favor an ancient colonization. We investigated the demographic history of Bornean elephants using full-likelihood and approximate Bayesian computation analyses. Our results are at odds with both the recent and ancient colonization hypotheses, and favour a third intermediate scenario. We find that genetic data favour a scenario in which Bornean elephants experienced a bottleneck during the last glacial period, possibly as a consequence of the colonization of Borneo, and from which it has slowly recovered since. Altogether the data support a natural colonization of Bornean elephants at a time when large terrestrial mammals could colonise from the Sunda shelf when sea levels were much lower. Our results are important

not only in understanding the unique history of the colonization of Borneo by elephants, but also for their long-term conservation. © 2018 The Authors.

P. Siengdee, S. Klinhom, C. Thitaram & K. Nganvongpanit

Isolation and culture of primary adult skin fibroblasts from the Asian elephant (*Elephas maximus*)

Abstract. Primary cultures from Asian elephants (*Elephas maximus*) allow scientists to obtain representative cells that have conserved most of their original characteristics, function, physiology and biochemistry. This technique has thus gained significant importance as a foundation for further cellular, cell biology and molecular research. Therefore, the aim of this study was to describe conditions for the successful establishment of primary adult fibroblasts from Asian elephant carcasses. Ear tissue sample collection from Asian elephant carcasses and our recommendations are given. We describe here a simple modified protocol for successful isolation and maintenance of primary adult fibroblasts from elephant ear skin. Ear samples from each individual (five 3 × 3 cm² pieces) were brought to the laboratory within 3 h after collection, kept in transportation medium at 0–4ºC. The ear tissues were prepared by a combination of 10% collagenase type II digestion procedure together with a simple explant procedure. Primary fibroblasts were cultured at 37ºC in Dulbecco's modified Eagle's medium (DMEM) with 20% fetal calf serum (FCS) in a humidified atmosphere containing 5% CO_2. After the third passage, fibroblasts were routinely trypsinized with 0.25% trypsin/EDTA and cultured in DMEM with 10% FCS at 37ºC and 5% CO_2. Traditional cell counting method was used to measure cell viability and growth curve. Long-term storage of cells used freezing medium consisting of 40% FCS (v/v). We explored the most suitable conditions during sample collection (post- mortem storage time and sample storage temperature), which is the most important step in determining primary outgrowth. Our study successfully established and cultured primary adult skin fibroblasts obtained from post-mortem *E. maximus* ear skin tissues from six carcasses, with a success rate of around 83.3%. Outgrowth could be seen 4–12 days after explantation, and epithelial-like cells were found after 4–7 days of culture, while fibroblasts appeared at around day 7–10. The fibroblasts had viability and post-freezing recovery rates of around 97.3 ± 4.3% and 95.5 ± 7.3%, respectively, and doubling time was about 25 h (passage 6). To our knowledge, this report is the first to describe primary cell cultures derived from adult Asian elephant skin. Future studies should benefit from the information and useful suggestions herein, which may be used as a standard method for establishing primary skin fibroblast cultures in future experiments. © 2018 The Authors.

S. de Silva, V. Schmid & G. Wittemyer

Fission–fusion processes weaken dominance networks of female Asian elephants in a productive habitat

Abstract. No permission to print abstract.

R.B. Suba, N.G.P. Beveridge, W. Kustiawan, G.R. de Snoo & H.H. de Iongh

Foraging ecology and diet of Bornean elephants (*Elephas maximus borneensis*) in the Sebuku forest area, North Kalimantan Province of Indonesia: Do the choices matter?

Abstract. none.

K. Suraprasit, H. Bocherens, Y. Chaimanee, S. Panha & J.-J. Jaeger

Late Middle Pleistocene ecology and climate in Northeastern Thailand inferred from the stable isotope analysis of Khok Sung herbivore tooth enamel and the land mammal cenogram

Abstract. Paleoecological and paleoclimatic records based on the stable isotopes of mammalian tooth enamel are poorly known in mainland Southeast Asia during the Pleistocene. Khok Sung in Northeastern Thailand is a late Middle Pleistocene terrace deposit, tentatively dated either as 213 ka or 188 ka, yielding 15 described mammalian taxa with especially abundant and complete fossil remains. To investigate paleodiets and habitats of these ancient mammals and to understand the corresponding regional

climate, we performed an analysis of stable carbon and oxygen isotopes extracted from tooth enamel carbonate of various mammalian taxa, coupled with the cenogram method. The enamel $\delta^{13}C$ values of Khok Sung mammals indicate a variety of diets, ranging from pure C_3 to C_4 plants, suggesting that C_4 grasses were a major component of local Thai ecosystems during the late Middle Pleistocene. The stable isotopic distinction between C_3 and C_4 plants suggests that the Pleistocene wildlife habitats ranged from closed forests to open grasslands for the Khok Sung area. Moreover, differences within sympatric Pleistocene herbivores such as proboscideans, rhinoceroses, and cervids characterize possible niche partitioning by minimizing interspecific overlap. Paleoclimatic interpretations based on the intra-tooth variability in enamel $\delta^{18}O$ values from large mammals and on the cenogram analysis reflect significant seasonal variations in precipitation and temperature, and humid conditions, for the Khok Sung locality. Compared to modern environments in Thailand, it is apparent that C_4-dominated grasslands were more widespread at that time when anthropic impacts on the ecosystems were presumably absent or minimal. © 2018 Reprinted with permission from Elsevier

K. Takehana, K. Hatate & N. Yamagishi
Serum activities of two bone markers in captive Asian elephants (*Elephas maximus*) at different ages
Abstract. The blood biochemical analysis of bone markers could have a role in the early diagnosis of metabolic bone disease in animals; however, there is limited information on bone markers in captive Asian elephants (*Elephas maximus*). Serum samples from ten captive Asian elephants were obtained to clarify the relationship between age and the blood bone markers tartrate-resistant acid phosphatase isoform 5b (TRAP5b) and bone specific alkaline phosphatase (BALP). Serum TRAP5b and BALP activities were negatively correlated with age. A positive correlation was observed between TRAP5b activity and BALP activity. These results may contribute to the health management of captive Asian elephants. © 2018 The Japanese Society of Veterinary Science.

J. Terborgh, L.C. Davenport, L. Ong & A. Campos-Arceiz
Foraging impacts of Asian megafauna on tropical rain forest structure and biodiversity
Abstract. Megaherbivores are known to influence the structure, composition, and diversity of vegetation. In Central Africa, forest elephants act as ecological filters by breaking tree saplings and stripping them of foliage. Much less is known about impacts of megafauna on Southeast Asian rain forests. Here, we ask whether herbivory by Asian megafauna has impacts analogous to those of African forest elephants. To answer this, we studied forest (1) structure, (2) composition, (3) diversity, and (4) tree scars in Belum and Krau, two protected areas of Peninsular Malaysia, and compared the results with those obtained in African forests. Elephants are abundant in Belum but have been absent in Krau since 1993. We found that stem density and diversity, especially of tree saplings, were higher in Krau than in Belum. Palms and other monocots were also more abundant in Krau. In Belum, however, small monocots (<1 m tall) were very abundant but larger ones (>1 m tall) were virtually absent, suggesting size-selective removal. The frequency of stem-break scars was equal at Belum and Krau but less than in Central Africa and greater than in the Peruvian Amazon where tapirs are the only megafauna. Pigs and tapirs could also contribute to the high frequency of tree scars recorded in Malaysian forests. Forest-dwelling elephants in Asia seem to have a reduced impact on tree saplings compared to African forest elephants, but a very strong impact on monocots. © 2017 Association for Tropical Biology and Conservation.

C. Thitaram & J.L. Brown
Monitoring and controlling ovarian activity in elephants
Abstract. Both Asian (*Elephas maximus*) and African (*Loxodonta africana*) elephants are important keystone, umbrella and flagship species. Paradoxically, world population numbers of both species are declining in many of their natural ranges due mainly to poaching, while over population of elephants in some

areas is resulting in serious human-elephant conflict, and modifications of natural habitats that impact biodiversity. Understanding mechanisms of reproductive control is vital to effective population management, and for that reason significant advances have been made in endocrine and ultrasonographic monitoring techniques, particularly in studies of elephants ex situ. However, there remains a need to develop new methods to control ovarian activity, both for enhancing and inhibiting reproduction, to maintain population numbers at levels that ensure species survival and their ability to safely cohabitate with humans and other species. We present an overview of reproductive monitoring methods and how they have contributed to our knowledge of elephant reproductive biology, as well as their application for in situ and ex situ conservation purposes. © 2017 Reprinted with permission from Elsevier.

C. Thitaram, P. Matchimakul, W. Pongkan, W. Tangphokhanon, R. Maktrirat, J. Khonmee, A. Sathanawongs, P. Kongtueng & K. Nganvongpani

Histology of 24 organs from Asian elephant calves (*Elephas maximus*)

Abstract. Elephants are the largest and heaviest living terrestrial animals, but information on their histology is still lacking. This study provides a unique insight into the elephant's organs and also provides a comparison between juvenile Asian elephants and adult Asian elephants or other species. Here we report on the histological structure of 24 organs, including the skin, brain (cerebrum, cerebellar hemisphere, vermis, thalamus, midbrain), spinal cord, sciatic nerve, striated skeletal muscle, cardiac muscle, bone (flat bone and long bone), cartilage (hyaline cartilage and fibrocartilage), heart (right atrium, right ventricle), blood vessels (aorta, pulmonary artery and caudal vena cava), trunk, trachea, lung, tongue, esophagus, stomach, small intestine (duodenum, jejunum, ileum), large intestine (cecum, colon, rectum), liver and pancreas, kidney, ovary, uterus (body and horn) and spleen of two juvenile Asian elephants. Tissue sections were stained with Harris's hematoxylin and eosin Y. While almost all structures were similar to those of other species or adult elephants, some structures were different from other mammalian species, such as: plexiform bone was found in flat bone only; a thin trachealis muscle was observed in the trachea; and no serous or mucinous glands were found in the submucosa of the trachea. Histological information from various organs can serve as an important foundation of basal data for future microanatomical studies, and help in the diagnosis and pathogenesis in sick elephants or those with an unknown cause of death. © 2018 The Authors.

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

The diagnostic X-ray exposure technique guidelines for elephants' limbs in Elephant Hospital, Thai Elephant Conservation Center, Thailand

Abstract. Radiographic image is the first of choice for diagnosing complications involving elephants' limbs. The extreme thickness of their limbs causes inaccurate image quality. Therefore, an appropriate procedure is hereby investigated as a matter concerned. Because of difference of X-ray absorption in elephant tissue from human tissue, the Sante's rule cannot be directly applied. This study sought to acquire the appropriate equation by modifying the Sante's rule with a tissue factor for calculating the exposure technique for Asian elephants' limbs. Firstly, capacity of a mobile X-ray machine was evaluated in terms of dose rate, precision, and accuracy of radiation. The exposure techniques were then designed using the modified Sante's rule and tested with the hind limbs of 10 live elephants. Output of X-ray machine revealed the dose rate in milli-Rontgen per mAs equal to 4×10^{-4} of kVp^2, and the machine factor equal to 6.4. The radiographic images taken using the calculated exposure techniques showed good quality, and so, it is possible to differentiate between the medullar and the cortex of the bone. Equations suitable for designing the exposure technique are kVp equal to two times of sample thickness in cm plus source image distance in inch and the tissue correcting factor 5, and mAs equal to two-fifths of the sample thickness in cm. © 2018 Journal of Associated Medical Sciences.

A. van de Water & K. Matteson

Human-elephant conflict in western Thailand: Socio-economic drivers and potential mitigation strategies

Abstract. Understanding human-wildlife conflict is an important first step in the conservation of highly endangered species that can have adverse effects on human communities, such as elephants. To gain insights into variables that shape attitudes toward elephant conservation in Asia, we surveyed 410 households and 46 plantation owners in seven villages around the Salakpra Wildlife Sanctuary in western Thailand, an area of high human-elephant conflict. We sought to evaluate how past experiences with elephants (positive or negative), as well as socio-economic variables (age, income level, gender, and employment type) affect attitudes toward elephant conservation and coexistence in this area. In addition, we quantified deterrence methods currently used and identify potential mitigation strategies supported by community members. In general, less supportive attitudes toward elephant conservation and coexistence were held by individuals older than 35 years of age, those who had previously had experienced negative interactions with elephants, those with lower incomes, and those working in the agricultural sector. Conversely, those who had received benefits from living near elephants (e.g., supplemental income or feelings of pride from hosting volunteers or participating in conservation work) had more supportive views of elephant coexistence. Plantation owners reported using a variety of deterrence methods with varying success, with firecrackers being the most commonly utilized method. Community members identified several potentially beneficial mitigation strategies including forest restorations and patrol teams, adding water sources to wild elephant habitat, and education of local school and community groups. Overall, our results highlight the value of community members receiving benefits from living near elephants and suggest that special incentives may be needed for demographic groups disproportionately affected by elephants (e.g. those at lower income levels, those working in agriculture). A combination of these and other approaches will be required if human-elephant coexistence in western Thailand is to be realized. © 2018 The Authors.

J. Wadey, H.L. Beyer, S. Saaban, N. Othman, P. Leimgruber & A. Campos-Arceiz

Why did the elephant cross the road? The complex response of wild elephants to a major road in Peninsular Malaysia

Abstract. Roads cause negative impacts on wildlife by directly and indirectly facilitating habitat destruction and wildlife mortality. We used GPS telemetry to study the movements of 17 wild Asian elephants (*Elephas maximus*) and a mechanistic modelling framework to analyse elephant response to a road bisecting their habitat in Belum-Temengor, northern Peninsular Malaysia. Our objectives were to (1) describe patterns of road crossing, (2) quantify road effects on movement patterns and habitat preference, and (3) quantify individual variation in elephant responses to the road. Elephants crossed the road on average 3.9 ± 0.6 times a month, mostly (81% of times) at night, and crossing was not evenly distributed in space. The road caused a strong and consistent barrier effect for elephants, reducing permeability an average of 79.5%. Elephants, however, were attracted to the proximity to the road, where secondary forest and open habitats are more abundant and contain more food resources for elephants. Although the road acts as a strong barrier to movement (a direct effect), local changes to vegetation communities near roads attract elephants (an indirect effect). Given that risk of mortality (from poaching and vehicle collisions) increases near roads, roads may, therefore, create attractive sinks for elephants. To mitigate the impact of this road we recommend avoiding further road expansion, reducing and enforcing speed limits, limiting traffic volume at night, managing habitat near the road and, importantly, enhancing pa- trolling and other anti-poaching efforts. Our results are relevant for landscapes throughout Asia and Africa, where existing or planned roads fragment elephant habitats. © 2017 Reprinted with permission from Elsevier.