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 (2019) publications on Asian elephants.

M. Ackermann & J.-M. Hatt
To treat or not to treat?
Vet. Record Case Reports 7 (2019) e000847
Abstract. In a world of ever-increasing liability, the decision not to treat a patient comes less and less easily, even though both evidence-based medical and financial reasons may speak against treatment. Elephant haemorrhagic disease (EHD), associated with viraemia with elephant endotheliotropic viruses (EEHV), may kill within hours after onset of clinical signs. Here, the authors present a case, where a three-year-old female Asian elephant (*Elephas maximus*) developed viraemia with EEHV1 but was deliberately left without antiviral treatment and survived without developing clinical signs. Considering the mostly fatal outcome of EHD, this decision may at first glance appear hazardous. However, the reasoning included knowledge about herpesviruses in general, past and present EEHV status of the individual, EEHV epidemiology within the herd as well as stress and costs involved in treatment. It is important to consider those parameters for each impeding case separately in order to assure the best welfare of the animal. © 2019 British Veterinary Association.

Ebru Albayrak
The ancient Asian elephant of Turkey in the light of new specimens: Does it have regional features?
Quaternary Science Reviews 218 (2019) 189-199
Abstract. Although today the Asian elephant, *Elephas maximus*, exists in a number of fragmented and isolated populations in south and southeast Asia, its historical range was extended westwards as far as Iraq. Because *E. maximus* is rarely preserved in fossil form and the remains from these peripheral ancient populations are scant, not much is known about their relationship to modern Asian elephant. The elephants in Tigris-Euphrates region, sometimes referred to as *E. maximus asurus*, had died out during the first half of the first millennium BCE. Some researchers have supported the idea that a living Asian elephant population inhabited the Euphrates-Tigris region in the late Holocene. The remains of ancient Asian elephant from the southeastern part of Turkey are known from several studies, and Gavur Lake Swamp (southeast Turkey) in particular is the only natural locality that yielded both dental and postcranial remains in southwest Asia. In this study new specimens including mandibles, isolated teeth, scapula, humeri and vertebras from Gavur Lake Swamp were studied. Moreover, the wear patterns of lower molars are examined in detail as they have an ambiguous pattern, which is mostly associated with *Palaeoloxodon antiquus* and is not very common in recent Asian elephant. Comparisons with the recent Asian elephant teeth may point out that the extinct westernmost population of Asian elephant in Gavur Lake Swamp might have local or regional features in wear pattern in the lower molars. © 2019 Reprinted with permission from Elsevier.

T. Angkawanish, M. Nielen, H. Vernooij, J.L. Brown, P.J.S. van Kooten, P.B. van den Doel, W. Schaftenaar, K.N. Lampang & V.P.M.G. Rutten
Evidence of high EEHV antibody seroprevalence and spatial variation among captive Asian elephants (*Elephas maximus*) in Thailand
Virology Journal 16 (2019) e33

Abstract. Elephant endotheliotropic herpesviruses (EEHV) can cause an acute highly fatal hemorrhagic disease in young Asian elephants (*Elephas maximus*), both ex situ and in situ. Amongst eight EEHV types described so far, type 1 (subtype 1A and 1B) is the predominant disease-associated type. Little is known about routes of infection and pathogenesis of EEHV, and knowledge of disease prevalence, especially in range countries, is limited. A large cross-sectional serological survey was conducted in captive elephants (n = 994) throughout Thailand using an EEHV-1A glycoprotein B protein antigen specific antibody ELISA. Antibody seroprevalence was 42.3%, with 420 of 994 elephants testing positive. Associations between seropositivity and potential risk factors for EEHV infection were assessed and included: elephant age, sex, camp cluster size, management type (extensive versus intensive), sampling period (wet vs. dry season) and location of camp (region). Univariable regression analysis identified management system and region as risk factors for the presence of EEHV antibodies in elephants, with region being significant in the final multivariable regression model. Prevalence was highest in the North region of the country (49.4%). This study produced baseline serological data for captive elephants throughout Thailand, and showed a significant EEHV burden likely to be maintained in the captive population. © 2019 The Authors.

J. Benoit, L.J. Legendre, R. Tabuce, T. Obada, V. Mararescul & P. Manger

Brain evolution in proboscidea (Mammalia, Afrotheria) across the Cenozoic

Scientific Reports 9 (2019) e9323

Abstract. As the largest and among the most behaviourally complex extant terrestrial mammals, proboscideans (elephants and their extinct relatives) are iconic representatives of the modern megafauna. The timing of the evolution of large brain size and above average encephalization quotient remains poorly understood due to the paucity of described endocranial casts. Here we created the most complete dataset on proboscidean endocranial capacity and analysed it using phylogenetic comparative methods and ancestral character states reconstruction using maximum likelihood. Our analyses support that, in general, brain size and body mass co-evolved in proboscideans across the Cenozoic; however, this pattern appears disrupted by two instances of specific increases in relative brain size in the late oligocene and early Miocene. These increases in encephalization quotients seem to correspond to intervals of important climatic, environmental and faunal changes in Africa that may have positively selected for larger brain size or body mass. © 2019 The Authors.

K. Boonprasert, V. Punyapornwithaya, P. Tankaew, T. Angkawanish, S. Sriphiboon, C. Titharam, J.L. Brown & C. Somgird

Survival analysis of confirmed elephant endotheliotropic herpes virus cases in Thailand from 2006 – 2018

PLoS ONE 14 (2019) e0219288

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

J.L. Brown, K. Carlstead, J.D. Bray, D. Dickey, C. Farin & K. Ange-van Heugten

Individual and environmental risk factors associated with fecal glucocorticoid metabolite concentrations in zoo-housed Asian and African elephants

PLoS ONE 14 (2019) e0217326

Abstract. A recent large-scale welfare study in North America involving 106 Asian (*Elephas maximus*) and 131 African (*Loxodonta*

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

K. Carlstead, S. Paris & J.L. Brown

Good keeper-elephant relationships in North American zoos are mutually beneficial to welfare

Applied Animal Behaviour Science 211 (2019) 103-111

Abstract. Relationships between animals and their human caretakers can have profound impacts on animal welfare in farms, laboratories and zoos, while human attitudes are important predictors of caretaker behavior towards livestock. In this study, we examined the impact of keeper attitudes about working with elephants on Keeper-Elephant Relationships (KERs) and Bonds (KEBs), and found evidence for reciprocity and welfare benefits to both parties. As part of a large, multi-institutional study of zoo elephant welfare conducted at 60 zoos accredited by the American Zoo and Aquarium Association, blood samples were collected twice monthly for 1 year from 117 African (*Loxodonta africanus*) and 96 Asian (*Elephas maximus*) elephants for serum cortisol analyses as a measure of well-being. Information was collected via three online questionnaires: 1) a Keeper Survey of 277 elephant keepers about their opinions of and attitudes towards working with elephants and their job satisfaction; 2) an Elephant Behavior Profile Survey where keepers rated a total of 234 elephants on the frequencies of 24 behaviors, and 3) a Keeper-Elephant Bonds Survey in which 209 individual keepers rated the strength of their bond with a specific elephant for a total of 427 keeper-elephant pairings. From the first two surveys, principle components analysis was used to create subscales of keeper attitudes, elephant behaviors and keeper job satisfaction. Component scores were then used as independent variables in epidemiological analyses of elephant mean serum cortisol and mixed model regressions of keeper job satisfaction. For African elephants, risk factors of low serum cortisol included Positive interactions with elephants ($p=0.039$), Positive behaviors of elephants (friendly, affiliative) ($P=0.001$), and Elephant interacts with public ($P=0.009$). Age of the elephant was a small, but significant risk factor for higher cortisol ($P=0.005$). For Asian elephants, the risk factors for low cortisol were attitudes indicating social inclusion in elephant groups (Keeper as herdmate, $P=0.039$) and Elephant interacts with public ($P=0.006$). Latitude of zoo was a predictor of higher cortisol ($P=0.041$). Significant predictors of keeper Dissatisfaction with job were weaker Keeper-Elephant Bonds ($P=0.003$) and African Species ($P=0.038$). Species differences in KERs and KEBs are discussed in terms of differing elephant management factors in zoos. The results provide evidence of the reciprocity of KERs and the mutual benefits of KEBs to both elephant and keeper. These results are relevant for zoo animal management and staff training. © 2019 The Authors.

W. Chanthorn, F. Hartig, W.Y. Brockelman, W. Srisang, A. Nathalang & J. Santon

Defaunation of large-bodied frugivores reduces carbon storage in a tropical forest of Southeast Asia

Scientific Reports 9 (2019) e10015

Abstract. Recent studies have suggested that defaunation of large-bodied frugivores reduces above-ground carbon storage in tropical forests of South America and Africa, but not, or less so, in Southeast Asian tropical forests. Here we analyze the issue using the seed dispersal network (data of interaction between trees and animal seed dispersers) and forest composition of a 30-ha forest dynamics plot in central Thailand, where an intact fauna of primates, ungulates, bears and birds of all sizes still exists. We simulate the effect of two defaunation scenarios on forest biomass: 1) only primates extirpated (a realistic possibility in near future), and 2) extirpation of all large-bodied frugivores (LBF) including gibbons, macaques, hornbills and terrestrial mammals, the main targets of poachers in this region. For each scenario, we varied the population size reduction of the LBF dispersed tree species from 20% to 100%. We find that tree species dependent on seed dispersal by large-bodied frugivores (LBF) account for nearly one-third of the total carbon biomass on the plot, and that the community turnover following a complete defaunation would result in a carbon reduction of 2.4% to 3.0%, depending on the defaunation scenario and the model assumptions. The reduction was always greater than 1% when the defaunation intensity was at least 40%. These effect sizes are comparable to values reported for Neotropical forests, suggesting that the impact of defaunation on carbon deficit is not necessarily lower in Southeast Asian forests. The problem of defaunation, and the mutual benefits between biodiversity conservation and climate change mitigation, should therefore not be neglected by global policies to reduce carbon emissions.

E. Chavea, K.L. Edwards, S. Paris, N. Prado, K.A. Morfeld & J.L. Brown

Variation in metabolic factors and gonadal, pituitary, thyroid, and adrenal hormones in association with musth in African and Asian elephant bulls

General and Comparative Endocrinology 276 (2019) 1-13

Abstract. Longitudinal analyses of serum testosterone, luteinizing hormone (LH), follicle-stimulating hormone (FSH), prolactin, glucose, insulin, triglycerides, cholesterol, total and free thyroxine (T4), total triiodothyronine (T3), thyroid stimulating hormone (TSH), and cortisol were conducted to investigate pituitary, metabolic, and adrenal changes related to testicular function and musth status in zoo-housed elephant bulls. Blood samples were collected twice a month for 12 months from 14 African and 12 Asian bulls at 17 facilities in North America. Building on previous studies, our results show that musth is associated with increased testosterone, LH, FSH, and cortisol secretion, and a decrease in thyroid hormone (total and free T4) production. In addition, glucose and triglycerides were higher during musth than non-musth periods, indicative of altered sugar and fat metabolism. There were significant differences associated with age for LH, FSH and testosterone, all increasing, whereas the glucose-to-insulin ratio (G:I) decreased with age. A species comparison found African and Asian elephants differed in measures of insulin, prolactin, cholesterol and the G:I. Across all hormones, high inter-individual variability was observed, making it difficult to define a general musth endocrine profile or to assess musth status from single samples. These results highlight the need for facilities hosting bulls to closely and consistently monitor each individual from an early age and throughout musth and non-musth periods to determine the pattern for each male. © 2019 Reprinted with permission from Elsevier.

J.A.H. Crawley, M. Lahdenperä, M.W. Seltmann, W. Htut, H.H. Aung, K. Nyein & V. Lummaa

Investigating changes within the handling system of the largest semi-captive population of Asian elephants

PLoS ONE 14(2019) e0209701

Abstract. The current extinction crisis leaves us increasingly reliant on captive populations to maintain vulnerable species. Approximately one third of Asian elephants (*Elephas maximus*) are living in semi-captive conditions in range countries. Their relationship with humans stretches back millennia, yet elephants have never

been fully domesticated. We rely on the expertise of traditional handlers (mahouts) to manage these essentially wild animals, yet this profession may be threatened in the modern day. Here, we study the handling system of semi-captive timber elephants in Myanmar; the largest global semi-captive population (~5000). We investigate how recent changes in Myanmar may have affected the keeping system and mahout-elephant interactions. Structured interviews investigated changes to mahout attitude and experience over the last two decades, as perceived by those who had worked in the industry for at least 10 years (n = 23) and as evaluated in current mahouts (n = 210), finding mahouts today are younger (median age 22 yrs), less experienced (median experience 3 yrs), and change elephants frequently, threatening traditional knowledge transfer. Mahout-elephant interactions manifested as 5 components ('job appreciation'; 'experience is necessary'; 'human-elephant interaction'; 'own knowledge'; 'elephant relationship'), according to Principal Components Analysis. Experienced mahouts and mahouts of bulls and younger elephants were more likely to agree that 'experience is necessary' to be a mahout. Mahouts with difficult elephants scored lower on 'human-elephant interaction' and a mahout's perception of their 'own knowledge' increased with more experience. Our finding of change in terms of mahout experience, age and commitment in the largest semi-captive elephant population suggests need for formal training and assessment of impacts on elephant welfare; these are findings applicable to thousands of elephants under similar management. © 2019 The Authors.

K.L. Edwards, P. Bansiddhi, S. Paris, M. Galloway & J.L. Brown

The development of an immunoassay to measure immunoglobulin A in Asian elephant feces, saliva, urine and serum as a potential biomarker of well-being

Conservation Physiology 7 (2019) coy077

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

L.W. Firdausy, R. Prahardani, L.S. Wusahaningtyas, S. Indarjulianto, M. Wahyu, M.T. Nursalim & W. Nurcahyo

Morphological and molecular identification of *Pfenderius heterocaeca* (Trematode: Paramphistomoidea) from Sumatran elephant (*Elephas maximus sumatranus*)

Veterinary World 12 (2019) 1341-1345

Abstract. Paramphistomiasis is common in tropical countries such as Indonesia and affects livestock and various endemic wild animals such

as Sumatran elephants. However, the specific species of paramphistomoid worm that causes paramphistomiasis are rarely reported. The study aims at identifying paramphistomoid worm that infects Sumatran elephants. Flukes were collected from the feces of five semi-captive Sumatran elephants that lived at Tegal Yoso Elephant Response Unit in Way Kambas National Park, in 2018, after treatment of oxyclozanide 1 g at the dose of approximately 5–8 mg/kg of body weight. Eight paramphistomoid worms were flattened and stained in Semichon's carmine for morphological identification, and five other worms were used for molecular identification at second internal transcribed spacer (ITS-2) of ribosomal deoxyribonucleic acid sequence. Forty-five flukes were collected from five Sumatran elephants in Lampung, Indonesia. Eight paramphistomoid worms were morphologically identified as *Pfenderius heterocaeca* and five isolates did not show any variation in ITS-2. Phylogenetic analysis showed that there was a close genetic relationship between our sample and *Chiorchis fabaceus* that had a family similar to the samples. Based on the morphological and molecular characteristics, the paramphistomoids found in Sumatran elephant on Way Kambas National Park are *P. heterocaeca*. © 2019 The Authors.

T.G. Goh, J.-S. Loo, N. Farahin-Mustafa, N. Sakinah-Myassin & R. Hashim

The habitat preference of dung beetle species associated with elephant dung of the Malay Peninsula

Raffles Bulletin of Zoology 67 (2019) 328-336

Abstract. Dung beetles are often used as indicators of forest health. However, not much is known about the non-forest dwelling dung beetle species of the Malay Peninsula and the species in this habitat have not been compared to communities recorded in anthropogenically altered habitats in South East Asia. Grassland along forest edges is the habitat of grazing megafauna and the dung produced by these mammals is a potentially large resource to dung beetles that can adapt to non-forest habitats. In this study, we classified 25 dung beetle species associated with elephant dung based on their habitat preference. We sampled six different localities on the Malay Peninsula, placing transects within forests and along forest edges. Elephant dung baited traps were deployed at regular intervals along these transects. Forest sampling points had higher abundance, species richness and Shannon diversity than forest edge sampling points, but there was no significant difference in species accumulation curves or rarefied species richness. Hierarchical cluster analysis and ordination indicated a clear division between forest and forest edge species. A binomial generalised linear mixed model further showed that 14 species preferred forest habitats and eight preferred forest edge habitats. These classifications largely agreed with previous habitat preference studies conducted in Borneo and Sulawesi. It is likely that habitat preference in dung beetles is dependent on abiotic factors such as temperature as well as biotic factors such as forest cover and mammalian diversity. The lack of records of non-forest species in literature indicates that non-forest habitats may be neglected in terms of dung beetle studies. © 2019 National University of Singapore. Reprinted with permission from Lee Kong Chian Natural History Museum.

S.Z. Goldenberg, M.A. Owen, J.L. Brown, G. Wittemyer, Z.M. Oo & P. Leimgruber

Increasing conservation translocation success by building social functionality in released populations

Global Ecology and Conservation 18 (2019) e00604

The importance of animal behavior to successful wildlife translocations has been acknowledged in recent decades, and it has been increasingly considered and more frequently incorporated into translocation management and research. However, explicit consideration of social behavior is often overlooked in this context. Social relationships take a variety of forms (e.g., cooperative partners, members of a dominance hierarchy, territorial neighbors) and play important roles in survival, reproduction, and resource exploitation. We review the ways in which concepts from studies of social behavior in wild populations may be leveraged to increase translocation success. Social structure and cohesion, social roles, social learning, and social

competency may all be important to consider in building populations that are resilient and likely to persist. We argue that relevant data collected at all stages of translocation, including candidate selection, and during pre-release, release, and post-release monitoring, may inform the establishment of functional social structure post-release in species dependent on social processes. Integrating knowledge of social behavior into management decisions may be particularly useful when comparing the success of alternative release protocols or release candidate behavioral traits. Complementary datasets on a range of fitness-related metrics post- release will further leverage our understanding of social establishment in translocated populations. We illustrate the potential of these ideas using Asian and African elephants as a model. Both species are particularly challenging to manage but are translocated frequently; thus, evidence-based protocols for conservation translocations of elephants are urgently needed. © 2019 The Authors.

V.R. Goswami, M.K. Yadava, D. Vasudev, P.K. Prasad, P. Sharma & D. Jathanna

Towards a reliable assessment of Asian elephant population parameters: The application of photographic spatial capture–recapture sampling in a priority floodplain ecosystem

Scientific Reports 9 (2019) e8578

Abstract. The hitherto difficult task of reliably estimating populations of wide-ranging megafauna has been enabled by advances in capture–recapture methodology. Here we combine photographic sampling with a Bayesian spatially-explicit capture–recapture (SCR) model to estimate population parameters for the endangered Asian elephant *Elephas maximus* in the productive floodplain ecosystem of Kaziranga National Park, India. Posterior density estimates of herd-living adult females and sub-adult males and females (herd-adults) was 0.68 elephants/km^2 (95% Credible Intervals, CrI = 0.56–0.81) while that of adult males was 0.24 elephants/km^2 (95% CrI = 0.18–0.30), with posterior density estimates highlighting spatial heterogeneity in elephant distribution. Estimates of the space-usage parameter suggested that herd-adults (σ_{HA} = 5.91 km, 95% CrI = 5.18–6.81) moved around considerably more than adult males (σ_{AM} = 3.64 km, 95% CrI = 3.09–4.34). Based on elephant movement and age–sex composition, we derived the population that contributed individuals sampled in Kaziranga to be 908 herd-adults, 228 adult males and 610 young (density = 0.46 young/km^2, SD = 0.06). Our study demonstrates how SCR is suited to estimating geographically open populations, characterising spatial heterogeneity in fine-scale density, and facilitating reliable monitoring to assess population status and dynamics for science and conservation. © The Authors 2019.

W. Greene, E.S. Dierenfeld & S. Mikota

A review of Asian and African elephant gastrointestinal anatomy, physiology, and pharmacology

J. of Zoo and Aquarium Research 7 (2019) 1-14

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

Gözde Gürelli

New entodiniomorphid ciliates, *Buetschlia minuta* n. sp., *B. cirrata* n. sp., *Charonina elephanti* n. sp., from Asian elephants of Turkey

Zootaxa 4545 (2019) 419-433

Abstract. Three new entodiniomorphid species, *Buetschlia minuta* n. sp., *Buetschlia cirrata* n. sp., and *Charonina elephanti* n. sp., were described from the hindgut of Asian elephants (*Elephas maximus*) from Gaziantep, Turkey. *B. minuta* n. sp. has an ovoid body shape with a truncated anterior end and a rounded posterior end, an adoral ciliary zone surrounding the cytostome,

somatic ciliary rows in the anterior two thirds of the body, an ovoid macronucleus without a constant position, and a concretion vacuole in the anterior one third of the body. *B. cirrata* n. sp. has an ovoid body shape with the anterior end truncated and the posterior end rounded, an adoral ciliary zone surrounding the cytostome, unevenly distributed somatic cilia, an ovoid macronucleus without a constant position, and a concretion vacuole in the anterior one third of the body. *C. elephanti* n. sp. has an ovoid body shape with both ends rounded, an ovoid macronucleus without a constant position, two buccal ciliary zones, an adoral ciliary zone, a vestibular ciliary zone, three somatic ciliary zones, a dorsal ciliary zone, two posterior ciliary zones, dorsal and ventral, and a vestibulum with a Y-shaped infraciliature. © 2019 Magnolia Press.

N.H. Hall, J.S. Hall, E. Wiedner, N.I. Stacy, C. Bandt & R. Isaza

Oncotic pressure and the effects of water deprivation in healthy captive Asian elephants

Journal of Veterinary Diagnostic Investigation 31 (2019) 572-575

Abstract. We evaluated the oncotic pressure (plasma colloid osmotic pressure, πc) in a group of healthy, captive Asian elephants (*Elephas maximus*; n = 21) with a colloid osmometer with a membrane cutoff of >20,000 daltons. The median πc for these elephants was 26.3 mm Hg with an interquartile interval of 25.5–26.8 mm Hg. The mean πc value was 26.0 mm Hg ± SD 1.1. We found moderate correlation between albumin measured by electrophoresis and πc (r = 0.622; p = 0.003). After a 16-h water deprivation test in a subset of elephants (n = 16), a difference in πc was not detected, despite a significant increase in serum total proteins, urea, and osmolality. These results indicate that πc is not a sensitive indicator of hydration status in elephants after a short period of water deprivation. Use of oncotic pressure as a diagnostic tool in diseased Asian elephants warrants further investigation. © 2019 The Authors.

C. Huang, X. Li, L. Khanal & X. Jiang

Habitat suitability and connectivity inform a co-management policy of protected area network for Asian elephants in China

PeerJ 7 (2019) e6791

Abstract. Enlarging protected area networks (PANs) is critical to ensure the long-term population viability of Asian elephants (*Elephas maximus*), which are threatened by habitat loss and fragmentation. Strict policies of PAN enlargement that focus on wildlife conservation have failed largely due to difficulties in encouraging stakeholder participation and meeting the elephant habitat requirement. A co-management policy that promotes sustainable resource use, wildlife conservation, and stakeholder participation may have greater feasibility than the strict policies in a developing world. Here, we identified the suitable habitat of elephants using maximum entropy models and examined whether habitat suitability is indirectly associated with local economic development in human-dominated landscapes. We found that (1) the suitable habitat was mainly in areas of forest matrix (50% natural forest cover) with multiple land-use practices rather than relatively intact forest and near communities (mean distance two km) and (2) habitat suitability was negatively associated with local economic development (r_p = –0.37, P = 0.04). From the standpoint of elephant habitat and its socio-economic background, our results indicate that co-management will be more effective than the currently strict approaches of enlarging PAN. Additionally, our results provide on-ground information for elephant corridor design in southern China.

J. Jackson, D.Z. Childs, K.U. Mar, W. Htut & V. Lummaa

Long-term trends in wild-capture and population dynamics point to an uncertain future for captive elephants

Proc. R. Soc. B 286 (2019) e20182810

Abstract. Maintaining sustainable populations in captivity without supplementation through wild-capture is a major challenge in conservation that zoos and aquaria are working towards. However, the capture of wild animals continues for many purposes where conservation is not the primary focus. Wild-capture hinders long-term conservation goals by reducing remaining wild populations, but the direct and long-term indirect consequences of wild-capture for captive population viability are rarely addressed using

longitudinal data. We explored the implications of changes in wild-capture on population dynamics in captivity over 54 years using a multi-generational studbook of working Asian elephants (*Elephas maximus*) from Myanmar, the largest remaining captive elephant population. Here we show that population growth and birth rates declined between 1960 and 2014 with declines in wild-capture. Importantly, wild-caught females had reduced birth rates and a higher mortality risk. However, despite the disadvantages of wild-capture, the population may not be sustainable without it, with immediate declines owing to an unstable age-structure that may last for 50 years. Our results highlight the need to assess the long-term demographic consequences of wild-capture to ensure the sustainability of captive and wild populations as species are increasingly managed and conserved in altered or novel environments. © 2019 The Authors.

A. Jambari, S. Sasidhran, H.R.A. Halim, K.A. Mohamed, A. Ashton-Butt, A.M. Lechner & B. Azhar

Quantifying species richness and composition of elusive rainforest mammals in Taman Negara National Park, Peninsular Malaysia

Global Ecology and Conserv. 18 (2019) e00607

Abstract. Rapid urban and agricultural expansions are taking place across Peninsular Malaysia resulting in wide spread forest conversion impacting on important conservation areas. Taman Negara National Park is one of the few protected nature reserves remaining largely intact from such anthropogenic threats. In this study we aimed to quantify species richness, and relative abundance and composition of native mammals in lowland and highland forest in Taman Negara National Park. We deployed cameras at 216 sampling plots in the study areas for 14,776 and 6935 trap nights in lowland and highland forest respectively. Our results show that lowland and highland forest have similar species richness, while highland forest has higher mammal abundance, which is likely to be caused by anthropogenic pressures on lowland forest adversely affecting mammal populations. Both forest types have similar mammal species composition. The mammal community includes most of the rare and endangered species in the region, including Malayan pangolin, Asian elephant, tiger, dhole, large-spotted civet, and Asian tapir. The region of the national park that was less likely to be vulnerable to logging, human settlement, agricultural expansion, and poaching (i.e. the Terengganu's sector), had higher mammal species richness, while the Pahang's sector had lower species richness. Mammal species richness increased with proximity to the park boundary and distance from the nearest river but decreased with the increasing number of intruders. This has important implications for management of the edges of protected nature reserves. In the coming decades, the pristine nature of Taman Negara National Park will become highly threatened if anthropogenic activities inside and outside the park are not monitored. It is vital that the responsible agencies tackle these threats through aggressive enforcement and the creation of a robust framework to monitor any land developments that take place in the vicinity of Taman Negara National Park. © 2019 The Authors.

R. Kanagaraj, M.B. Araujo, R. Barman, P. Davidar, R. De, D.K. Digal, G.V. Gopi, *et al*.

Predicting range shifts of Asian elephants under global change

Diversity and Distributions 25 (2019) 822-838

Abstract. Climate change alters the water cycle, potentially affecting the distribution of species. Using an ensemble of species distribution models (SDMs), we predicted changes in distribution of the Asian elephant in South Asia due to increasing climatic variability under warming climate and human pressures. We compiled a comprehensive geodatabase of 115 predictor variables, which included climatic, topographic, human pressures and land use, at a resolution of 1 km^2, and an extensive database on current distribution of elephants. For variable selection, we first developed 14 candidate models based on different hypotheses on elephant habitat selection. For each candidate model, a series of 240 individual models were evaluated using several metrics. Using three climatic and one land use change datasets for two greenhouse gas scenarios, ensemble SDMs were used to predict future projections. Nine predictor variables were selected for ensemble SDMs. Elephant

distribution is driven predominantly by changes in climatic water balance (>60%), followed by changes in temperature and human-induced disturbance. The results suggest that around 41.8% of the 256,518 km^2 of habitat available at present will be lost by the end of this century due to combined effects of climate change and human pressure. Projected habitat loss will be higher in human-dominated sites at lower elevations due to intensifying droughts, leading elephants to seek refuge at higher elevations along valleys with greater water availability in the Himalayan Mountains. Changes in climatic water balance could play a crucial role in driving species distributions in regions with monsoonal climates. In response, species would shift their range upwards along gradients of water availability and seasonal droughts. Conservation and management of elephant populations under global change should include design of movement corridors to enable dispersal of the elephant and other associated species to more conducive environments. © 2019 The Authors.

J. Khonmee, J.L. Brown, M.-Y. Li, C. Somgird, K. Boonprasert, T. Norkaew, V. Punyapornwithaya, W.-M. Lee & C. Thitaram

Effect of time and temperature on stability of progestagens, testosterone and cortisol in Asian elephant blood stored with and without anticoagulant

Conservation Physiology 7 (2019) coz031

Abstract. The value of biological samples collected in the field is compromised if storage conditions result in analyte degradation, especially in warmer climates like Thailand. We evaluated the effects of time and temperature on immunoactive steroid hormone stability in Asian elephant (*Elephas maximus*) blood stored with and without an anti-coagulant before centrifugation. For each elephant (5 male, 5 female), whole blood was aliquoted (n = 2 ml each) into 13 red top (without anticoagulant) or purple top (with anticoagulant) tubes. One tube from each treatment was centrifuged immediately and the serum or plasma frozen at −20°C (Time 0, T0). The remaining 12 aliquots were divided into stored temperature groups: 4°C, room temperature (RT, ~22°C), and 37°C, and centrifuged after 6, 24, 48 and 62 h of storage. Serum and plasma concentrations of progestagens in females, testosterone in males and cortisol in both sexes were quantified by validated enzyme immunoassays. Steroid concentration differences from T0 were determined by a randomized complete block ANOVA and Dunnett's tests. The only evidence of hormone degradation was cortisol and testosterone concentrations in serum stored at 37°C. Testosterone concentrations declined by 34% at 48 h and 52% at 62 h, cortisol was decreased by 19% after 48 h and 27% after 62 h at 37°C, respectively. None of the other aliquots displayed significant changes over time at any temperature. In conclusion, steroids appear to be stable in blood for nearly 3 days at room or refrigeration temperatures before centrifugation; steroids in samples with ethylenediaminetetraacetic acid were particularly stable. However, warmer temperatures may negatively affect steroids stored without anti-coagulant, perhaps due to red blood cell metabolism. Thus, under field conditions with no access to cold or freezer temperatures, collection of plasma is a better choice for elephants up to at least 62 h before centrifugation. © 2019 The Authors.

S. Klinhom, P. Siengdee, K. Nganvongpanit, D. Boonyawan, A. Silva-Fletcher & C. Thitaram

Effect of culture medium treated with non-thermal plasma energy on the growth and viability in-vitro of fibroblast cells from Asian elephants (*Elephas maximus*)

Kafkas Universitesi Veteriner Fakultesi Dergisi 25 (2019) 815-823

Abstract. Non-thermal plasma (NTP) is being developed for a wide-range of medical applications such as improvement of wound healing, elimination of infective microorganisms, and treatment of cancer. This study investigated the effect of culture medium exposed to NTP on the proliferation in-vitro of skin fibroblasts from Asian elephants. Dulbecco's Modified Eagle's Medium (DMEM) was used as culture medium and was exposed to NTP with three different intensities. The NTP reactive species Nitrite (NO2-) was measured in the treated medium before addition to cells. Fibroblasts were incubated for 24 h with NTP-treated complete medium supplemented with 10% Fetal Bovine

Serum (FBS) and 1% antibiotic/antimycotic. Cell proliferation, the number of cells and viability rate were analysed using flow cytometry 24, 48 and 72 h after the start of the incubation. The proliferation rate of fibroblasts incubated with NTP treated medium was significantly higher ($P<0.05$) than controls and increased in a dose-dependent manner with increasing amount of NTP. Incubation of fibroblasts with NTP did not reduce their viability even at the highest dose of NTP. Culture medium treated with NTP energy may be used to improve healing of skin wounds in elephants. This study successfully shows that the medium treated with NTP was able to stimulate elephant skin fibroblasts proliferation and increase the total cell count but did not reduce cell viability in vitro. Containing buffering agent in culture media might reduce the effect of ROS generated by NTP. This might prevent using high dose of NTP to cause cell apoptosis and induce cell necrosis in this study. Future studies on the skin of living elephant are encouraged to develop more effective and optimum treatment conditions.

Y. Kobayashi, T. Shimazu, K. Murata, T. Itou & Y. Suzuki

An endogenous adeno-associated virus element in elephants

Virus Research 262 (2019) 10-14

Abstract. An endogenous viral element derived from adeno-associated virus containing a nearly intact open reading frame (ORF) of the rep gene (enAAV-rep) has been identified in the genomes of various mammals including degu and African elephant. Particularly, in degu, mRNA expression of enAAV-rep has been observed specifically in the liver. Here we newly identified enAAV-rep in Asian elephant and rock hyrax, both of which are afrotherians. The enAAV-rep of African and Asian elephants appeared to be orthologous and originated from an integration event of the entire genome of AAV into the ancestral genome of elephants more than 6 million years ago, whereas that of rock hyrax appeared to have originated independently. Negative selection operating at the amino acid sequence level was detected for the ORF of enAAV-rep in elephants. As in degu, mRNA expression of enAAV-rep was specifically observed in the liver in Asian elephant. Integrations of enAAV-rep appeared to have occurred independently on the evolutionary lineages of elephants and degu, suggesting that the AAV Rep protein has been co-opted repeatedly in the mammalian liver. © 2018 Reprinted with permission from Elsevier.

V. Krishnan, M.A. Kumar, G. Raghunathan & S. Vijayakrishnan

Distribution and habitat use by Asian elephants (*Elephas maximus*) in a coffee-dominated landscape of Southern India

Tropical Conservation Science 12 (2019) 1-12

Abstract. Understanding the impacts of land-use mosaics on elephant distribution and the patterns of habitat use is essential for their conservation in modified landscapes. We carried out a study in 205 villages, covering 610 km^2 of plantation–agriculture–forest mosaic of Hassan–Madikeri divisions in southern India, an area of intense human–elephant interactions. We monitored elephant movements, crop damage incidents, and human casualties on a daily basis for a 2-year period (2015–2017) to understand the patterns of elephant distribution across the landscape and habitat-use patterns, resulting in 1,117 GPS locations across six major habitats. Elephants were distributed across the landscape in the first year, but a high concentration of locations were noticed toward northern part of the study area during the second year, owing to clear felling of trees and installation of barriers around coffee plantations, causing an overall shift in their distribution. Investigations into habitat use by elephants revealed that during the day, elephants preferred monoculture refuges of acacia, eucalyptus, and so on, and forest fragments, avoiding reservoir, coffee, roads, and habitations. At night, agricultural lands were used more frequently while moving between refuges compared with forest fragments and habitations. Seasonally, forest fragments and agriculture were used significantly more during dry and wet, respectively. Across years, use of monoculture refuges and coffee increased with a corresponding decrease in the use of forest fragments and agriculture. In areas devoid of forest habitats, retention of monoculture refuges which provide shelter for elephants and facilitating free movement through open habitats

may help minimize human–elephant conflict and promote coexistence in such land-use mosaics. © 2019 The Authors.

B. Lander & K. Brunson

Wild mammals of ancient North China

Journal of Chinese History 2 (2018) 291-312

Abstract. Human activity has eliminated many of the natural lowland ecosystems of the Middle and Lower Yellow River Valley, and has modified the rest, making it difficult to understand what species are native to the region. As a step towards the reconstruction of these lost environments, this paper employs zooarchaeological and other evidence to identify the native mammals of the region. We provide basic ecological information about these animals and discuss controversial or difficult cases in more depth. Our goal is not only to study China's environmental history, but also to make clear that conventional understandings of species ranges are based on the distributions of animals in the modern period, when many had already been eliminated from large areas by human activity. © 2018 Cambridge Univ. Press.

W. Li, Y. Yu, P. Liu, R. Tang, Y. Dai, L. Li & L. Zhang

Identifying climate refugia and its potential impact on small population of Asian elephant (*Elephas maximus*) in China

Global Ecology and Conservation 19 (2019) e00664

Abstract. Climate change is anticipated to alter both wildlife distributions and their movement patterns, due to shifts, loss, and fragmentation of habitat, increasing the risk of extinction for many endangered species. Therefore, climate change must be integrated into wildlife conservation strategies. Using the case study of Asian elephants in China, we used the maximum entropy model to assess habitat suitability by incorporating current and future (2050s) bioclimatic and environmental variables. We then delineated climate refugia where suitable habitat overlapped under both scenarios. Then, we use circuit theory model to analyse potential movement by elephants (through measuring current flow), by linking current habitats and future habitats. Our results showed that current suitable habitat covers an area of about 5228.18 km^2, of which 45.71% is projected to be lost by 2050 due to climate change, leaving 2836.76 km^2. Just 327.2 km^2 new suitable habitat was projected in 2050s. Climate refugia covered 2509.56 km^2, and were mainly located in Mengyang and Shangyong reserves and their surrounding regions. Moreover, maps connecting suitable habitats under current and 2050s identified different regions delineated as important for the potential movement of elephants, which mainly distributed in regions of climate refugia. We proposed various actions to ameliorate the predicted impacts of climate change on Asian elephant, including protecting suitable habitat within regions where elephant are currently distributed, establishing corridors between areas where elephant are distributed, creating cross-boundary protected areas, and translocating elephants. This approach could be applied to the conservation planning of other wildlife, especially for umbrella species that support high biodiversity. © 2019 The Authors.

P. Liu, W. Li, Y. Yu, R. Tang, X. Guo, B. Wang, B. Yang & L. Zhang

How much will cash forest encroachment in rainforests cost? A case from valuation to payment for ecosystem services in China

Ecosystem Services 38 (2019) e100949

Abstract. Over the past 50 years, cash forest encroachment presents a major threat to tropical rainforests in Southeast Asia. Economic and social benefits provided by natural conservation and the loss of these benefits through encroachment must be accounted for. Here, we evaluated ecosystem services provided by a protected rainforest, Mengyang Reserve in China, in comparison to a simulated scenario where possible encroachment occurs. Strict conservation (i.e., current state) provided more value from carbon stocks, greenhouse gas sequestration, domestic water supply, and nature-based recreation. Yet, local villagers still aspire to expand their cash forests, especially rubber and tea. Based on our conservative estimate, the cash tree encroachment basically satisfying the cultivation needs of the villagers would reduce the net value by approximately 50% per year. Through placing numerical values on loss and benefit, governmental policy makers and local stakeholders might be able to visualize

the impact of conservation policy guidance. Horizontal transfer payment based on village-explicit opportunity costs should be proposed from the context-specific valuation of ecosystem services, and should include increased funding, simplifying the process, and expanding the scope of payments. Our results provide a useful lesson on the understanding the effectiveness of ecosystem services value in tropical reserves. © 2019 Reprinted with permission from Elsevier.

E.C. Lynch, V. Lummaa, W. Htut & M. Lahdenperä

Evolutionary significance of maternal kinship in a long-lived mammal

Phil. Trans. R. Soc. B 374 (2019) e20180067

Abstract. Preferential treatment of kin is widespread across social species and is considered a central prerequisite to the evolution of cooperation through kin selection. Though it is well known that, among most social mammals, females will remain within their natal group and often bias social behaviour towards female maternal kin, less is known about the fitness consequences of these relationships. We test the fitness benefits of living with maternal sisters, measured by age-specific female reproduction, using an unusually large database of a semi-captive Asian elephant (*Elephas maximus*) population. This study system is particularly valuable to an exploration of reproductive trends in a long-lived mammal, because it includes life-history data that span multiple generations, enabling a study of the effects of kinship across a female's lifespan. We find that living near a sister significantly increased the likelihood of annual reproduction among young female elephants, and this effect was strongest when living near a sister 0–5 years younger. Our results show that fitness benefits gained from relationships with kin are age-specific, establish the basis necessary for the formation and maintenance of close social relationships with female kin, and highlight the adaptive importance of matriliny in a long-lived mammal. © 2019 The Authors.

J. Ma, Y. Wang, C. Jin, Y. Hu & H. Bocherens

Ecological flexibility and differential survival of Pleistocene *Stegodon orientalis* and *Elephas maximus* in mainland southeast Asia revealed by stable isotope (C, O) analysis

Quaternary Science Reviews 212 (2019) 33-44

Abstract. *Elephas maximus* and *Stegodon orientalis* were two keystone proboscideans in southern Asia that coexisted mainly after the Middle Pleistocene in many regions. The long-term paleoecology and possible foraging competition of these two species have not been intensively investigated yet. Here, we applied stable isotope (C, O) analysis to the tooth enamel of coexisting *Elephas maximus*, *Stegodon orientalis*, and other associated mammalian species in Quzai Cave, southern China, dated to the early Late Pleistocene, to explore their paleoenvironmental context and foraging ecology. The $d^{13}C$ values of *Elephas maximus* were widely distributed between 17.9‰ and 11.9‰ (n = 10), while *Stegodon orientalis* $d^{13}C$ values ranged from 16.7‰ to 14.7‰ (n = 7). These results suggest that *Elephas maximus* was possibly a mixed feeder with a broader range of dietary resources than *Stegodon orientalis*, which probably browsed on a narrower range of plant resources in more densely forested landscape. A chronological comparison (from 8 Ma to recent) of published $d^{13}C$ data for these two species from Asia showed that none of them were dietary specialists. However, *Elephas* had a more flexible foraging ecology and a stronger ability to exploit abrasive grasses than *Stegodon*. The niche partitioning and perceived different foraging behaviors of *Stegodon* and *Elephas* might have reduced the level of interspecific competition and allowed them to coexist during the Pleistocene. Moreover, the high-level of ecological flexibility of *Elephas* might have helped them to survive until the present day, while *Stegodon* eventually went extinct by the terminal Pleistocene ~12 ka. An extensive comparison and evaluation of the $d^{13}C$ data from fossil mammals in mainland southeast Asia during the Early to Late Pleistocene suggests that southern China was dominated by C_3 vegetation throughout the Pleistocene, in contrast with the evidence of C_4 biomes in neighboring Laos, Cambodia, and Thailand. Southern China experienced relatively stable environments during the Pleistocene, which can be attributed to the wide range of mountainous regions that acted as ecological refugia from human interference and climatic

fluctuations, and allowed the preservation of high biodiversity. The isotopic data we present here provides new evidence about the ecological complexity of mainland southeast Asia and elucidates the need for more systematic research to investigate extinction models and ecological conservation in this region. © 2019 Reprinted with permission from Elsevier.

J. Ma, Y. Wang, C.Z. Jin, H.-W. Zhang & Y-W. Hu

A preliminary study of serial stable isotope analysis tracks foraging ecology of fossil Asian elephants in South China

Vertebrata PalAsiatica 57 (2019) 225-240

Abstract. Until now, feeding ecology has been found to play a significant role in the evolution of Asian elephant *Elephas maximus*. As the most widely-applied method in this field, bulk stable isotope analysis on tooth enamel had revealed important evidence on their paleodiet and paleoecology. However, it might be not skilled at reflecting the overview of the paleoecology of elephants, considering their huge tooth mophology and long dental ontogeny process. A newly-developing serial sampling strategy on tooth enamel sections could provide an effective approach reconstructing the long-term individual life history of mammals covering the whole tooth formation time with higher precision. In this study, serial sampling isotope analysis was firstly undertaken on tooth enamel of Asian elephants from Baxian Cave, South China during the Late Pleistocene. The within-tooth isotopic variations of three teeth (one DP4 and two M1s) are all surprisingly subtle (standard deviations of $\delta^{13}C$ and $\delta^{18}O$ values are all less than 0.6‰), though some obvious variations might be caused by weaning and/or possible migration. No seasonal variation was observed, possibly indicating that these elephants had a stable foraging ecology. Back to our previous bulk tooth enamel isotope analysis on this same site, we could confirm that the varied bulk isotope results of Asian elephants factually represent their flexible foraging ecology. We may thereby conclude that the increasing bulk isotopic analysis in this region can provide a reliable paleoecological proxy for Pleistocene proboscidea in the warm regions of South and Southeast Asia.

Hadas Marcus

Picturing elephants in captivity

Journal of Animal Ethics 9 (2019) 104-112

Abstract. The photo essay that comprises Elephant House bears mournful testimony to the severely restricted lives of the world's largest terrestrial mammals at the Oregon Zoo, as well as similar "educational" institutions throughout the United States and the world. While purporting to remain neutral regarding the ethics of keeping pachyderms in captivity, ethno-photographer Dick Blau and author-historian Nigel Rothfels's provocative book could easily arouse angry or disconsolate reactions in many readers. Rather than focusing on the pachyderms themselves, Elephant House takes a more anthropocentric stance (through zookeepers' eyes), pinpointing the intertwined relationships between these magnificent animals and the humans who strive to keep them as mentally stimulated and healthy as possible, albeit in a hopelessly confined and unnatural environment. © 2019 Board of Trustees of the University of Illinois.

J.F. McEvoy, G. Connette, Q. Huang, P. Soe, K.H.H. Pyone, M. Valitutto, Y.L. Htun, A.N. Lin, A.L. Thant, W.Y. Htun, K.H. Paing, K.K. Swe, M. Aund, S. Min, M. Songer & P. Leimgruber

Two sides of the same coin – Wildmeat consumption and illegal wildlife trade at the crossroads of Asia

Biological Conservation 238 (2019) e108197

Abstract. Domestic trade and consumption of wildmeat is intricately linked with the international trade of wildlife and together they are driving a biodiversity crisis across Southeast Asia. Forming a key juncture between countries and bioregions, Myanmar is an important piece of this puzzle and acts as a source and a conduit for illegal wildlife trade across Asia. While some information on key markets and border crossings exists, this is frequently limited to single taxa. An assessment of wildlife trade across Myanmar that quantifies international and domestic trade, and consumption is missing. We summarize results from a nationwide hunter survey, linking hunting practices at the local level to specific markets and to broader trends in illegal wildlife trade. Our survey results reveal widespread, intense hunting around Myanmar for local trade and wildmeat

consumption. The majority of hunters surveyed can be classified as 'subsistence harvesters'. Hunters report declines in populations across a range of species of conservation concern. Pangolin is hunted extensively, and Myanmar is a major contributor to the illegal pangolin trade. A better understanding of internal trade routes is needed to prevent wildlife products reaching markets that are largely outside government control. Legislative changes are encouraging, but en- forcement at the local level must be combined with community-level action to provide alternatives for subsistence harvesters to halt the rapid declines reported in endangered animal populations. © 2019 Reprinted with permission from Elsevier

D. Naha, S. Sathyakumar, S. Dash, A. Chettri & G.S. Rawat

Assessment and prediction of spatial patterns of human-elephant conflicts in changing land cover scenarios of a human-dominated landscape in North Bengal

PLoS ONE 14 (2019) e0210580

Abstract. It is of utmost importance to research on the spatial patterns of human-wildlife conflicts to understand the underlying mechanism of such interactions, i.e. major land use changes and prominent ecological drivers. In the north eastern part of India there has been a disparity between nature, economic development and fragmentation of wildlife habitats leading to intense conflicts between humans and Asian elephants (*Elephas maximus*) in recent times. Both the elephant and human population have increased in the past few decades with large tracts of forests converted to commercial tea plantations, army camps and human settlements. We analyzed data maintained by the wildlife department on human deaths and injuries caused by elephant attacks between 2006–2016 to understand spatial and temporal patterns of human-elephant conflict, frequency and distribution. The average annual number of human deaths and injuries to elephant attacks between 2006 to 2016 was estimated to be 212 (SE 103) with the highest number of such incidents recorded in 2010–2011. Based on a grid based design of 5 km^2 and 25 km^2 resolution, the main spatial predictors of human-elephant conflicts identified through Maxent presence only models are annual mean precipitation, altitude, distance from protected area, area under forests, tea plantations and agriculture. Major land use changes were assessed for this region from 2008 to 2018 using satellite imageries in Arc GIS and a predicted imagery of 2028 was prepared using Idrisi Selva. Based on the 2018 imagery it was found that forest area had increased by 446 km^2 within 10 years (2008–2018) and the annual rate of change was 12%. Area under agriculture had reduced by 128 km^2 with an annual (-) rate of change of 2.5%. Area under tea plantation declined by 307 km^2 with an annual (-) rate of change of 12% whereas area under human settlements increased by 61 km^2 with an annual (-) rate of change of 44%. Hotspots of human-elephant conflicts were identified in an east west direction primarily around protected areas, tea plantations and along major riverine corridors. During informal interactions with farmers, tea estate labors it was revealed that local community members chased and harassed elephants from agriculture fields, human settlements under the influence of alcohol and thus were primary victims of fatal interactions. Our analytical approach can be replicated for other species in sites with similar issues of human-wildlife conflicts. The hotspot maps of conflict risk will help in developing appropriate mitigation strategies such as setting up early warning systems, restoration of wildlife corridors especially along dry river beds, using deterrents and barriers for vulnerable. Awareness about alcohol related incidents and basic biology of elephants should be organized regularly involving non-governmental organizations targeting the marginalized farmers and tea estate workers. © 2019 The Authors.

D. Neupane, Y. Kwon, T.S. Risch, A.C.Williams & R.L. Johnson

Habitat use by Asian elephants: Context matters

Global Ecology and Conservation 17 (2019) e00570

Abstract. Asian elephants are isolated in fragmented habitat patches in and around Bardia National Park (BNP), Nepal. To describe habitat use patterns and ecogeographical variables (EGVs) that determine an elephant's niche in BNP, we used a General Niche-Environment

System Factor Analysis (GNESFA) modeling framework. Novel to our study was the comparison of niche requirements between core (residential) and corridor (travel corridor) areas to elucidate site-specific preferences of Asian elephants in BNP. A total of 13 EGVs (four topographic variables, six land covers, heterogeneity index and two anthropogenic variables) were examined. We implemented a 'bias file' approach to address potential sampling bias in the transect survey methods for presence records. Our study illustrated that, regardless of study area, elephants' habitat use was positively influenced by presence of grasslands, mixed forest, and landscape heterogeneity, whereas use was restricted by the topographic variables of slope and elevation. Results also demonstrated different habitat preferences between elephants in the core and corridor, which may be attributed to differences in potential dangers posed in these areas; in the core, elephant habitat preference was mainly associated with food resources such as grassland or mixed forest, whereas in the corridor, where elephants are more likely to encounter human conflict, the anthropogenic factor of distance to human settlements contributed the most in predicting elephant presence. Correlations among significant factors from the three methods (FANTER, ENFA, and MADIFA) demonstrated the consistent and reliable results of these approaches. While these methods complemented each other by providing different points of view, FANTER was especially useful when bimodal niches were analyzed. We suggest a detailed conservation plan for the small populations of elephants in BNP and surrounding areas, while considering the protection of travel routes from human activities in the corridor habitats, and lastly, maintaining grasslands and waterholes in core habitats. © 2019 The Authors.

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

Associations among tourist camp management, high and low tourist seasons, and welfare factors in female Asian elephants in Thailand

PLoS ONE 14 (2019) e0218579

Abstract. This study investigated how camp management and tourist activities affect body condition, adrenocortical function, lipid profiles and metabolic status in female tourist elephants. We compared twice monthly serum insulin, glucose, fructosamine, total cholesterol (TC), triglyceride (TG), low density lipoprotein (LDL), high density lipoprotein (HDL), and fecal glucocorticoid metabolite (FGM) concentrations to body condition scores (BCS) at five camps with different management styles (e.g., tourist activities, work type, diet) between the High (November–February) and Low (March–October) tourist seasons. There were significant camp effects on health parameters, with BCS, TC, HDL, insulin and glucose being among the highest, and G:I being the lowest (less heathy) in elephants at an observation camp compared to those at camps where elephants received exercise by providing rides to tourists. Differences between High and Low tourist season months also were found for all measures, except TG and FGM concentrations. Both work time and walking distance were negatively correlated to glucose, fructosamine and insulin, while walking distance was negatively related to FGM concentrations. By contrast, positive associations were found between tourist number and BCS, TG, and insulin, perhaps related to tourists feeding elephants. Quantity of supplementary diet items (e.g., bananas, sugar cane, pumpkin) were positively correlated with FGM concentrations, glucose, fructosamine, and insulin. This study provides evidence that body condition, adrenal activity, metabolic markers, and lipid profiles in captive elephants may be affected by visitor numbers, work activities, and the amount of supplementary foods offered by tourists. Some activities appear to have negative (e.g., feeding), while others (e.g., exercise) may have positive effects on health and welfare. We conclude that camps adopting a more hands-off approach to tourism need to ensure elephants remain healthy by providing environments that encourage activity and rely on more natural diets or foraging. © 2019 The Authors.

A. Ota, E. Takagi, M. Yasuda, M. Hashim, T. Hosaka & S. Numata

Effects of nonlethal tourist activity on the diel activity patterns of mammals in a National

Park in Peninsular Malaysia

Global Ecology and Conservation 20 (2019) e00772

Abstract. The activity patterns of mammals are highly variable across species and can be affected by many factors, such as daytime length (i.e., sunrise to sunset), temperature, precipitation, predator–prey or competitive interactions and human activities. However, while several studies have investigated the seasonal and diel activity patterns of mammals using camera traps, information on their diel activity patterns in relation to nonlethal tourist activity is limited. Therefore, here, we conducted video-camera-trap surveys in Endau Rompin National Park in Peninsular Malaysia to examine the detection rates and diel activity patterns of the mammals living there, as well as differences in their diel activity patterns between the open and closed tourist seasons. Barking deer (*Muntiacus muntjak*), bearded pig (*Sus barbatus*), wild boar (*S. scrofa*), greater oriental chevrotain (*Tragulus napu*) and Malayan tapir (*Tapirus indicus*) exhibited significant differences in their diel activities among time periods: Malayan tapir was predominantly nocturnal, the greater oriental chevrotain was predominantly crepuscular and all other species were strongly diurnal. In addition, the data indicated that the Malayan porcupine (*Hystrix brachyura*) was nocturnal and the Asian elephant (*Elephas maximus*) was cathemeral, although the differences between time periods were not significant for these species. The detection frequencies of barking deer, bearded pig, wild boar and Malayan porcupine were higher in the open season. However, these differences were not related to human activity recorded by the cameras, and none of the mammalian species exhibited significant differences in their diel activity patterns between the open and closed seasons, suggesting that nonlethal tourist activity has limited effects on the diel activity patterns of wild mammals in this National Park. © 2019 The Authors.

J.M. Plotnik, D.L. Brubaker, R. Dale, L.N. Tiller, H.S. Mumby & N.S. Clayton

Elephants have a nose for quantity

PNAS 116 (2019) 12566-12571

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

R. Prahardani, L.W. Firdausy, Yanuartono & W. Nurcahyo

Morphology and morphometry of adult nematodes on Sumatran elephants (*Elephas maximus sumatranus*) in Way Kambas National Park area, Indonesia

Veterinary World 12 (2019) 249-253

Abstract. Worms from nematodes are the most numerous and the most detrimental in elephants. Most adult worms are located in the digestive tract. Nematode infection is at higher risk in young elephants, which caused several cases such as anemia, hypoalbuminemia, enteritis, and even death. This study aimed to determine the

morphology and morphometry of adult nematodes on Sumatran elephants in Way Kambas National Park area. Nematode samples were obtained from Sumatran elephants' feces (*Elephas maximus sumatranus*) in Way Kambas National Park, Lampung Province, after being given Kalbazen® containing albendazole 1000 mg at a dose of 10 mg/kg by the veterinarian in charge of the National Park area. For the morphological and morphometric examinations, we used an Olympus BX 51 microscope equipped with Olympus DP 12 camera. The scanning electron microscopic (SEM) analysis was carried out. The results of macroscopic observations of the obtained nematodes showed that the nematodes which were found, have the characteristics of round, slim, and white color. The size of a female worm was larger than a male worm. Microscopic examination in four anterior papillae indicated that the dorsal lobe in the copulatory bursa was longer than lateral lobe. The result of inspection with the SEM showed a leaf crown consisting of 10 elements, a pair of amphids laterally, and two pairs of papilla in a submedian region. Based on our morphology and morphometry examinations of adult nematodes in Sumatran elephant in Way Kambas National Park area, the adult nematodes which were found are species of *Quilonia travancra*. © 2019 The Authors.

J.-P. Puyravaud, S. Gubbi, H.C. Poornesha & P. Davidar

Deforestation increases frequency of incidents with elephants (*Elephas maximus*)

Tropical Conservation Science 12 (2019) 1-11

Abstract. Damages by the Asian elephant (*Elephas maximus*) range from crop raiding to loss of human lives, and understanding the underlying causes thereof could help reduce such incidents. Land-use change could be among the major causes of elephant incidents since they are long-lived and tend to have particular home ranges. To test this hypothesis, we assessed deforestation rates in sites between the Nilgiris Biosphere Reserve and the Bhadra Tiger Reserve, Western Ghats of India between the 1960s and 2000s. Deforestation was calculated in windows of varying sizes to account for spatial scale responses. The locations of 624 incidents between April 2008 and March 2011 were used, and a database of 20,000 random locations provided contrasts. We used sets of 250 logistic regressions at each scale of deforestation to ensure that the significance of deforestation was independent of the randomly sampled contrast locations. A total of 6,761 km^2 of forest and scrubland have disappeared from private forests in 50 years, with an average deforestation rate of –0.85% y^{-1}. The distribution of incidents followed an exponential decay with increasing distance from protected areas and a beta distribution against deforestation. Logistic regressions indicated a significant effect of deforestation at the small scale (1 km^2 particularly and 4 km^2). These results show that (a) incidents occur mostly near protected areas, and barriers or adaptation of livelihoods could address this problem and (b) deforestation is associated with increasing incidents with elephants. Avoiding deforestation and maintaining elephant population connectivity may help avoid incidents. © 2019 The Authors.

G. Quarta, M. D'Elia, E. Braione & L. Calcagnile

Radiocarbon dating of ivory: Potentialities and limitations in forensics

Forensic Science International 299 (2019) 114-118

Abstract. The determination of the age of elephant ivory is a crucial aspect in the fight against illegal ivory trade which is still a relevant problem having triggered the decline of elephant populations due to poaching in different areas of the globe. Indeed, the absolute dating of the ivory allows, in forensics practice, to establish whether a determined sample or object was obtained and imported illegally, violating the international trade ban. In this frame the use radiocarbon dating has surely a great potential and is widely used. In this paper we review the potential of the method in this field, highlighting its advantages and drawbacks. In particular we show, through the discussion of real cases, how it is possible to improve the achievable chronological resolution by refining the obtained ages trough the proper use of available information and considerations. © 2019 Reprinted with permission from Elsevier.

S.L. Rodriguez & C. Sampson

Expanding beyond carnivores to improve livestock protection and conservation

PLoS Biology 17 (2019) e3000386

Abstract. Promoting human–wildlife coexistence is critical to the long-term conservation of many wild animal species that come into conflict with humans. Loss of livestock to carnivore species (e.g., lions, tigers, wolves) is a well-documented occurrence and the focus of mitigation strategies around the world. One area that has received little research is the impact of noncarnivores on livestock. Both African and Asian elephant species are known to cause livestock injuries and deaths. Livestock owners within elephant ranges perceive elephants as a risk to their livestock, which may reduce their tolerance towards elephants and jeopardize conservation efforts in the area. Though feral hogs may not be of conservation concern, these animals contribute significant losses to farmers' livelihoods. We advocate for the inclusion of noncarnivore species in policies that promote livestock protection because it will allow for better communication regarding effective strategies and more application in the field. © 2019 The Authors.

C. Sampson, P. Leimgruber, S. Rodriguez, J. McEvoy, E. Sotherden & D. Tonkyn

Perception of human-elephant conflict and conservation attitudes of affected communities in Myanmar

Tropical Conservation Science 12 (2019) 1-17

Abstract. Myanmar is an ideal location for Asian elephant (*Elephas maximus* L.) conservation because it still contains large expanses of elephant habitat. However, increasing human-elephant conflict (HEC) threatens to derail ongoing elephant conservation programs. We conducted 303 interviews in rural communities living near elephants to help inform long-term management strategies to conserve this endangered species. We sought to understand the main challenges that people in these communities face in improving their quality of life, as well as the types and levels of HEC they experience and their attitudes toward elephant conservation. Poverty, not conflict with elephants, was the greatest obstacle reported by our participants. However, HEC was deemed a moderate to major problem, with 38% of farmers indicating they lost half or more of their crops to elephants the previous year. Our results showed that communities living in proximity to and often harmed by elephants were nevertheless supportive of elephant conservation and willing to contribute to conservation efforts. This result offers hope in the quest to maintain elephant populations in Myanmar. We conclude that conservation policies that also address societal challenges such as poverty may be more effective in protecting elephants than policies that address HEC alone. © 2019 The Authors.

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

Body Condition Scores (BCS) in European zoo elephants' (*Loxodonta africana* and *Elephas maximus*) lifetimes – a longitudinal analysis

Journal of Zoo and Aquarium Research 7 (2019) 74-86

Abstract. In further improving zoo elephant welfare, the diet and feeding regime are key factors. Together with the encouragement of physical activity, they may support the management and prevention of overweight and obesity, which are considered a common concern in zoo elephants. Besides weight monitoring, visual body condition scoring (BCS) has proven a practical tool for the assessment of (zoo) elephants' physical condition. From the individual management as well as the medical perspective, documentation of an elephant's BCS development over time might be much more informative than a population-wide cross-sectional analysis. We present a compilation of comprehensive data over zoo elephants' lifetimes regarding BCS and influencing factors such as reproductive activity, physical disorders, advanced age, stressful situations and diet adaptations. Our study of the European zoo elephant population describes the reflection of various life circumstances and management adaptations in the BCS of individual elephants, and changes of population-wide BCS over time. The establishment of an online archive to build up a reliable, individual-based data basis with minimal additional workload for elephant-keeping facilities is proposed. © 2019 The Authors.

H. Schmidt & J. Kappelhof

Review of the management of the Asian elephant *Elephas maximus* EEP: Current

challenges and future solutions
International Zoo Yearbook 53 (2019) 1-14
Abstract. This article reviews the current situation in the Asian Elephant *Elephas maximus* European Association of Zoos and Aquaria Ex situ Programme (EEP). In recent years, developments in husbandry and gained knowledge about the reproductive biology of Asian elephants have contributed to increased breeding success and resulted in a mean of 15 births per year in the last 5 years. At the time of writing, the Asian elephant EEP population contains 307 individuals: 90.217 (♂♂.♀♀). Based on the life table for 1998–2018, most demographic parameters show healthy numbers [e.g. lambda (k) = 1 025], while the population has retained 98 44% of the gene diversity. However, this EEP is also facing multiple challenges, such as the presence of subspecies, transport barriers between some EEP participants and the societal debate about the purpose of zoos. The growing number of male elephants in the EEP population appears to be the most immediate challenge. In the short term, the authors suggest that females could be managed to conceive for the first time at 8 years of age and adhere to an interbirth interval of 7 years. This would be an attempt to decrease the reproductive rate without compromising the future reproductive potential of the population. The authors also prescribe improving facilities for elephants to allow zoos to utilize a fission–fusion housing strategy, making it possible to house the increasing number of males appropriately over the longer term. © 2019 The Authors.

M.W. Seltmann, S. Helle, W. Htut & M. Lahdenperä
Males have more aggressive and less sociable personalities than females in semi-captive Asian elephants
Scientific Reports 9 (2019) e2668
Abstract. Personality, i.e. consistent between-individual differences in behaviour, has been documented in many species. Yet little is known about how males and females of long-lived, highly social species differ in their measures of personality structure. We investigated sex differences in the mean, variance, and covariance of three previously reported personality traits (Attentiveness, Sociability, Aggressiveness) in 150 female and 107 male Asian elephants (*Elephas maximus*) from a semi-captive population in Myanmar. These three personality traits were obtained by performing exploratory factor analysis on 28 behavioural items that had been rated by experienced elephant handlers. We found that males scored significantly higher on Aggressiveness and tended to score lower on Sociability than females. However, no sex difference was found in the mean scores of Attentiveness. Variances for the three personality traits did not differ between the sexes, suggesting that male and female elephants share the same range of personality variation. Likewise, trait covariances were similar between the sexes. While both sexes show complex sociality in the wild, female Asian elephants typically live in highly social family units, whereas male elephants' social bonds are weaker. Males usually form dominance ranks by aggressive interactions, especially during musth. Our results on a large sample of individuals living in their natural environment are thus in agreement with elephant life-histories and parallel the findings of sex differences in other long-lived highly social species with similar life-histories. © 2019 The Authors.

Jacob Shell
Elephant convoys beyond the state: Animal-based transport as subversive logistics
Environment and Planning D: Society and Space 37 (2019) 905-923
Abstract. This article explores and analyzes a form of subversive logistics: the use of trained Asian elephants in the mobilization of cargo and people. This unusual means of conveyance, whose zone of persistence is mainly in the forested uplands of Burma (Myanmar) and parts of northeast India, most comes into its own during logistical operations which occur without the use of fixed-route roads. Empirically, the article presents fieldwork conducted in Burma and northeast India between 2013 and 2017, as well as related archival research, including research about other transport animals like sled dogs and camels. The (perhaps surprising) role played by elephants during flood relief operations in recent times receives special attention here, as does the theme of elephant-based transportation

during modern armed conflicts, such as the ongoing Kachin conflict in northern Burma and in the Burma theater of World War II. The article aims to help theorize the connection between mobility and political subversion, highlighting how landscapes which do not lend themselves to permanent transport infrastructure—and thus the presence of the state—are simultaneously places of potential resistance. A related aim is to contribute to our understanding of the elephant–human relationship itself, demonstrating how elephants and humans have worked together to produce constantly shifting systems of mobility. © 2018 The Author.

S. de Silva & P. Leimgruber

Demographic tipping points as early indicators of vulnerability for slow-breeding megafaunal populations

Frontiers in Ecology and Evol. 7 (2019) e171

Abstract. Decisions based on trends in population abundance and distribution may fail to protect populations of slow-breeding, long-lived megafauna from irrevocable decline if they ignore demographic constraints. For such taxa, we urge that effort be directed at understanding the interactions among vital rates governing population growth rates, rather than on predicting probabilities of extinction. The proximity of a population to demographic tipping points, i.e., where growth rate switches from positive to negative, can signal vulnerability to perturbation long before numbers drop below a point of no return. We define the "demographic safe space" as the combination of key vital rates that support a non-negative growth rate and illustrate this approach for Asian elephants. Through simulations, we find that even with optimal reproduction, Asian elephant populations cannot tolerate annual female mortality rates exceeding 7.5%. If adult mortality is very low (3%/year), populations can tolerate high annual mortality in calves below age 3 (up to 31.5%/year), or slow female reproduction (primiparity at 30 years or average inter-birth interval of up to 7.68 years). We then evaluate the potential impact of current threats, showing that near-optimal reproduction and high calf survival is necessary to offset even modestly increased mortality among adult female age classes. We suggest that rather than rely on simple counts or "viability" assessments, conservation planners for slow-breeding megafauna should consider demographic tipping points and strive to keep populations within their safe spaces. © 2019 The Authors.

S.K. Singh, G. Jabin, T. Basumatary, G.P. Bhattarai, K. Chandra & M. Thakur

Resolving the trans-boundary dispute of elephant poaching between India and Nepal

Forensic Science International: Synergy 1 (2019) 146-150

Abstract. In Kangchenjunga Landscape (KL), which is shared by three countries – Bhutan, India, and Nepal, the wild elephants migrate from east of Jhapa (Nepal), through West Bengal (India) and Sibsoo (Bhutan) to further east in Assam (India). The route Jhapa-WB-Sibsoo-Assam is a known route for elephant movements where maximum causalities have been reported in the past. The present study was undertaken to ascertain the individual identity of a poached elephant in Jhapa, Nepal and ivory, which was suspected to be from the same individual elephant confiscated in Siliguri, India. We undertook STR profiling of the confiscated specimens with nine polymorphic STRs. The forensic parameters have established the fact that the two analyzed samples of elephant were not identical and belong to two different individuals. The present study highlights the necessity of transboundary research for elephant conservation and monitoring their movements in Kangchenjunga Landscape and emphasizes the use of forensic genetics in curbing illegal wildlife trade. © 2019 The Authors.

T.M.C. Sosnowski, T.G. Knowles, T. Takahashi & N.J. Rooney

Global ivory market prices since the 1989 CITES ban

Biological Conservation 237 (2019) 392-399

Abstract. Poaching associated with the ivory trade is estimated to cause an 8% annual loss in the world elephant population. Although international trade in ivory was banned by the Convention on the International Trade in Endangered Species in 1989, elephant populations continue to suffer. Together with global price data on ivory transactions, information on ivory product type, weight, region, legality of sale, and

year of transaction, were used alongside an ivory Transaction Index (TI) and world gold price to: (1) examine the temporal and geographic trends in ivory price; (2) determine variables associated with ivory price; and (3) propose a predictive equation based on these variables. Results indicate that ivory price has been rising since the CITES ban, with highest values observed across Asia. Determinants significant to ivory market price include: (1) region; (2) type [raw, polished, carved]; (3) TI; and (4) legality. Interaction effects were present between region and legality, and between region and type. The predictive equation successfully explained 72.5% of variation in price. It is hoped that an improved understanding of the market mechanism will lead to more effective policy interventions, which can ensure a secure future for elephants as a species. © 2019 Reprinted with permission from Elsevier.

N. Srinivasaiah, V. Kumar, S. Vaidyanathan, R. Sukumar & A. Sinha

All-male groups in Asian elephants: A novel, adaptive social strategy in increasingly anthropogenic landscapes of southern India

Scientific Reports 9 (2019) e8678

Abstract. Male Asian elephants are known to adopt a high-risk high-gain foraging strategy by venturing into agricultural areas and feeding on nutritious crops in order to improve their reproductive fitness. We hypothesised that the high risks to survival posed by increasingly urbanising and often unpredictable production landscapes may necessitate the emergence of behavioural strategies that allow male elephants to persist in such landscapes. Using 1445 photographic records of 248 uniquely identified male Asian elephants over a 23-month period, we show that male Asian elephants display striking emergent behaviour, particularly the formation of stable, long-term all-male groups, typically in non- forested or human-modified and highly fragmented areas. They remained solitary or associated in mixed-sex groups, however, within forested habitats. These novel, large all-male associations, may constitute a unique life history strategy for male elephants in the high-risk but resource-rich production landscapes of southern India. This may be especially true for the adolescent males, which seemed to effectively improve their body condition by increasingly exploiting anthropogenic resources when in all-male groups. This observation further supports our hypothesis that such emergent behaviours are likely to constitute an adaptive strategy for male Asian elephants that may be forced to increasingly confront anthropogenically intrusive environments. © 2019 The Authors.

S. Srivorakul, T. Guntawang, V. Kochagul, K. Photichai, T. Sittisak, T. Janyamethakul, K. Boonprasert, S. Khammesri, W. Langkaphin, V. Punyapornwithaya, P. Chuammitri, C. Thitaram & K. Pringproa

Possible roles of monocytes/macrophages in response to elephant endotheliotropic herpesvirus (EEHV) infections in Asian elephants (*Elephas maximus*)

PLoS ONE 14 (2019) e0222158

Abstract. Elephant endotheliotropic herpesvirus-hemorrhagic disease (EEHV-HD) is the primary cause of acute, highly fatal, hemorrhagic diseases in young Asian elephants. Although monocytopenia is frequently observed in EEHV-HD cases, the role monocytes play in EEHV-disease pathogenesis is unknown. This study seeks to explain the responses of monocytes/macrophages in the pathogenesis of EEHV-HD. Samples of blood, frozen tissues, and formalin-fixed, paraffin-embedded (FFPE) tissues from EEHV1A-HD, EEHV4-HD, co-infected EEHV1A and 4-HD, and EEHV-negative calves were analyzed. Peripheral blood mononuclear cells (PBMCs) from the persistent EEHV4-infected and EEHV-negative calves were also studied. The results showed increased infiltration of Iba-1-positive macrophages in the inflamed tissues of the internal organs of elephant calves with EEHV-HD. In addition, cellular apoptosis also increased in the tissues of elephants with EEHV-HD, especially in the PBMCs, compared to the EEHV-negative control. In the PBMCs of persistent EEHV4-infected elephants, cytokine mRNA expression was high, particularly up-regulation of TNF-α and IFN-γ. Moreover, viral particles were observed in the cytoplasm of the persistent EEHV4-infected elephant monocytes. Our study demonstrated for the first time that apoptosis of the PBMCs increased in cases of EEHV-HD. Furthermore, this study showed

that monocytes may serve as a vehicle for viral dissemination during EEHV infection in Asian elephants. © 2019 The Authors.

W. Suksavate, P. Duengkae & A. Chaiyes

Quantifying landscape connectivity for wild Asian elephant populations among fragmented habitats in Thailand

Global Ecology and Conservation 19 (2019) e00685

Abstract. The information on landscape connectivity among wildlife populations is crucial for conservation of endangered species. In this study, connectivity between core habitat areas was mapped and prioritized for the potential corridors among elephant populations in two separated regions in Thailand. The step selection function modeling approach was employed to estimate resistance surfaces based on elephant occurrence data. Connectivity maps were created based on the estimated resistance surfaces by employing the least-cost path and circuit theory through a proposed analytical method. As the results of resistance modeling, the averaged model showed that four of fifteen covariates were positively associated with the selection of the steps. The predictors consist of landcover, elevation, terrain ruggedness, and distance to the nearest cell of specific landcover. The connectivity maps indicated multiple potential connectivity pathways, bottlenecks, and varied important linkages between core areas in both regions. This gave an alternative opportunity in acquiring information of landscape connectivity for providing aid in conservation planning at landscape-level. © 2019 The Authors.

K. Takehana, T. Kinjyo, M. Nemoto & K. Matsuno

Rapid and sensitive detection of elephant endotheliotropic herpesvirus 1 (EEHV1) in blood by loop-mediated isothermal amplification (LAMP)

Journal of Veterinary Medical Science 81 (2019) 504-507

Abstract. Elephant endotheliotropic herpesvirus type 1 (EEHV1) is the most important causative agent of an acute fatal hemorrhagic disease in Asian elephants (*Elephas maximus*). We employed loop-mediated isothermal amplification (LAMP) to develop a rapid and simple detection method for EEHV1 in blood. When used to test 21 clinical samples collected in Japan, the EEHV1 assay correctly identified one positive and 20 negative clinical samples. It was observed that when samples were spiked with synthetic DNA plasmids including EEHV1 polymerase gene, the detection limit of the LAMP assay was $10^{1.2}$ copies/μl and 100-fold higher than that of conventional PCR. These advantages of the LAMP assay for EEHV1 detection may facilitate better veterinary practices for treating elephants suffering from the acute disease. © 2019 The Japanese Society of Veterinary Science.

R. Tang, K. Xu, X. Yang, H. Yang, M. Bao, T. Jia, J. Zhang & L. Zhang

Impact of social pressure on the estrus of captive female Asian elephants (*Elephas maximus*)

Acta Theriologica Sinica 29 (2019) 111-118

Abstract. Asian elephants (*Elephas maximus*) are considered an endangered species, and their reproduction in captivity is important for their conservation. In this study, we analyzed the impact of social pressure on stress status and the estrous cycle of captive female Asian elephants with the aim of determining the reason for their prolonged anestrous status. The levels of estradiol and progesterone indicate the estrous phase, and those of cortisol show stress status; therefore, we measured estradiol and cortisol in urine and feces, and progesterone in the urine of female elephants by radioimmunoassay. Social pressure was determined by the degree of aggressive and nonaggressive behavior. The results indicate the following: (1) females in a dominant position were more frequently engaged in aggressive behavior compared with those in a subordinate position; (2) cortisol levels in dominant females were significantly higher than those in subordinate females; (3) the levels of estradiol and progesterone in dominant individuals showed cyclic fluctuations, but those in subordinate individuals did not. These data suggest that among captive Asian elephants, social pressure may be the cause of low sex hormone levels and prolonged anestrus in subordinate females, which are therefore not engaged in reproductive behavior for a long time.

K. Thapa, M.J. Kelly & N.M.B. Pradhan

Elephant (*Elephas maximus*) temporal activity, distribution, and habitat use patterns on the tiger's forgotten trails across the seasonally dry, subtropical, hilly Churia forests of Nepal

PLoS ONE 14 (2019) e0216504

Abstract. Understanding spatial distribution, habitat use, and temporal activity patterns is important for species conservation planning. This information especially is crucial for mega herbivores like elephants as their ranging patterns encompass a myriad of habitats types. Churia habitat is geological fragile yet important for wildlife in Nepal and India. We used camera trapping and sign surveys covering 536 km^2 of Churia and surrounding areas within Chitwan National Park. Across 152 trapping locations, we accumulated 2,097 trap nights in a 60-day survey during the winter season of 2010–11. We used a non-parametric kernel density function to analyze winter activity patterns of elephants detected in camera-traps. Additionally, we walked 643 km over 76 grid cells in two surveys (winter and summer) to estimate elephant distribution and intensity of habitat use using an occupancy framework. Multi-season models allowed us to make seasonal (winter versus summer) inferences regarding changes in habitat use based on covariates influencing use and detection. We photographed 25 mammalian species including elephants with calves with a trapping rate of 2.72 elephant photos events per 100 trap nights. Elephant winter activity pattern was found to be mainly nocturnal, with crepuscular peaks. Covariates such as normalized differential vegetation index and terrain ruggedness positively influenced elephant spatial distribution and habitat use patterns within the Churia habitat. We also found lower elephant habitat use (Ÿ SE (Ÿ)) of Churia in winter 0.51 (0.02) than in summer 0.57 (0.02). Elephants heavily used the eastern portion of Churia in both seasons (67–69%). Overall, Churia habitat, which is often ignored, clearly is used by elephants, with increases in summer use in the west and high use year-round in the east, and thus should no longer be neglected or forgotten in species conservation planning. © 2019 The Authors.

S.T. Wong, J.L. Belant, R. Sollmann, A. Mohamed, J. Niedballa, J. Mathai, G.M. Street & A. Wilting

Influence of body mass, sociality, and movement behavior on improved detection probabilities when using a second camera trap

Global Ecology and Conserv. 20 (2019) e00791

Abstract. Maximizing detection probability is a common goal for occupancy studies using camera traps for data collection. Placing additional cameras at a survey station may improve precision of occupancy and detection estimates. However, these benefits are situational and potentially influenced by species' physical characteristics and behavior. We estimated null occupancy and detection probabilities for 20 mammalian species with >10 detections at multiple sites from one- and two-camera data sets from 63 stations set in a commercial forest reserve in Sabah, Malaysian Borneo during October–December 2015. We used a cross-validated absolute shrinkage and selection operator approach to model the effects of species' body mass, social behavior, dietary niche, and foot posture on detection probability using one- and two-camera designs. The number of species detections, sites where species were detected, detection probability estimates, and precision of model parameter estimates for all species improved using two cameras. Our results showed that unguligrade species were associated with both high detection probability estimates with one camera and also the greatest improvements using the two-camera design in detection probability compared to all other species. Greater improvements in precision of model parameter estimates from two-camera designs were observed in species detected less frequently. Our data suggests that camera designs need to be adapted based on the focal species and we suggest that future occupancy studies collect preliminary information to maximize effectiveness of camera effort and ensure that data collection is efficient and meets project needs. © 2019 Elsevier.