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Number 57 (2024)

The journal is intended as a medium of communication on issues that concern Asian elephants both in the wild and in captivity. Areas of interest include but are not limited to conservation, management, behaviour, ecology, health, history and cultural aspects related to Asian elephants. It is a means by which everyone concerned with the Asian elephant (*Elephas maximus*), whether members of the Asian Elephant Specialist Group or not, can communicate their experiences, ideas and perceptions freely, so that the conservation of Asian elephants can benefit. The journal welcomes researchers worldwide to publish their original research articles. All articles published in *Gajah* reflect the individual views of the authors and not necessarily that of the editorial board or the Asian Elephant Specialist Group, the Species Survival Commission, or IUCN.

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Editorial Note

Gajah will be published as both a hard copy and an online version accessible from the AsESG web site (https://www.asesg.org/gajah.php). If you would like to be informed when a new issue comes out, please provide your e-mail address. If you need to have a hardcopy, please send a request with your name and postal address by e-mail to <j.pastorini@icloud.com>.

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Cover

An iconic tuskless bull (Makuna) of the
Koshi Tappu Wildlife Reserve, Nepal
Photo by Chungba Sherpa
(See article on page 3)

Layout and formatting by Dr. Jennifer Pastorini

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Editorial

Jennifer Pastorini (Editor)

E-mail: j.pastorini@icloud.com

In the first *Gajah* of 2024 we present two research articles and five short communications about Asian elephants from India, Laos, Myanmar and Nepal. This issue also includes notes from two of the Asian Elephant Specialist Group's (AsESG) working groups and three reports on workshops dealing with Asian elephant conservation topics. This issue concludes with the usual compilation of abstracts.

In the **Research Articles** Aayush Shrestha and co-authors studied human-elephant conflict (HEC) around a wildlife reserve in Nepal. They found that the majority of human casualties were caused by people's negligence of threats and their confrontation of elephants. Therefore, awareness programs may help address this issue. Khyne U Mar describes how Myanmar Timber Enterprise elephants obtain food. Whereas most elephants gather sufficient fodder when released at night, individuals with special needs are provided a supplemental diet.

In **Short Communications** R.R. Kumara and B.P. Paramesha evaluated traditional sericulture and HEC. They found that mulberry is easily grown, was an economically beneficial crop and was not raided by elephants. Michael Falshaw conducted a camera trap study in a protected area in Laos. A total of 52 individual elephants including juveniles were identified in two areas. They were in good body condition. Michael Falshaw also reports on the re-wilding of four working elephants in Laos. They were closely monitored with GPS collars, which allowed providing timely medical treatment to an elephant that became immobile due to health issues. Mirza Vaseem *et al*. present the case of a captive elephant with oesophageal obstruction. Despite immediate veterinary intervention it was not possible to save the animal. Post-mortem findings are discussed. P. Aswathi compiled a list of 57 plants traditionally used for medical treatment and managing musth.

In **News and Briefs** the AsESG's Transport Working Group presents its report on problems caused by new linear infrastructure and how to reduce their impacts on elephants. Chatchote Thitaram *et al*. give a brief summary on a workshop held by the EEHV Working Group in Thailand last year. They assessed the current situation with EEHV in elephants and discuss possible strategies to fight it. The Elephant Conservation Group (ECG) held a meeting last year in India and briefly present the topics that were discussed. Mai Thi Nguyen and Hoa Thi Tran organised a workshop where the newest findings of studies conducted in Dong Nai were presented and discussed. With only 100–130 wild elephants remaining in Vietnam, conserving this population of 25 elephants is crucial. Chution Savini reports from a workshop held in Thailand to provide communication skills to communities and park rangers around Kui Buri National Park.

Great news! *Gajah* has now been accepted into the Directory of Open Access Journals (DOAJ). *Gajah* will reach wider audiences which will increase its impact on Asian elephant conservation. Also – thanks to the DOI numbers – *Gajah*'s articles are now being listed in the Web of Science. This should make *Gajah* more attractive to people from academia to publish their work. A big thank you is due to Gabriela Hidalgo, the librarian at IUCN, for doing all the paperwork to get *Gajah* into DOAJ!

I am most grateful to the editorial board members who have been working with the authors to improve their manuscripts. I thank the authors for taking the effort to publish their work. The AsESG greatly appreciates the funding from "SAFE: Saving Animals from Extinction" which enables us to print *Gajah* and mail it to an international readership free of charge.

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Notes from the Chair IUCN SSC Asian Elephant Specialist Group

Vivek Menon

Chair's e-mail: vivek@wti.org.in

Dear Members

While I am delighted by the exceptional progress, we are making in fulfilling the commitments of our Asian Elephant Specialist Group (AsESG), I am equally bereft of the demise of our senior member and legendary elephant and large mammal conservationist, prolific writer and a great teacher, Dr A. J. T. Johnsingh. As we commemorate his life and work, let us also recommit ourselves to the causes he championed, ensuring that his contributions continue to shape the future of conservation and our understanding of these majestic creatures.

I am elated to share with you a significant milestone in our conservation efforts – the addition of the Bornean elephants to the Red List of Threatened Species. This fills a crucial gap in red listing of all elephant populations in the wild. This achievement is a testament to the dedication and hard work of the Working Group. The fact that the taxon has been listed as Endangered means that our cheering is limited to the listing but not to the status of the Bornean elephant and I hope this will spur Malaysia and Indonesia to take special measures for the conservation of the species.

The AsESG has finalised the "National Elephant Conservation Action Plan of Peninsular Malaysia" and the plan now has been approved by the Government of Peninsular Malaysia. The "Sumatran National Elephant Conservation Action Plan" has also been approved by the government. The Asian Elephant Transport Working Group, a joint collaboration of the AsESG and the IUCN WCPA Connectivity Conservation SG, has released the "Handbook on Mitigation for Roads and Railways in Asian Elephant Landscapes" that provides recommendations and for elephant-specific crossing structures and mitigation measures to address linear infrastructure impacts to elephants. The documents can be downloaded at the AsESG's website.

Our Membership Advisory Committee has reviewed applications and added seven more members to this group. bringing our total to 125 members from 21 countries. I thank the Committee for taking due diligence towards including more members from Southeast Asia.

I am delighted that many members actively participated in the 19th International Elephant Conservation and Research Symposium in Chiang Mai, Thailand and showcased the depth of expertise within our group and contributed to discussions on conservation challenges and solutions. Representing the AsESG at the CoP 28 UN Climate Change Conference in Dubai I delivered a talk that referred to the paper drafted by our Climate Change Working Group. It was also appropriate that we organised a side event on "Room to roam for elephants: Conservation and connectivity in Africa and Asia" at the CoP 14 of Convention on Migratory Species at Samarkand, Uzbekistan. This provided us with a valuable opportunity to highlight the importance of connectivity for elephants and addressed the challenges and opportunities associated with elephant movement and habitat connectivity and urged for dialogue and collaboration among stakeholders to ensure unhindered passage of elephants across landscapes.

It is overwhelming to see the support and contribution of the AsESG members being put to protect and conserve Asian elephants. I would like to thank our partners and donors for financial support to AsESG. I look forward to working closely with each of you and achieving significant milestones in Asian elephant conservation.

Vivek Menon
Chair IUCN SSC AsESG

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Research Article
Gajah 57 (2024) 3-12

Human Casualties from Human-Elephant Conflict around Koshi Tappu Wildlife Reserve, Nepal

Aayush Shrestha[1]*, Narendra M. B. Pradhan[2], Bikram Shrestha[3,4], Mandip Pangeni[5] and Bishnu P. Pandey[1]

[1]*Institute of Forestry Hetauda Campus, Tribhuvan University, Hetauda, Nepal*
[2]*International Union for Conservation of Nature (IUCN), Nepal*
[3]*Department of Biodiversity Research, Global Change Research Institute, Czech Academy of Sciences, Brno, Czech Republic*
[4]*Conservation Development Foundation Nepal (Codefund), Kathmandu, Nepal*
[5]*Department of National Parks and Wildlife Conservation, Babarmahal, Kathmandu, Nepal*
**Corresponding author's e-mail: aayush.shrestha69@gmail.com*

Abstract. We studied human casualties in the buffer zone of Koshi Tappu Wildlife Reserve to gain insights into the factors responsible for elephant attacks on humans. We interviewed victims' families for those that got killed and victims that got injured, over the past six years. Human behaviour was responsible for more casualties than elephant behaviour. Casualties were mainly caused by people's negligence of threats and confrontation of elephants. Providing awareness about elephant ecology and training people about deterrents and methods for avoiding conflict, along with regular patrolling and maintenance of electric fences is required to ensure the safety of both people and elephants.

Introduction

In recent times, one of the most pressing challenges in wildlife conservation in Nepal is the human-wildlife conflict, with Asian elephants (*Elephas maximus*) being particularly prone to conflicts (Acharya *et al*. 2016; Ram *et al*. 2021). Approximately 20% of the human population resides near wild elephant habitats in South Asia (Bandara & Tisdell 2003). The conflict between humans and elephants has escalated due to expanding human settlements and habitat loss and fragmentation.

The Asian elephant population in Nepal has increased significantly from 105–125 in 2002 (Kharel 2002) to 109–142 in 2010 (Pradhan *et al*. 2011) and to 203–227 individuals in 2022, distributed across six clusters (Ram *et al*. 2022). Historically, elephants inhabited Nepal's undisturbed lowland forests (Olivier 1978; Smith & Mishra 1992) and the Chure Foothills across Nepal (Thapa *et al*. 2019; Ram *et al*. 2022), which extend from the Brahmaputra River in India in the east to the Indus River in Pakistan in the west, covering 13% of the country's land area. Currently Asian elephants are distributed across the Terai region of Nepal and present in 22 of the 77 districts of Nepal.

Elephant attacks account for approximately 40% of human-wildlife conflicts and 70% of wildlife-related human casualties in Nepal (Bajimaya 2012). The Jhapa District in the eastern lowland region has a particularly high number of human-elephant conflict (HEC) incidents (Pradhan *et al*. 2011; Ram 2014). In Koshi Tappu Wildlife Reserve (KTWR) as well, there is a very high number of conflicts, which can be attributed to the migration of elephants from the Chure region, limited habitat area within the reserve and limited possibility of movement to areas beyond the reserve (KTWR Office 2018).

Research in Nepal has explored crop and property damage caused by elephants (Graham *et al*. 2012; Neupane *et al*. 2014; Pant *et al*. 2016; Gross *et al*. 2022). However, few studies have focussed on elephant attacks on humans. Ram *et al*. (2021) conducted a study across the Terai and Siwalik regions, which showed people who

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were drunk and chasing elephants using firecrackers were at higher risk of fatalities.

We conducted situation analyses to assess whether the causation of HEC incidents around KTWR was due to humans, elephants or accidental, and to assess the potential for minimising them through modifying human behaviour.

Materials and Methods

Study area

The study area covers the buffer zone of KTWR, which lies within 86°53'41" – 87°06' 32"E longitude and 26°33'58" – 26°43'42''N latitude. It lies across the three districts Sunsari, Saptari and Udaypur in Koshi Province of the Federal Republic of Nepal covering 5 municipalities and one rural municipality. A buffer zone was declared in 2004 covering 173 km^2.

The core area of KTWR is 175 km^2 in extent. The habitat in the core area consists of mixed deciduous riverine forest alongside the Koshi River. The habitats within the reserve consist of grasslands (53%), river (22%), forest areas (10%) and sandy riversides (15%) (KTWR Office 2018). The boundary of the core area with the buffer zone represents the forest edge. Unlike other protected areas, KTWR has only a few forest patches in its buffer zone. The land use in the buffer zone consists of agricultural land, grasslands, settlement areas, rivers and very little areas with tree cover. Out of the 55 km of the perimeter of the reserve, on about 18 km a solar fence has been constructed to prevent

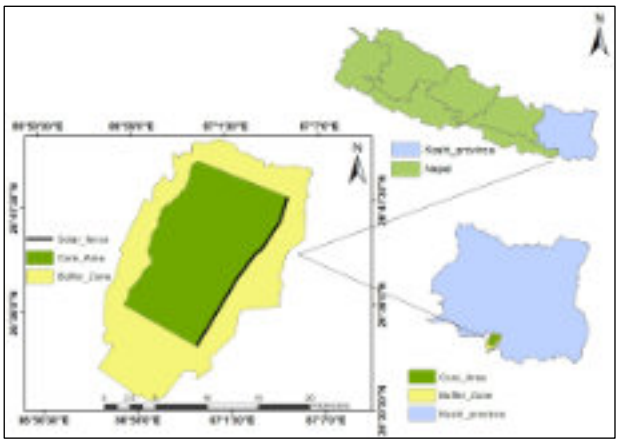

Figure 1. Map of study area.

wild water buffaloes and wild elephants from entering the buffer zone (KTWR Office 2018) (Fig. 1). The buffer zone is surrounded by settlement areas and agricultural lands in the east, west and south, and by the Chure forests to the northwest.

The Reserve experiences a subtropical monsoon climate, with distinct seasons: spring, summer, autumn, and winter. Spring (February – April) brings pleasant warm temperatures and strong winds. Summer (May) is hot, reaching temperatures up to 40°C with minimal rainfall whereas autumn (August – October) accounts for 80–85% of the total annual rainfall. Winter (November – January) features clear skies, cold mornings, and warm days with the lowest temperature of 3.3°C in January. The area receives some winter rain from south-westerly winds. The average annual rainfall is 2019 mm, with daily maximum temperatures ranging from 23.5 to 33.4°C, and minimum temperatures between 7.8 to 25.3°C. Monthly average temperatures range from 15.7 to 29.2°C. Humidity remains consistently high throughout the year, with monthly averages ranging from 76 to 94% (DHM 2017).

Data collection

Data on human casualties caused by Asian elephants over the past six years was obtained from the official records of the KTWR office where the office personnel maintain comprehensive information gathered from detailed field reports. After visiting all locations of the reported incidents, semi-structured interviews were conducted with the victim's family members for deaths, and the victims interviewed in the case of injuries. Information such as gender, age, and occupation as well as causes of conflict, time (year, season, time of day), location of the house, location of the incident, number of elephants involved, mitigation measures applied and people's perception on the elephant attacks were obtained.

About 10–12 elephants are thought to occur in KTWR and the surrounding area. The elephants in KTWR especially males, either singly or in groups, spend a lot of time in and around the buffer zone near crop fields and in the vicinity

of settlement areas. As they are frequently seen during the day and night-time patrolling, the residents and the office staff knew many of them. Male elephants without tusks, are locally referred to as 'Makuna'. There was only one such 'Makuna' in KTWR and he was sometimes observed alone and at other times associating with herds. Makuna has been in the KTWR since 12 years and has never left it. The verification of which elephant caused a death is conducted by a team of experts from the reserve, in collaboration with the police, and involved an investigation based on information provided by local people. In cases of human fatalities, other people were often present at the incident and could provide details.

Measures practiced by respondents were grouped into five categories. They were deterrents, patrolling, physical barrier, awareness and training and compensation. Deterrents consisted of making noise using household items and use of fire. Patrolling means evening-to-early-morning patrolling by a joint team of wildlife and army officers along the boundary of the core area and buffer zone, where the solar fence is located. Physical barriers refer to fences, trenches and thorny bushes. Awareness refers to educating the local residents regarding elephants i.e. their behaviour and ecology, their historical range across lowlands of Nepal, causes of HEC and ways of conflict mitigation. Training refers to teaching of efficient ways to chase elephants without risking their lives. Compensation refers to the financial aid given by the government as a relief for the damage from HEC incidents.

Measures recommended by respondents to mitigate HEC were also categorised into five. They were: Proper electric fencing, proper patrolling, awareness and training, fencing around residential area and removing all elephants. Proper electric fencing means good maintenance and timely repair of fences if elephants break them. Fencing around residential area means electrifying boundaries with mains current around homes and adjoining land, activated particularly during night-time. Removing all elephants means translocation of the elephants from KTWR to other protected areas.

The respondents were asked to rank their responses for both the currently being practiced and recommended mitigation measures, on a scale of 1 to 5, with 5 indicating the highest rank, based on their perceived effectiveness.

Data analysis

The data was fed into Kobo collect toolbox and sorted into different topics. Analysis was done with IBM SPSS Statistics 25 and R statistical package v. 4.2.1. The distance of incidents and core area of the reserve was measured in Google Earth. Kernel density mapping was done to identify high HEC areas. Chi-square test was used to compare the significance of the frequency of incidents between variables. The Friedman ANOVA test was used to check the significance between the average mean score of the measures.

Results

Most incidents happened when people were chasing elephants (χ^2 = 10.118, df = 4, P = 0.038) (Fig. 2) and elephants were raiding crops (χ^2 = 6.05, df = 2, P = 0.048) (Fig. 3).

Solitary adult bulls were responsible for more incidents than groups (χ^2 = 9.529, df = 1, P = 0.002). Among the solitary bulls, Makuna was found to be involved in most cases (61.7%, n = 21) (Table 1).

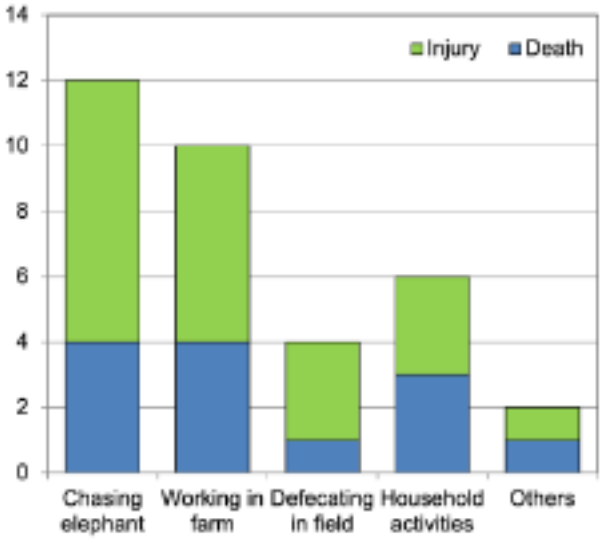

Figure 2. Human activity at the time of HEC incidents.

Table 1. Elephants involved in HEC incidents.

Elephants	Death	Injury	Total
Solitary			
Makuna	4	10	14
Other single male	6	6	12
Group			
with Makuna	2	5	7
without Makuna	1	0	1
Total	13	21	34

Spatial distribution of human casualties

Human casualties occurred at locations between 60–5515 m from the boundary of the core area (mean = 1250 ± 1500 m, n = 34). A total of 47.1% of incidents (n = 16) were less than 500 m away from the core area boundary and the rest (52.9%, n = 18) were more than 500 m from the boundary (Fig. 4). Casualties occurred within the buffer zone comprising all 5 Municipalities and 1 Rural Municipality, maximum being in the Koshi Rural Municipality (50%, n = 17) (Fig. 4).

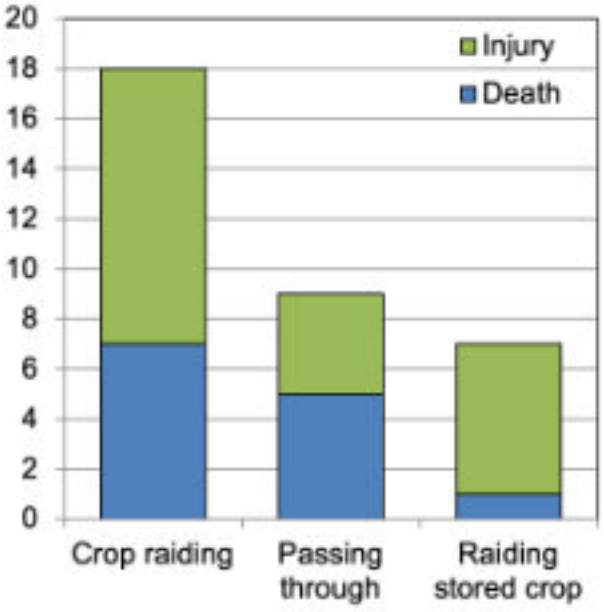

Figure 3. Elephant activity when HEC incidents occurred.

The largest Kernel density hotspot was concentrated in the Koshi Rural Municipality with an extremely high-risk area close to the core area boundary (Fig. 5). A second hot spot with a smaller extremely high-risk area was detected

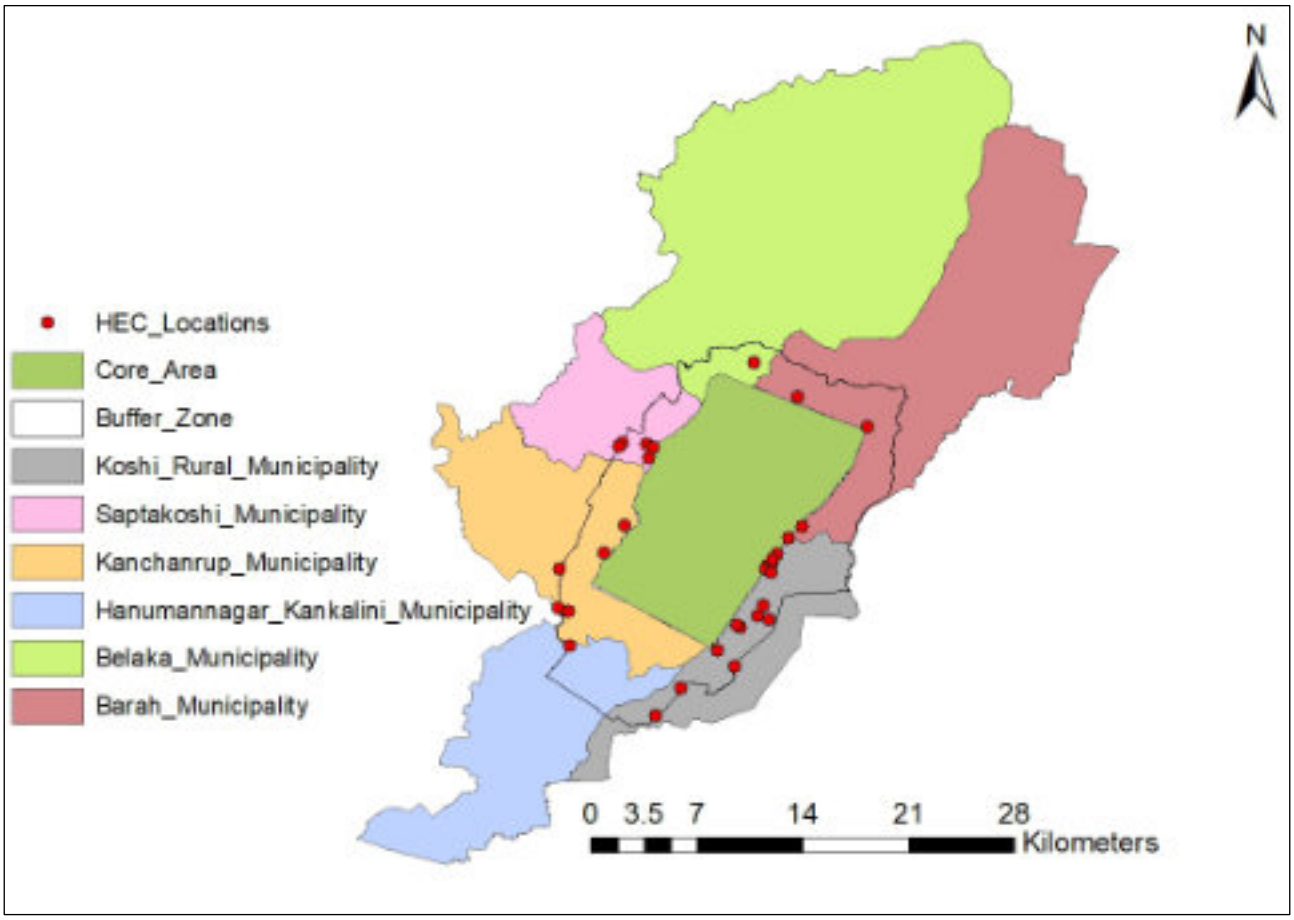

Figure 4. Human casualties in municipalities in the KTWR buffer zone.

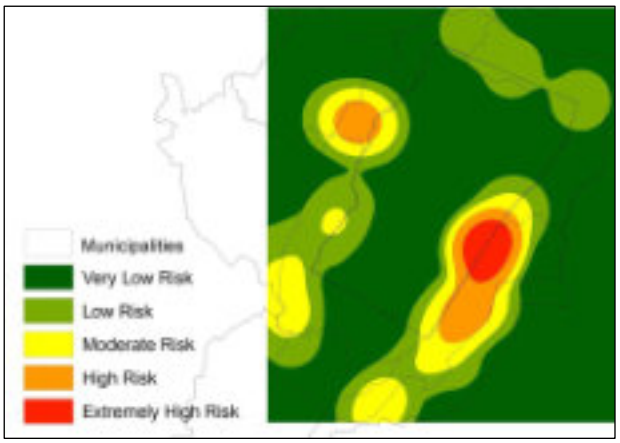

Figure 5. Kernel density map of incidents.

in the Saptakoshi Municipality (Fig. 5). Most incidents (35.3%, n = 12) happened in crop fields (Fig. 6).

Temporal pattern of HEC incidents

From 2015 to 2018, casualty cases were equal in number. The number of incidents peaked in 2019 followed by subsequent decrease in 2020 (Fig. 7). Most incidents occurred in winter (35.3%, n = 12) followed by summer (26.5%, n = 9), autumn (26.5%, n = 9) and spring (11.8%, n = 4) (Fig. 8). Regarding the time of the day, incidents mostly occurred in the night (Fig. 9).

Causes of HEC incidents

Human actions accounted for 25 cases (73.5%), elephants' actions were responsible for 2 (5.9%) and 7 (20.6%) were accidental (Table 2). Most victims were adult male farmers (Table 3).

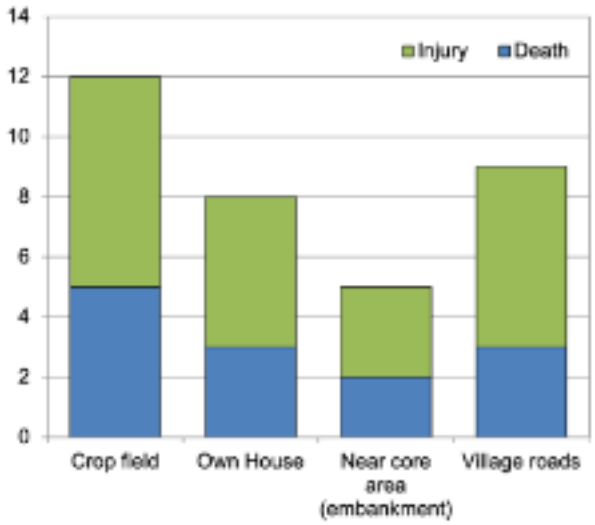

Figure 6. Land use of locations where HEC incidents occurred.

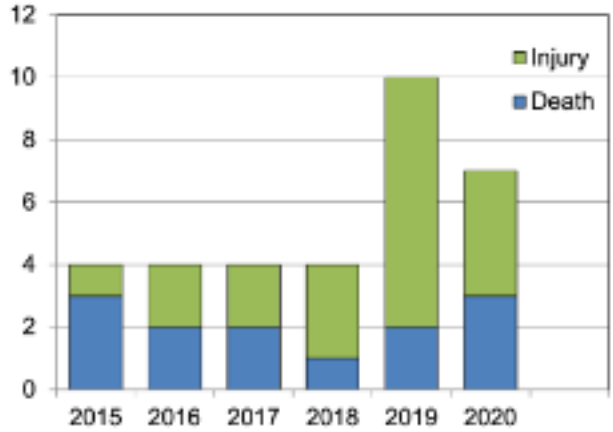

Figure 7. Yearly HEC incidents.

The majority of respondents agreed that the incident could have been avoided (76.5%, n = 26), 7 had no opinion (20.6%) and one respondent

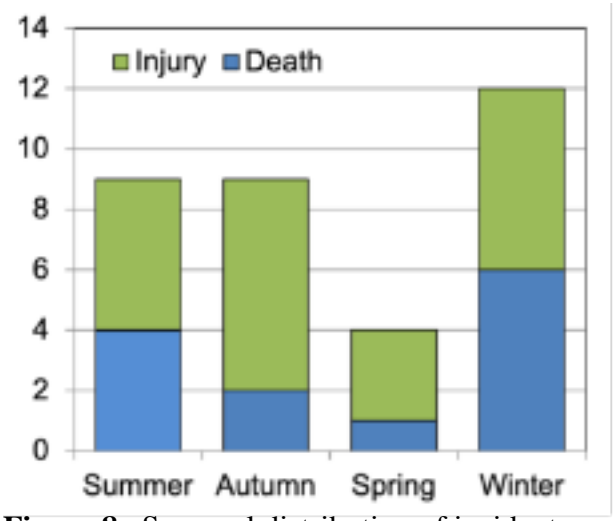

Figure 8. Seasonal distribution of incidents.

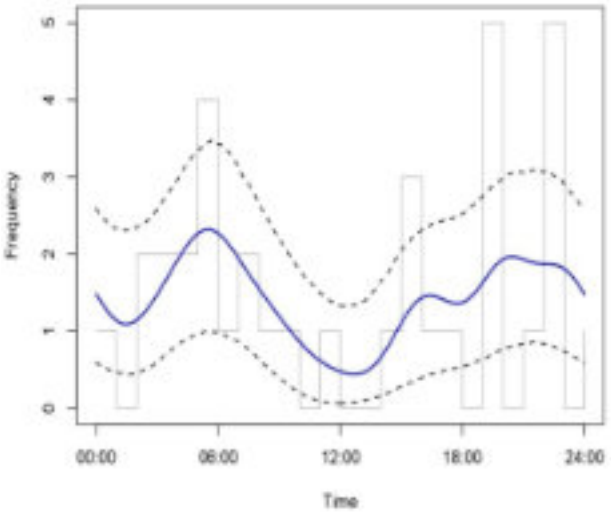

Figure 9. HEC incidents by time of day. Columns outlined in grey are observed frequencies of incidents, blue curved lines are fitted circular kernel distributions, dotted black lines are upper and lower confidence interval limits.

Table 2. Causes of HEC.

Category	Nature of incidents	Cases
Human activities	Running away from elephants	8
	Working in the field in the early morning and late nights	3
	Chasing elephants	5
	Defecating in the field in the early morning and night-time	4
	Shouting from outside house	1
	Celebrating festival at midnight	1
	Checking for elephants in the bushes	1
	Sleeping outside the house	1
	Sleeping in the field	1
Elephant activities	Raiding stored crops	1
	Damaging house	1
Accidents	Encounter in crop field during afternoon	3
	Elephant coming out of bushes and chasing a long distance while herding	1
	Elephant encounter due to dense fog in crop field	1
	Elephant attack on mentally unfit person within elephant migratory path, on foggy evening	1
Total		34

believed that the incident was unavoidable (2.9%).

The majority (52.9%, n = 18) supported keeping elephants in the reserve while the rest were negative towards it.

All respondents knew about compensation schemes for damage caused by elephants.

Measures to mitigate HEC

There was a significant difference between the average ranks of the mitigation measures practiced by respondents to control HEC incidents ($\chi^2 = 96.067$, df = 4, $P < 0.001$), with deterrents receiving the highest ranking (Fig. 10).

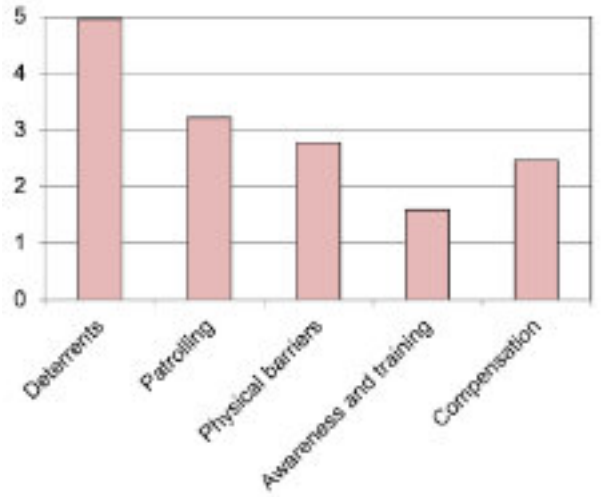

Figure 10. Mean rank of practiced mitigation measures.

There was a significant difference between the average ranks of the mitigation measures to control HEC incidents recommended by respondents ($\chi^2 = 115.436$, df = 4, $P < 0.001$), with proper patrolling receiving the highest ranking (Fig. 11).

Table 3. Socio-economic and demographic characteristics of human casualties.

Characteristics	Death	Injury	Total
Sex			
Female	5	4	9
Male	8	17	25
Age			
<15	1	1	2
15-24	1	1	2
25-44	5	8	13
45-64	4	8	12
65+	2	3	5
Occupation			
Farmer	6	11	17
Business	1	2	3
Government employee	1	3	4
Unemployed	3	2	5
Other	2	3	5
Total	13	21	34

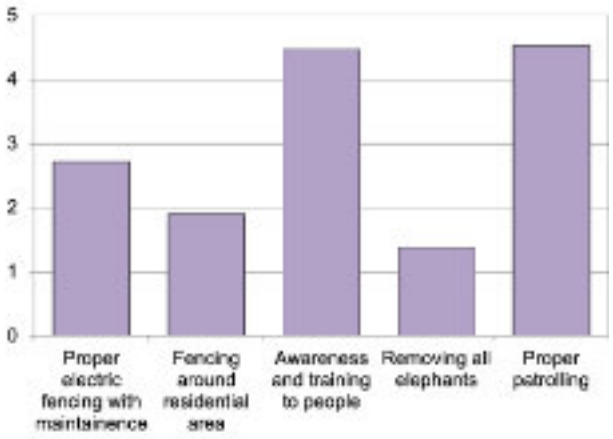

Figure 11. Mean rank of recommended mitigation measures by respondents.

Discussion

Factors causing casualties

We found that the significant number of casualties occurred while chasing elephants. Nelson *et al*. (2003) and Ram *et al*. (2021) also found that most human casualties happened due to aggressive human behaviour towards elephants. We also found casualties of men were much more than that of women. The male bias in casualties could be due to their greater participation in chasing elephants (Sarker *et al*. 2015; Karki 2018) and greater involvement in fieldwork (Ram *et al*. 2021).

Solitary bulls caused significantly more incidents than groups. Among them, Makuna, the tuskless bull elephant of KTWR was identified as being responsible for most cases (61.7%). According to Ram *et al*. (2021) a few individual bulls that regularly entered human settlements and agricultural areas, were involved in the majority of attacks on humans in Nepal. Similar findings of attacks on humans by solitary bulls are reported in south-east Bangladesh (Sarker *et al*. 2015). Such individuals can be termed "problem individuals" (Lamichhane *et al*. 2017; Swan *et al*. 2018). Our findings highlight the necessity of conflict mitigation strategies for problem bulls like Makuna, around KTWR and other protected areas. We recommend conducting awareness programs about the behaviour of such animals and early warning systems that can be employed to warn residents about the presence of such animals in their neighbourhood.

We found a significant number of incidents happened in farmland when elephants were crop raiding, than when they were passing through or raiding stored crops. Sarker *et al*. (2015) found that in Bangladesh within the period 1989–2012, most casualties happened outside forest areas by elephants in search of food. Acharya *et al*. (2016) also observed that in Nepal most of the elephant attacks occurred in farmland. Therefore, our results are consistent with findings by other studies and appear to show a pattern widespread in Asian elephant range.

We found that an equal number of incidents occurred at a distance of less than 500 m and more than 500 m from the core area boundary of KTWR. Therefore, the number of incidents per unit area was higher within 500 m from the core. A study of HEC incidents across Nepal indicated that approximately two-thirds of elephant attacks on humans took place within 500 m from the forest edge (Ram *et al*. 2021). The somewhat lower incidence observed by us might be attributed to the smaller sample size in our study, land use and physical characteristics of the area around KTWR or elephants venturing out further from the core area than in the past. As about half of the incidents happened within 500 m of the core area, individuals residing nearer the core area faced higher vulnerability to elephant attacks. This may be due to factors like greater likelihood of encountering elephants closer to the forest, areas closer to the core being inhabited by marginalised communities residing in houses which offer little protection against elephants, and lower levels of education and awareness (Pant *et al*. 2016; Ram *et al*. 2021).

The residents of Koshi Rural Municipality faced a heightened vulnerability to HEC incidents compared to other areas. This may be due to elephants using the area more intensively, as groups of elephants are frequently seen near agricultural fields along the border of Koshi Rural Municipality and the core area. In western Nepal, male elephants caused HEC incidents primarily when they sought oestrous females in elephant stables (Shrestha *et al*. 2007) and in central Nepal settlements experiencing high HEC were often located in proximity to ele-

phant stables in protected areas (Pant *et al*. 2016). The location of stables with captive female elephants at the head office of KTWR, which is in Koshi Rural Municipality, could be another contributory factor for the high HEC there. This indicates that Koshi Rural Municipality is a priority for HEC mitigation.

During the study period, the number of HEC incidents remained static over the first few years but sharply increased in 2019, followed by a subsequent decrease in 2020. However, there was no clear reason observed for such ascent followed by a decline.

We found there were a higher number of HEC incidents in winter. Similar findings were observed in Central and Western lowland of Nepal by Shrestha *et al*. (2007) and in Chitwan National Park, Nepal by Dangol *et al*. (2020). The increase of incidents in winter may have been due to shorter daylight hours and foggy conditions, which persist throughout the day in the lowland areas of Nepal (Acharya *et al*. 2016; Karki 2018). It is crucial to raise awareness among people about taking precautions during the winter, as this season witnesses a higher frequency of HEC incidents.

We observed that most incidents occurred during early morning and from evening until midnight. Similarly, Neupane *et al*. (2014) reported that 70% of incidents in Nepal in 2003–2012 occurred from evening to early morning, Ram *et al*. (2021) that a high number of incidents happened during evening and Sarker *et al*. (2015) that about 58% (n = 130) of incidents occurred at similar times in Bangladesh. Elephants mostly raid at night and tend to return to forest areas early morning. During raiding, people often take risks in trying to chase away the elephants, putting them in danger. People may also be injured or killed by falling debris when elephants damage houses in search of stored crops, which also happens in the night.

Causes of HEC

The situation analysis revealed that humans bear most responsibility for the causation of HEC incidents. Similarly, Karki (2018) found 75% of incidents in Bardiya and Shuklaphanta National Parks in Nepal and Sunar (2017) found 55% of incidents in Jhapa, Nepal, were due to human actions. We found negligence of safety when chasing elephants, underestimating their speed and defecating outside at night-time or sleeping in the fields were mainly responsible for causing incidents, which were also cited by Karki (2018) and Ram *et al*. (2021). Nelson *et al*. (2003) suggested that aggressive human behaviour characterised by intolerance towards elephants is the primary cause of conflict incidents as the majority of incidents occurred while chasing elephants using firecrackers, loud sounds and bright lights.

Electric fencing stands out as the most effective method for preventing elephants from entering community areas. A majority of incidents occurred during attempts to chase elephants that had entered fields or approached households. Therefore, if the fence is breached and elephants enter the fields, vehicles like tractors and jeeps should be used to drive the elephants back into the forest by the night elephant patrolling team as they do now in KTWR. Many respondents recognised that incidents could have been prevented, by exercising greater caution, understanding of elephant behaviour and adherence to safety protocols. Therefore, we propose that if community members participate in chasing elephants, they keep a distance of at least 100m from elephants. However, as most people may not know proper techniques to chase elephants and as crop damage will then anyhow occur, staying away from the elephants and later obtaining compensation may be a better option. Additional research is needed to examine the efficacy of programs and administrative processes, to determine whether the current compensation system is adequate.

Perception of respondents regarding HEC

The majority of respondents had a positive attitude towards elephant conservation in KTWR. Around half of the people surveyed expressed their support for retaining the elephants instead of removing them. Similar findings were observed by Karki (2018) in Bardiya National Park. Therefore, implementing awareness and

educational initiatives focused on elephant behaviour such as their historical pathways across lowland of Nepal, their ecology, reasons for HEC, ways to minimise it and promoting peaceful coexistence can assist in elephant conservation and reducing conflicts.

Measures to mitigate HEC

The most utilised measures to address HEC were deterrents such as noise and fire, followed by regular patrolling by the operating team of KTWR, physical barriers, compensation, and awareness and training. The respondents' recommended mitigation measures indicated prioritising proper patrolling, followed by implementing awareness and training programs, timely maintenance of electric fencing to effectively mitigate HEC incidents. These results strongly indicate that providing awareness and training programs to the local population, enlightening them on mitigating HEC incidents and equipping them with appropriate methods to ensure their safety is a priority.

In conclusion our findings suggest that people are mainly responsible for human casualties due to HEC and that they mainly occur due to negligence and lack of knowledge regarding elephant behaviour and ecology, causes of HEC, and ways of conflict mitigation.

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Research Article
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Feeding Programme in Captive Working Elephants of Myanmar

Khyne U Mar

Freelance Researcher, Sheffield, UK
Author's e-mail: emaximus2014@gmail.com

Abstract. Nutrition is important for a variety of reasons. Animals need the proper nutrition for growth, maintenance, reproduction and for providing energy. For animals used for draught purposes, their nutritional requirements are higher than those of non-working animals. Extensively kept elephants seem to thrive well on the jungle forages, tree fodders, shrubs, herbs and other natural vegetation. However, the nutritional value of forages in natural habitat is closely associated with the preservation of forest, climatic variation and season of the year. This manuscript will focus on the feeding programmes practiced in extensively kept captive working Asian elephants of Myanmar.

Introduction

Myanmar is home to the second largest total population of Asian elephants (*Elephas maximus*) remaining worldwide (after India), with a captive population of approximately 5,500 – the largest in the world today – where half is state-owned and the other half is privately-owned. Most of the elephants in captivity are employed by the State-run timber enterprise, Myanma Timber Enterprise (MTE) as logging elephants. These elephants are characterised as semi-captive because they are released at nights for foraging in forests with their family groups unsupervised, where they can feed on a broad spectrum of naturally found forage and are traditionally not provisioned nor aided in mating or calving. The MTE elephants work 5–8 h/day and 5 days/week. They have 10–12 h of foraging time at nights during working months (mid-June to mid-February). Elephants are given access to round the clock foraging in the non-working periods (mid-February to mid-June) which coincides with summer where daytime temperatures can reach 45°C.

Feeding habits of Myanmar elephants

A study of free-ranging Asian elephants in southern India documented that 112 plant species were edible (Sukumar 1990). Based on interviews of mahouts and veterinarians working at the Phokyar Elephant Camp operated by MTE in the northern Bago Yoma mountain range, MTE elephants consumed 103 plant species (Campos-Arceiz *et al*. 2008). Another study conducted in an MTE elephant camp in Okkan Reserved Forest of Myanmar documented that 124 plant species were eaten by elephants and feeding activity was significantly different between male and female elephants. Males foraged a wider area and more frequently while females consumed a more diverse diet (Himmelsbach *et al*. 2006). In Myanmar, captive elephants are traditionally released in a nearby forest at night to forage. Studies have shown that the daily mobility of MTE elephants for foraging did not differ greatly from the reported travel distance of wild Asian elephants (Minn *et al*. 2022). Obesity- and sedentary-related foot pad and musculo-skeletal pathologies as seen in zoo elephants (Miller *et al*. 2016; Wendler *et al*. 2019) are not common in MTE elephants because their diet is natural, and they have an energy-demanding long-distance mobility for daily foraging activities at nights. During the night, elephants are released with front legs loosely hobbled to prevent them from going astray.

While free foraging provides a greater selection of food choices, females with suckling calves and elderly (50+ years old) elephants that are not as mobile as their younger counterparts may not reach the best quality forage and may experience inadequate energy intake. Myanmar ele-

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phant managers are fully aware that the practice of hobbling restricts movement but also makes it time and energy demanding for the animal to reach the good quality habitat. For these reasons, supplementary diet is arranged, especially in the summer when there is low quality forage around the forests.

Elephant feeding management

The standing order of MTE on the elephant feeding management and care are as follows:

1. There is no supplementary feeding or hand feeding to healthy elephants. However, MTE allows supplementary feeding of paddy (rice before threshing/polishing and with husk) or cooked rice mixed with corn or pulses to elephants with the following conditions:

- sick elephants
- pregnant females
- females with young calves (<1 year)
- elephants with occupational injuries and mobility problems
- elephants separated from other elephants
- newly captured elephants
- elephants under taming training
- elephants working in logging sites that are close to agriculture land or in difficult terrain

2. Elephants must be offered a balanced diet composed of a variety of food items provided in quantities that are sufficient for each elephant to maintain appropriate body condition. The body condition of working elephants is visually assessed by officials and veterinarians on weekly health checks. Elephants' fodders should consist of grasses, bamboo, creepers/vines and leaves from ficus trees, wild palm tree stems, young banana stems/leaves and various fruits/vegetables.

3. Tree barks and vines (climbers) are the elephants' favourite food especially in summers. Vines/climbers from a large deciduous climber tree *Tinospora cordifolis*, (sin done ma nwae in Myanmar), is the most preferred food choice by elephants. It is used for various diseases in the traditional ayurvedic medicine and is believed to boost the immune system of the animals. It also aids digestion in elephants.

4. In the rainy and cold season, various grass species and bamboo shoots are the major food for elephants. In summer, young grass and fresh bamboo become scarce, so elephants mainly feed on barks, twigs, vines, fruits, creepers and bamboo clumps. By law, MTE elephants are given an official rest period starting from 15. February until the monsoon arrives (mid-June). During this period elephants are taken to summer rest camps where they can find wild banana, wild coconut (*Cocos* spp.), wild palm (*Livistona* spp.), jackfruit, mango etc. and bark, stems and leaves from trees like teak (*Tectona grandis*), and under-story trees like *Mitragyna diversifolia* (Bin ga), *Bombax malabarica* (Lat pan), *Albizia procera* (Thit Phyu), *Albizia Lucida* (Than that) etc. According to veterinary records of MTE elephants, the elephants are prone to constipation in summer months which is believed to be due to indigestible fibrous contents of forages. Tamarind and salt are the traditionally used herbal laxative to prevent constipation and to soften the hard stool. Elephants should be given access to water for drinking and for grooming 24/7.

5. The departmental instruction has stated that the staff should find new foraging areas during the summer rest period if the foraging grounds are scarce of good quality forage. However, old elephants (>50 years) and those with mobility problems should not be forced to move to a new location to avoid exhaustion. Old elephants with worn teeth should stay in the area where succulent food can be found. They need to consume 200–250 kg of forage and 125–150 litres of water every day. Mahouts of these old and sick elephants must stay in the same location. Elephants that are prone to constipate should be given cooked rice or thick porridge mixed with groundnut cake, jaggery or coconut powder. The same amount of extra food should be given to sick, pregnant females and females with suckling calves and those elephants with mobility problems. The extra food is given in evenings before they are released at nights for free foraging. All staffs are instructed to guide elephants to good quality foraging ground.

6. If the weather changes or if elephants are transported/moved to new campsites, the fodders they can access during night foraging may

be less than usual foraging. Mahouts must bring cut fodders to meet their requirements. Elephants should not work at the new locations until the animals know the new terrain and foraging grounds. It is advised to give a minimum of 2 months rest. Elephants must have good digestion and normal bowel movement before they start working.

Care of newborn elephants

Healthy calves can stand on their own and walk within hours after birth. On average, newborn calves stand about 1 m high and weigh around 70 kg at birth. When calves nurse, they are using their mouths, not their trunks. A healthy calf can find the mother's teat on its own.

Calves with a shoulder height less than 1 m (or weighing less than 70 kg) are not able to reach the mothers' teat and they need replacement neonatal milk starting from day 1 of age. It is utmost important to help these undersized calves to get colostrum immediately after birth. Colostrum is high in calories, but more importantly, contains immunoglobulins which aid in the prevention of disease in the first few weeks of life while the calf's own immune system is developing. Staff must collect as much colostrum as possible manually from the mother and feed it to the newborn by bottle. Colostrum should be given when the calf is less than 12 h old if possible. Normally mothers cease to produce colostrum after 24 h and it is painful to collect colostrum manually from mothers after 12 h. Mothers' plasma can be given orally as a replacement of colostrum. Whole blood from the mother elephant should be collected beginning at least eight weeks prior to the birth and plasma separated and stored.

The mother and calf should be monitored closely by staff especially during the first couple of weeks. Monitoring should continue for a number of weeks if the female is inexperienced, or if the female demonstrates aggression towards her own or other calves or staff. Elephant calves are solely dependent on receiving nourishment from their mother's milk for the first months. Camp managers need to choose the correct replacement formula for orphaned calves born to mothers that died during postnatal periods and those with low milk supply. A few MTE females do not have teats as the result of injury caused by improperly designed breastband or rubbing with ropes during taming at younger age. These females cannot nurse their young.

Limited data exist concerning the milk composition of captive Myanmar elephants and none to date from wild elephants. The only study of Myanmar elephant milk stated that milk samples from MTE female elephants showed 5.23% protein, 15.10% fat, 0.87% ash, and 0.18 μg/ml vitamin E (Dierenfeld *et al*. 2020). Total protein in milk was higher during the wet season compared to other seasons because the crude protein content of forage was also higher in the wet season. Protein composition was higher in milk of mothers with female calves compared to male calves. Milk from mothers nursing calves aged 1.5–3 years was high in fat, but milk solids and protein percentages increased when calves grew older. More studies need to be conducted to understand the variation associated with seasonality, geographic location, vegetation/diets to milk quality and quantity. Quantification of dietary adequacy, as well as nutritional status of both females and elephant calves, through assessment of diet ingredients and milk composition are still in its infancy.

Nutrition programme for calves (<5 years)

Calves born to mothers without teats, mothers with a low milk supply, or mothers that died during or soon after parturition should start bottle feeding as soon as possible after birth or the loss of the mother. During the first four months of age, newly born calves of MTE elephants are given human infant replacement formula. Milk replacement formulae from equid and exotic animals are not available in Myanmar.

Additional water or fresh fruits are provided to lactating mothers in hot temperatures. Dehydration can be serious, so it is important to make sure the lactating females are taking in extra fluid when it's hot. The water consumption of mothers and calves can be judged by the appearance of dullness or dryness of skin and decreased urine output.

Simple test for dehydration used in calves:

- Gently pinch the skin on shoulder blade or loin or brisket of calf with two fingers so that it makes a “tent” shape.
- Let the skin go.
- Calf is normal if the skin springs back to its normal position in 1–3 seconds.
- If the skin is slow to return to normal, the calf might be dehydrated.

Replacement milk formula for newborns

A common brand of neonatal replacement milk formula in Myanmar is Dumex Dupro by Dumex which is a human infants' and children's nutrition company. Its products are growing-up milk and follow-on milk. Dumex product is one of the Danone Group, company of Danone Dumex, headquartered in France (https://www.dumex.com.sg/products). Dumex Dupro Step 1 formula is used for calves under 6 months old and Dumex Dupro Step 2 formula is used for calves over 6 months.

This is a human infant replacement formula and is widely used in elephant calves. The formula is diluted strictly following the manufacturer’s instructions. MTE departmental instructions suggest giving replacement formula every 2–3 h until 4–6 months of age. Starting from a month old, newborn calves drink about 7–10 litres of replacement milk formula a day depending on weather (higher consumption in hot months) and growth rate (higher consumption in males with higher growth rate than females). Plastic nursing bottles and nipples are used for bottle feeding in calves (Fig. 1). It is important to clean the bottle thoroughly after use. Mahouts should be instructed to use boiled water to prepare the milk.

When the calf is old enough to use its trunk to manoeuvre skilfully, staff introduces soft and easily digestible fruits (banana, jackfruit, pineapple) to supplement the nutritional needs of calves, if mothers cannot produce enough milk. This practice is believed to help develop the browsing behaviour of calves and to train the calf’s digestive system to get used to non-dietary products. Rice water is also used instead of boiled water to prepare replacement milk when the calf starts eating soft shelled fruits. Rice water is the starchy water obtained by draining boiled rice. To make rice water, rice is cooked in a pot of boiling water according to the cooking instructions on the package or the same way Myanmar people traditionally cook the rice. When boiled, the starch from the rice is released into the water, creating the milky thick starchy rice water. Essential vitamins like vitamin B6, thiamine, niacin and riboflavin are abundantly present in rice water. Experienced mahouts in Myanmar also believe that diluting milk powder with rice water instead of boiled water can make the calf feel having a full stomach and provide much needed energy to the elephant calf. The downside of rice water is that it can be spoiled by fermentation within 24 h. Because it's a completely natural product, rice water doesn't have a long shelf life. When the replacement milk prepared with rice water has been used, the remaining portion should be refrigerated or kept in a cold place, and it should be used within 24 h. Because of the thick starchy nature of rice water-mixed milk formula, Myanmar mahouts trained the calves to suckle the milk formula via flexible wide-bored plastic tube (Fig. 2).

Figure 1. Feeding bottles.

Once the calves show no signs of digestion-related problems (tympany etc.) to the rice water-mixed milk formula, a soft ball of well-cooked rice (Fig. 3) is the start to introduce the calf (normally about 8 months old) to solid food. Such a rice ball is given a couple of times a day in between the bottle feedings. Weaning from milk gradually follows this process. To ease the expense of milk formula, bottle feeding is normally stopped when the calf is about one year old. Calves should not be completely weaned until they are over two years of age and must show that they can digest the foodstuff they have chosen, know the terrain, and can forage on their own. The calf should be nutritionally independent from its mother. The calf should find its nutritional needs from solid food

Figure 2. Calf trained to suckle the milk formula via tube.

(cooked rice is preferable), fruits, and grasses, with nursing only occasionally and primarily for comfort.

Parasite-associated mortality is regarded as one of the most common causes among young MTE elephants aged under 5 years (Mar *et al*. 2012; Lynsdale *et al*. 2017). Inadequate nutrition intake during the summer period (where the habitat had less nutritious forage) might play a role in the parasite-related mortality patterns observed (Mar *et al*. 2012). Departmental standing orders prescribe that Myanmar vets should deworm elephants before the summer in order to prevent mortality due to malnutrition-mediated parasitic infestation.

Nutrition programme for lactating mothers and adults (17–55 years)

Elephants are given supplements if the habitat does not bear fresh lustrous forage especially during the summer (February to June). The rate of grazing decreases as the grasses mature, become less palatable and dry up. The rate of browsing also decreases in the hot season when

Figure 3. Calf (age 8+ months) is trained to take cooked rice balls.

trees are losing their leaves. Therefore, the elephants have to spend more time searching for leaves on the trees than in the other two seasons and would thus have a lower rate of feeding. The lower quality and quantity of food eaten in the hot season may be reflected by a loss of body condition, which is an indication of malnutrition.

Lactating mothers and females that have given birth to more than two calves are given additional food even if they are in a good foraging ground. A suggested supplementary diet for an individual is cooked rice (3 kg) and half-boiled or water-soaked pulses especially chickpeas (*Cicer arietinum*) (≈2 kg) given once or twice daily. Sugar cane molasses can be added to improve the taste of the supplement and it is believed that it has some positive effects on digestion and energy. It is advised not to add sweetness when not necessary.

Nutrition programme for retired (>55 years) elephants

Elephants that eat natural fodder are healthier than those eating prepared food or pellets. If an elephant needs hand feeding, the staff has to find 400 kg of fodder per animal on a daily basis. The fodder given to elephants should be of young age and lush in nature. Fodders are cut into small portions to avoid indigestion or to prevent constipation.

In Asian elephants, the sixth molar – the largest and last molar – begins to wear when the elephant is about 50 years old. By the time the elephants reach retirement at age 55, many old elephants lose the ability to chew and digest food. Therefore, one of the leading causes of death in old elephants is chronic malnutrition.

Nutritionists suggested to give mineral salt blocks that are used for equines and livestock animals to working elephants as the salt blocks can improve appetite, muscle flexibility, healthy nerve impulses, balanced blood pH, water balance (hydration) and help alleviate nutritional deficiencies.

In Myanmar, each retired elephant is managed by one mahout who monitors and provides the care they need until they die. Elephants with problem teeth are taken to a good habitat area and allowed to forage ab libitum 24/7. Their health is checked daily, especially in the morning when the elephants are bathed by their mahouts.

If stool from old elephants contains undigested forage, supplementation with cooked rice (2–4 kg) and half-boiled or water-soaked pulses especially chickpeas (Cicer arietinum) or groundnut cake or flour (≈2 kg) should be fed in 2–4 divided portions daily. Vitamin premix used in livestock and molasses or jaggery can be added according to manufacturer's instruction. Young banana stem should be given in short pieces to avoid constipation.

Conclusion

Extensively kept logging elephants thrive well on the jungle forages, tree fodders, shrubs, herbs and other natural vegetation. The excessive use of natural resources by human causes shrinking of suitable elephant habitat and leads to competition between free-ranging wild elephants and captive logging elephants that share food sources in the same habitat. The availability of habitat is also compromised if grazing areas are also visited by domestic ruminants from nearby villages.

For animals used for draught purposes, inadequate nutrition is one of the major factors that affects their general health and draught power because their energy requirements are higher than those of non-working animals (Lawrence 1990; Pearson & Dijkman 1994). For example, the extra energy intake in draft cattle increases up to 1.8 times maintenance levels, and in horses up to 2.4 times (Pearson & Dijkman 1994). The nutritional implications of work in elephants are less completely understood than those for equines, camels, cattle and buffaloes. No research so far was done to measure energy expenditure and draught power of elephants to quantify their needs to the same extent as those of other livestock or hoof stock species.

Agricultural by-products, crop residues and low-quality roughage are normally regarded as elephant feed and are mostly given to captive

elephants with no or limited access to natural foraging. However, in this manuscript, attempts are made to document how Myanmar logging elephants are managed in semi-extensive living environment in order to maintain the vitality of elephants under our care.

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Short Communication
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Sericulture for Sustainable Livelihood, Where Humans and Elephants Co-exist in Karnataka, India

R. Ravi Kumara[1]* and B. P. Paramesha[2]

[1]*Department of Sericulture Science, University of Mysore, Mysuru, Karnataka, India*
[2]*Department of Zoology, University of Mysore, Mysuru, Karnataka, India*
**Corresponding author's e-mail: ravisilkstar5@gmail.com*

Introduction

Two-thirds of the global Asian elephant (*Elephas maximus*) population is in India, and the elephant is regarded as the country's 'National Heritage Animal'. Elephants are found in 32 Elephant Reserves in northeast, central, northwest, and south India, covering 65,270 km^2 of forest (MoEF 2019). Of the total Indian wild elephant population, 44% is in southern India. The state of Karnataka has witnessed a remarkable increase in the elephant population with the number of elephants increasing from an estimated 6,049 in 2017 to 6,395 in 2023, making it the State with the highest elephant population in the country (KFWD 2023).

Human-elephant conflict (HEC) arises due to land use change, habitat fragmentation, and increase in cultivation, settlements, and livestock grazing (Nelson *et al*. 2003). About 400 humans and 100 elephants are killed each year in India due to HEC, while agricultural losses affect nearly 500,000 families (MoEF 2010). The most common type of HEC incident is crop raiding.

Sericulture is a low-investment, environmentally friendly, and high-income-generating enterprise that includes on-farm (mulberry cultivation), off-farm (silkworm rearing), and industrial (reeling and spinning of silk) activities. Sericulture can be used for rural poverty alleviation as it offers a periodic income throughout the year and generates home-based employment opportunities for marginal and small farm holdings. India is the second-largest producer of silk in the world after China. In India, sericulture has traditionally been practiced in Karnataka, Tamil Nadu, Andhra Pradesh, and West Bengal, and to a lesser extent, in the temperate areas of Jammu and Kashmir. Karnataka is India's major sericulture state, accounting for 40 % of the country's total mulberry silk production (CSB 2022). Mulberry (*Morus* spp.) is mainly cultivated for the sericulture industry, as the leaves constitute the only food source for the silkworm, *Bombyx mori*. Also, the mulberry fruit can be used to make jams, juices, and fruit wines. Besides many pharmaceutical uses, mulberry leaf may be used as a beverage (Wen *et al*. 2019). The leaves can also be used as a supplement for dairy cattle and as primary feed for sheep, goats, and rabbits. Here we report on an assessment of sericulture for sustainable livelihood in the boundary villages of the Cauvery Wildlife Sanctuary (CWS), Karnataka, where elephants regularly raid crops.

Methods

The study was conducted from 2017 to 2021 in selected boundary villages of the CWS. There were 46 villages along the CWS boundary, of which 31 villages were selected for the study, based on the presence of sericulture. The distance between the boundary and selected villages ranged from 200 m to 7 km. The CWS lies in the districts of Ramanagara, Mandya, and Chamarajanagar. The average temperature of the study area ranges from 20–38°C, with summer temperatures reaching 40°C. Rainfall occurs during both the Northeast and Southwest monsoons, with an annual rainfall of 750–800 mm. Data on crops damaged by elephants were recorded in the study area from 2017 to 2021 through field visits, in-person interviews, and phone interviews with farmers. The area of mulberry cultivation was obtained from the Sericulture Departments of each district.

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Figure 1. Sericulture activities.

Results and discussion

The study villages were in areas that traditionally practiced sericulture (Fig. 1), with sericulture farmers constituting from 3–51% of the village population. We observed losses of agricultural, horticultural, and dairy forage crops due to raiding by elephants in the selected villages (Fig. 2). However, elephants did not raid or damage the mulberry plants (Table 1). Mulberry is a foliage crop for many species of livestock but is not preferred by elephants (Kumara & Yogendra 2022).

Mulberry is a high-biomass foliage plant and under irrigated conditions, the leaf yield is more than 60,000 kg/ha/year. Mulberry is propagated through cuttings, is comparatively resistant to environmental fluctuations and grows in tropical and sub-tropical climates and in different soil types. It can be cultivated both under rainfed and irrigated conditions. Therefore, it has wide application as a crop species.

Figure 2. Crop raiding elephants.

Role of sericulture for sustainable livelihood

The cultivation area of mulberry has been increasing in two of the three districts of CWS (Fig. 3). The increase of mulberry cultivation is mainly due to its high-income generation, and the absence of damage from elephants is an added advantage. Mulberry sericulture can provide farmers with an income of 961 – 1,561 $/acre/crop from the sale of cocoons and provide five to six crops per year.

Sericulture also offers many employment-generating activities such as silk reeling, silk weaving, and handicraft manufacturing from waste cocoons, and women are involved in almost all the activities. Therefore, mulberry cultivation and sericulture could help prevent and mitigate HEC and improve the livelihood of people in areas with elephants, while also providing many social benefits.

Acknowledgements

We would like to thank the villagers, sericulture farmers, forest officers, and sericulture officers for sharing necessary information. We would especially like to extend our sincere thanks to Mr. Varun B. S. for assisting with the study.

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Figure 3. Mulberry cultivation area in hectares from 2017 to 2021 in the study districts.

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Table 1. Crop plants in the surveyed area and damage (D) by elephants from feeding, trampling or breaking.

Common name	Scientific name	D*
Aloe vera	*Aloe barbadensis*	D
Amaranth	*Amaranthus* spp.	D
Amla	*Emblica officinalis*	D
Areca nut	*Areca catechu*	D
Ash gourd	*Benincasa hispida*	D
Banana	*Musa* spp.	D
Bean	*Phaseolus vulgaris*	D
Betelvine	*Piper betle*	D
Black-eyed bean	*Vigna unguiculata*	D
Bottle gourd	*Lagenaria siceraria*	D
Brinjal	*Solanum melongena*	D
Cashew nut	*Anacardium occidentale*	D
Castor	*Ricinus communis*	D
Chili	*Capsicum* spp.	D
Chrysanthemum	*Chrysanthemum indicum*	D
Coconut	*Cocos nucifera*	D
Coriander	*Coriandrum sativum*	D
Crossandra	*Crossandra infundibuliformis*	D
Cucumber	*Cucumis sativus*	D
Custard apple	*Annona reticulata*	D
Dolichos bean	*Lablab purpureus*	D
Garlic	*Allium sativum*	D
Ginger	*Zingiber officinale*	D
Ground nut	*Arachis hypogaea*	D
Guava	*Psidium guajava*	D
Holy basil	*Ocimum tenuiflorum*	ND
Horse gram	*Macrotyloma uniflorum*	D
Jack fruit	*Artocarpus heterophyllus*	D
Jasmine	*Jasminum* spp.	ND
Lemon	*Citrus limetta*	D
Lemon grass	*Cymbopogon* spp.	ND
Maize/corn	*Zea mays*	D
Mango	*Mangifera indica*	D
Marigold	*Tagetes* spp.	D
Mint	*Mentha piperita*	D
Moringa	*Moringa oleifera*	D
Mulberry	*Morus* spp.	ND
Napier	*Pennisetum* spp.	D
Okra	*Abelmoschus esculentus*	D
Onion	*Allium cepa*	D
Paddy/rice	*Oryza sativa*	D
Papaya	*Carica papaya*	D
Pigeon pea	*Cajanus cajan*	D
Pomegranate	*Punica granatum*	D
Pummelo	*Citrus maxima*	D
Pumpkin	*Cucurbita pepo*	D
Ragi / finger millet	*Eleusine coracana*	D
Ridge gourd	*Luffa acutangula*	D
Rose	*Rosa* spp.	ND
Sapota	*Manilkara zapota*	D
Sesame	*Sesamum indicum*	D
Sorghum / jowar	*Sorghum* spp.	D
Spinach	*Spinacia oleracea*	D
Sugar cane	*Saccharum officinarum*	D
Sweet potato	*Ipomoea batatas*	D
Tamarind	*Tamarindus indica*	D
Tomato	*Solanum lycopersicum*	D
Tuberose	*Polianthes tuberosa*	D
Turmeric	*Curcuma longa*	D
Watermelon	*Citrullus lanatus*	D

* D = damaged; ND = not damaged

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Camera Trap Study of Wild Elephants in Nam Poui National Protected Area

Michael Falshaw

Elephant Conservation Center, Nam Tien Lake, Sayaboury, Lao PDR
Author's e-mail: michaelsfalshaw@gmail.com

Introduction

Camera trapping is a useful tool to help conservationists understand the diversity of species present in a given area, population dynamics and abundance of species as well as aid understanding in population ranges. Camera traps are especially useful for elusive and dangerous species that are nocturnal and or live in remote areas. Asian elephants (*Elephas maximus*) are hard to observe due to their living predominately in forests, avoidance of humans and potentially aggressive nature. Therefore, deploying camera traps in elephant range can help obtain information about them,

The total elephant population estimate for Laos is 300–400 wild individuals, however, none of these population estimates are backed by rigorous data and could be significantly lower (Ministry of Agriculture and Forestry 2022). There is a need for better understanding wild elephant populations in Laos in order to allocate resources to correct areas. Many smaller populations, for example, may be on the brink of becoming functionally extinct without intervention and it will be important for the survival of elephants in Laos to identify those areas and consider what interventions could take place. Nam Poui National Protected Area (NPNPA) is home to what is likely the second largest population in Lao PDR (Laos). The population estimates range from 40–80 individuals (Ministry of Agriculture and Forestry 2022) However, this, like all other population estimates in Laos, is mostly guess-work from sightings by both locals and forestry officials. In an aim to gather some baseline information about the elephant population in Nam Poui, The Elephant Conservation Center (ECC) deployed ten camera traps around locations known to be frequented by wild elephants to try and identify individuals and lay the foundation for more rigorous, scientific population surveys.

NPNPA is situated in Sayaboury Province, in Northern Lao PDR, west of the Mekong River. It is one of Laos' original 18 National Biodiversity Conservation Areas (now called NPAs). Nam Poui NPA covers an area of 191,200 ha. NPNPA, which borders Thailand's Doi Phou Kha National Park and Phou Fa non-Hunting Area of Nan Province. A camera trapping study conducted jointly by Word Wildlife Fund (WWF) and ECC previously, found a number of large and medium-sized mammals including, Asian elephant, gaur, Asian golden cat, marbled cat, clouded leopard, sambar, Asiatic black bear and dhole.

The main objective of this study was to provide the NPNPA staff with some information on its elephant population, with a particular interest in identifying breeding-age males, evidence of breeding and to identify potential candidates for GPS collaring in the near-future.

Methodology

Ten camera traps were set around salt licks, paths and water sources where wild elephants were frequently spotted in Nam Poui during ranger patrols in 2022 and 2023. Four cameras were located in the west and six in the east (Fig. 1). Camera traps are still in use inside the park, some in the same locations, some in new areas, however the data described in this report is from January – April 2023.

Following Arivazhagan & Sukumar (2008) individuals were assigned to one of four categories:

- Calf: <1 year old
- Juvenile: 1–5 years old

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- Sub-adult: 5–15 years old
- Adult: >15 years old

Individuals were only identified as adult males if there was clear evidence (tusk, penis, sign of musth and/or head size/body composition), otherwise they were assumed to be female. Body condition scoring followed Fernando *et al.* (2009) using a scale of 0–10.

Results and discussion

Two camera traps were stolen (ECC_002 + ECC_011) while all other camera traps captured photos of elephants. Cameras ECC_009 in Paklai District and ECC_007 in Phieng District provided the clearest photographs. Two distinct elephant groups were identified, one in the west of NPNPA and one in the east. Photos of both groups were captured within one day of each other and given the distance and topography it can be confidently assumed that these elephant groups did not consist of the same individuals. The two groups are separated by a large mountain range and have been known by our ranger teams as distinctly different for some years. Therefore, we are quite certain that these are two distinct populations, separate from each other. We plan to GPS collar individuals from both groups to verify this in early 2024.

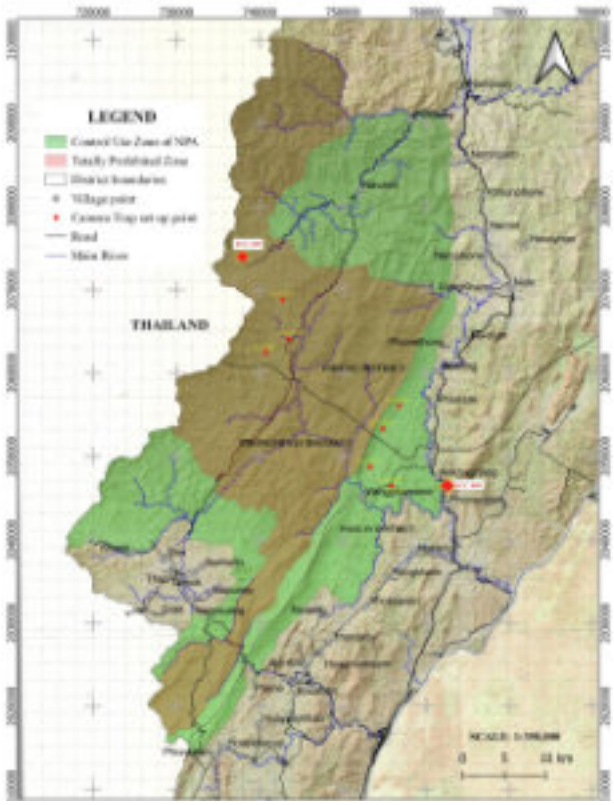

Figure 1. Camera trap locations in NPNPA.

A total of 52 individuals were identified including two tuskless males, with 26 individuals identified in each location (Table 1). In each instance, the groups were captured moving as a unit, which made identifying the number of individuals and age estimation straightforward as they moved almost single file across the camera.

The results of this survey show the presence of on-going reproduction with adult males, adult females, and juveniles being present in both the east and the west of Nam Poui (Table 1). All individuals seemed to be in good health, with no visible injuries and with a body score range of 5–7. In conversations with locals from the surrounding area many had stated that there is only one breeding-age male across the landscape, which was not the case, with three separate adult males identified and at least three sub-adults, ensuring a new generation of breeders.

These results, although far from a complete survey of the wild elephants in NPNPA, is a positive step and demonstrate the applicability of camera trap studies for population surveys in Nam Poui and other areas in Laos. This 'snapshot' into the wild elephant population in Nam Poui provides a baseline to work from, something lacking for elephant populations across Laos. Organizations such as ECC, WWF and Association Anoulack are pushing to better understand and protect the remaining wild elephant populations in Laos. ECC has dedicated elephant monitoring patrol units and will attempt to collar wild elephants in Nam Poui in

Table 1. Elephants identified in Paklai (camera ECC_009) and Phieng (camera ECC_007).

	Paklai	Phieng
Calf	2	2
Juvenile	10	5
Female sub-adult	1	7
Female adult	9	10
Male sub-adult	3	0
Male adult	1	2
Total	26	26

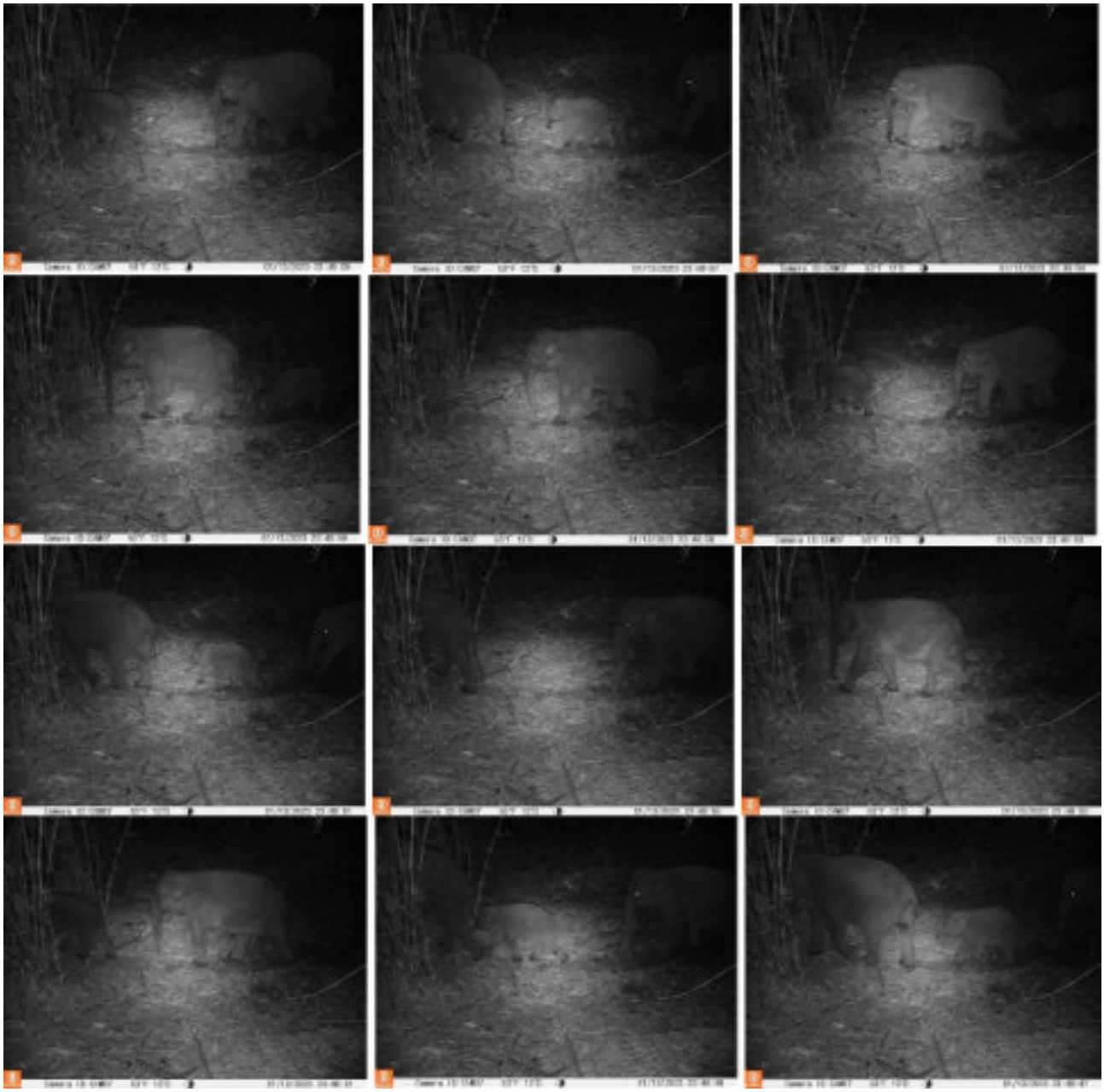

Figure 2. Elephants walking in a straight line past the camera ECC_007.

2024, together with assessing the genetic diversity of the captive elephant population. WWF works on law enforcement and will attempt a comprehensive population survey in Nam Poui in 2024.

Acknowledgements

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Short Communication
Gajah 57 (2024) 26-29

Using Satellite Tracking for Health Monitoring and Treatment of Released Work Elephants

Michael Falshaw

Elephant Conservation Center, Nam Tien Lake, Sayaboury, Lao PDR
Author's e-mail: michaelsfalshaw@gmail.com

Introduction

The Elephant Conservation Center (ECC) has been working with Asian elephants (*Elephas maximus*) in Laos since 2001. The ECC initially started as a captive elephant welfare organisation, assisting work elephants with veterinary care. In 2011 it transitioned into an eco-tourism venture, allowing people to observe captive elephants in a natural forest, providing time for captive elephants to form social bonds while giving tourists the opportunity to see elephants in a similar setting as they may find wild elephants.

In 2018 the ECC begun working with the government of Laos to assist in wild elephant conservation issues, working mainly in Nam Poui National Protected Area to help monitor and protect the second largest population in the country. The ECC also runs Laos' only reintroduction project in the south-west of Nam Poui, monitoring four released captive elephants as they roam freely for just over four years.

The ECC's reintroduction project hopes to lay the foundations for a successful captive elephant release program in Laos. The ECC believes there is a lot of potential for reintroduction across the country, with limited options currently for work elephants and several small wild populations that could benefit from augmentation (Ministry of Agriculture and Forestry 2022). The project focuses not only on captive elephants but also on mahouts, how their traditional knowledge can be used to facilitate soft releases and how they could transition into a monitoring and tracking role in the future.

The current release is centred around four non-related captive elephants, three adult females, 35–40 years old and one juvenile male approximately 11 years old (Table 1). All individuals in the soft-release are captive born, born to captive females that have bred with wild males inside Nam Poui National Protected Area. All three of the adult females are former logging elephants that worked in and around the area they are now released pulling logs. The juvenile male was trained specifically for circus and was destined to be the star of a show in a middle eastern zoo. All four elephants were part of a 13-elephant sale to a zoo that was stopped at the last moment due to significant external pressure. All these elephants were then given to the ECC by the government.

The reintroduction program started in March 2019 when these four individuals were released into an area of the NPA well-known by the mahouts of these elephants. This was initially a 3-month project to give the ECC team a large continuous forest where we could release elephants and know they are far away from farms with ample food sources. The first goal was simply to understand if these four individuals, who seemed to stay together consistently at the ECC (a much smaller and fragmented forest) would stay together when they have a large forest and real opportunity to disperse.

The first three-months saw the group stay together at all times with no instances of human-

Table 1. List of released elephants.

Name	Age	Collar ID
Mae Mah	35	5331
Mae Noy	35	5332
Mae Boun Me Yai	38	5330
Dor Khoun Mueang	11	5329

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elephant conflict. Because of the success of the first period, we asked for an additional six-months extension to continue the program. After this permission was granted for an additional year and currently, we can continue at least until December 2024, however talks are ongoing with the government to legally change the status of these four elephants, granting them permeant freedom as wild elephants.

After the first three months, once it was clear we would pursue a long-term project keeping these individuals free-roaming for extended periods of time, we start to collect faecal samples every two-weeks and blood samples once a month to monitor different parameters. Bodyweight and general health checks were also carried out monthly. All individuals were tested for infectious diseases such as tuberculosis pre-release and were vaccinated against tetanus.

The team in charge of tracking the elephants and monitoring their behaviour, consisting of 5 mahouts, 1 local assistant, 1 biologist and project manager stayed in the forest and went to check and monitor the group every day for the first three months. The release and monitoring were made possible thanks to the extensive knowledge of the landscape by the mahouts and their ability to track the elephants' using spoors, dung and a small 3 m drag chain on one leg.

With no real threats identified to the elephants or the local community the team took a less hands-on approach, seeing the mahouts go to check the group three times a week for the next 3 months. In 2022, after two years of using the traditional mahout skills to track the elephants, GPS collars were added to each individual thanks to financial support from The Smithsonian Institute. The tracking team now checks approximately once a week on the group, which spends the majority of its time together as a group of four. There have only been two instances of human-elephant conflict, both raiding rice and cassava plantations that reside inside NPA boundaries happening within three days of each other in late 2022 amounting to a total of 250 USD but the group does not appear motivated to crop-raid.

Treatment of Dor Khoun Mueang

The general movement of our released elephants seems to follow a pattern of spending 1–3 days in a small space of a few hectares before moving on to new feeding grounds (Fig. 1). However, on the rare occasions Dor Khoun Mueang leaves his surrogate group, he tends to be more active. This behaviour is normal for a male of his age in the wild, as they explore new areas independently, as they gradually leave the maternal herd and associate with adult bulls

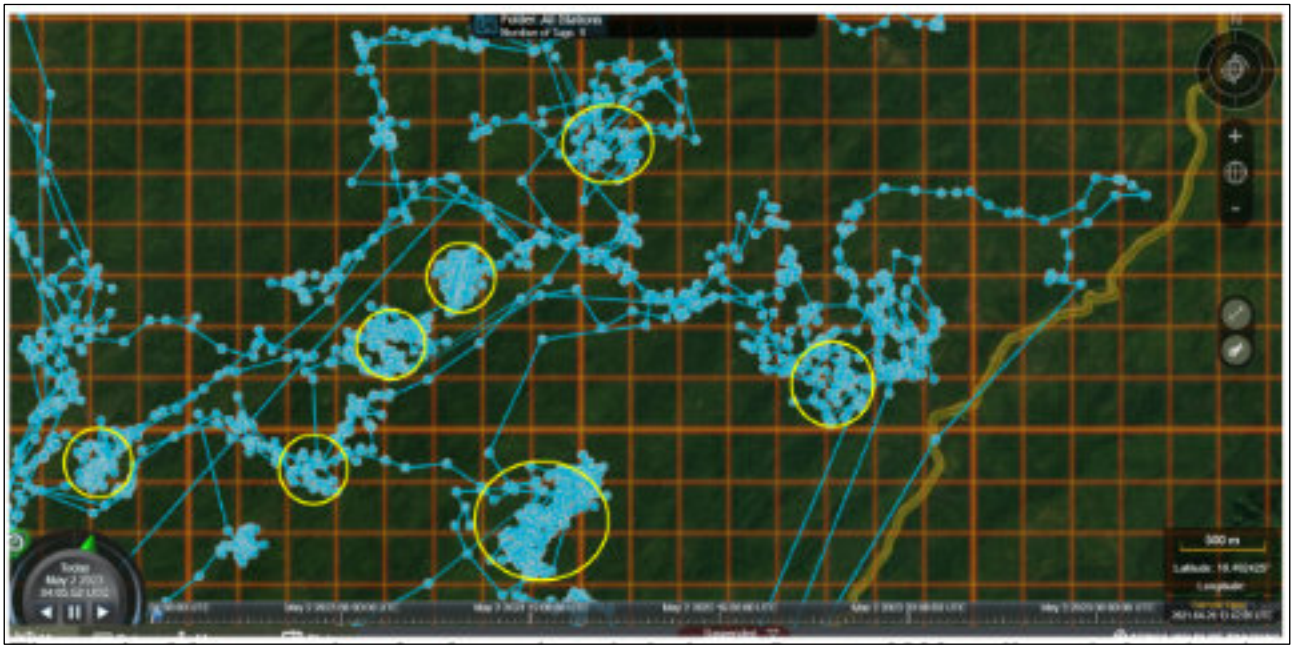

Figure 1. Movement data for four released elephants January 2023, yellow circles showing clusters where elephants' graze.

and/or looking for females in oestrous (Keerthipriya *et al*. 2021).

After a few days solitary roaming we noticed that Dor Khoun Mueang moved very little and remained in an area no larger than 300 m^2 for 3 days, prompting us to send the tracking team to check on him. After the first day the team called back to say they couldn't find him. They continued to reach for him the following day and luckily found him at 10 am the following morning. The team explained that he seemed very weak, had diarrhoea and was not eating. Due to the remote area DKM was found in it was not possible to perform any sort of blood, urine or parasitic analysis, however, based on the description and physical examination our veterinarian suspected a bacterial infection leading to dehydration. Our vet assistant and team then spent the next 4 days in the forest performing treatments (Figs. 2–4) including:

- Rectal and IV Fluid administration: Dextrose 5% (5 l), Ringer (4 l), Saline solution (4 l), for 4 days
- Enrofloxazine 10% (100 mg/ml): (5 mg/kg), IM, QD, for 7 days
- Flunixine Meglumine: dose 1.2 mg/kg, IM, QD, for 4 days
- Cathosal 10%: 100 ml, IV, QD, for 4 days
- Biosan TP: 100 ml, IM, QD, for 3 days
- Ivermectine: 0.1 mg/kg, IM, 1 time

The body score for each elephant is calculated using Fernando *et al*. (2009) description where 1 is very skinny and 10 is obese. Weight for

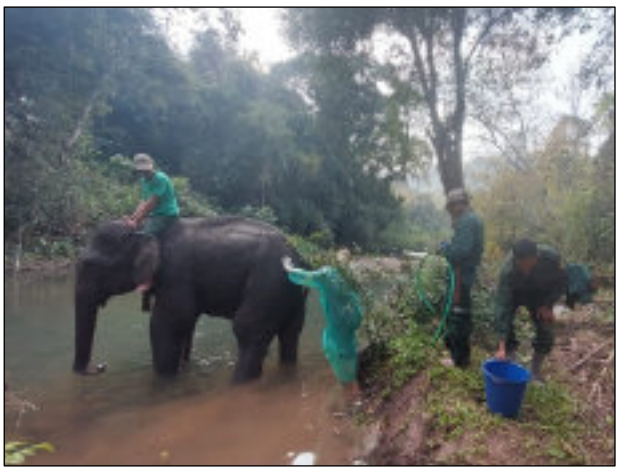

Figure 2. Rectal fluid administration for Dor Khoun Mueng.

Figure 3. Team assisting with the treatment.

dosage was calculated using the following calculation:

Girth (cm) x Girth (cm) x Shoulder Height (cm) x 0.93 ÷ 10,000 = Weight (kg)

After two days of treatment Dor Khoun Mueang showed a drastic improvement in his energy levels and appetite. He was eating, drinking and defecating regularly. The mahouts moved DKM to a more accessible area of the forest on day three so we could drive to the area with a 4x4 car in less than 1 hour instead of the 2.5-hour tractor trip at his current location and the mahouts and vet team continued to monitor him.

For the rest of January, Dor Khoun Mueang was kept isolated from the released group and managed in a more traditional way, on a 40 m chain tied up in the forest (Fig. 5). His mahout and the

Figure 4. Tracking team assisting with treatment.

Figure 5. Dor Khoun Mueng eating some watermelon after treatment.

rest of the tracking team camped nearby to continue monitoring until they assessed he was at full health. He was then released back with his surrogate herd and made a full recovery (Fig. 6). All of our mahout tracking team can still handle and manage their elephants without sedation, making these situations much easier.

Conclusion

Although a lot of the success of this soft-release program stems from the mahouts traditional tracking knowledge, it is highly likely that without the satellite data the team would not have been aware of his disease or in time and Dor Khoun Mueng would have not recovered from the illness. However, with satellite data alone, in a large forest such as Nam Poui, there is a likelihood that the veterinary team would not have been able to find him in the forest so efficiently. These situations perfectly highlight the need to merge traditional knowledge and skillsets with modern technological tools. This project aims to lay foundations for reintroduction programs in Laos which emphasises and champions traditional mahout skills.

This small group will continue to be monitored by their mahouts, now dubbed the 'reintroduction program monitoring team' for the foreseeable future. Even if the legal status of these elephants is changed to wild, we still see the team of 5 mahouts as a valuable unit to continue to monitor and provide information on this group. Their continued employment will help us fine-tune exactly what roles mahouts will be able to have long-term in elephant conservation. With potential across the country for elephant reintroduction, we hope expansion into new areas can be beneficial for elephants and mahouts alike, providing a new life for elephants and sustainable employment for mahouts.

Acknowledgements

This program is supported by the Elephant Conservation Center, International Elephant Project and the Smithsonian Institution.

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Figure 6. Dor Khoun Mueng (far right) back with the group in late April 2023.

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Short Communication *Gajah 57 (2024) 30-33*

Endoscopic Examination of Oesophagus for Obstruction with Concurrent Ventral Cervical Pyomyositis in an Asian Elephant

Mirza Vaseem[1]*, Rajesh Kumar[2], N. Kalaivanan[2], M. Kalamegam[3] and Ramesh Kumar[1]

[1]*Bandipur Tiger Reserve, Karnataka, India*
[2]*Mudhumalai Tiger Reserve, Tamil Nadu, India*
[3]*Aspital Equine Hospital, Bangalore, Karnataka, India*
**Corresponding author's e-mail: vaseem.vet@gmail.com*

Introduction

A 22-year-old, 3000 kg male Asian elephant (*Elephas maximus*) at Bandipur Tiger Reserve, Karnataka, India developed acute dullness, hyporexia and drooling in the month of September 2022. The animal caretakers reported no obvious change in diet or accidental ingestion of foreign bodies. The elephant had normal temperature and vitals but evinced pain upon palpation of the pharyngeal region. The animal showed willingness to eat by accepting oral fluids and gruel but would immediately regurgitate consumed contents, indicating a possible obstruction distal to the pharynx or proximal portion of the oesophagus. Injectable Meloxicam (Melonex, Intas Pharmaceuticals, Gujarat, India; 500 mg IM) was prescribed to manage pain.

Treatment

The following day (Day 2), elephant's condition remained unchanged and blood was collected for a complete count and chemistry panel (Table 1). Severe leucocytosis with shift to left along with elevated liver enzymes were noted. The animal was immediately catheterised intravenously and started on Dextrose Normal Saline (TruELixir Life Sciences labs., Maharashtra, India; 20 l IV), Ringers Lactate (TruELixir Life Sciences labs., Maharashtra, India; 20 l IV), Injectable Amoxycillin (Indian Genomix LAb., Hyderabad, India; 15 g IV), Meloxicam and multivitamins twice a day. 80–100 l of rectal fluids were administered daily to assist in correction of dehydration.

An ultrasound examination of the pharynx and cervical region was performed on the second day to identify any foreign body obstruction, abscess or abnormal growths that could be obstructing the oesophagus. Although a mass like structure could be observed at the proximal cervical region distal to the pharyngeal apparatus, it could not be confirmed due to lack of sufficient detail and findings were deemed to be inconsistent. Thereafter, it was decided to perform an endoscopic examination of the oesophagus to confirm the diagnosis and possible retrieval of any foreign body.

On Day 3, the elephant was positioned in left lateral recumbency and anaesthesia induced with Inj. Etorphine HcL (Captivon 9.8 mg/ml, Wildlife Pharmaceuticals, SA; 4 mg IM) alone. Anaesthetic induction was achieved within 8 minutes and the animal displayed reduced jaw tone and comfortable respiration and vitals. The mouth was opened using a custom gag and rope restraint fastened to the lower jaw for manual traction. Vitals were monitored manually to assess anaesthetic depth. Intravenous Ringers lactate was administered continuously throughout the process along with amoxycillin, ceftriaxone and tazobactam (Intas Pharmaceuticals, Gujarat, India; 15 g IM), multivitamins and meloxicam.

A 3-m flexible endoscope (Karl Storz & Co., Germany) with light source connected to a video monitor was introduced into the oral cavity and oesophagus (Fig. 1). Endoscopy revealed hard, matted dung like fibres lodged in the proximal aspect of the oesophagus, approximately 0.5–1.0 m from the commissure. Extraction of oesophageal contents using endoscope attachments such as forceps was not possible due to the hard texture and friable nature

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of the constricted dung mass. Manual removal of the oesophageal contents was carried out by hand and approximately 2 kg of hard, matted dung boluses were pulled out. Further endoscopic exam revealed presence of dung boluses in the mid-portion of the oesophagus as well. A long flexible PVC pipe with softened, lubricated edges was inserted into the oesophagus to push the blocked contents into the stomach to free the oesophageal lumen.

Once the lumen was confirmed to be free from blockage, the animal was revived using Diprenorphine HCL (Activon 12 mg/ml, Wildlife Pharmaceuticals, SA; 10 mg IV) and the elephant rose to stand without support over the next 8–10 minutes. Endoscopic findings also included erosion of the oesophageal lining and mucosa with severe inflammation and possible ulceration at the points of lodgement.

Oral feed except water was restricted for the next two days to facilitate healing and the animal was maintained on parenteral nutrition. Although the elephant appeared slightly relaxed and showed willingness to consume oral feed, it evinced pain during swallowing and regurgitated significant amounts of water almost immediately. Oral paraffin and injectable metoclopramide (Perinorm, Ipca Lab., Gujarat, India; 150 mg IV) with Neurobion (Martin Dow Ltd, Merck, Germany; 20 ml IV) were injected to facilitate improvement of potential ileus if any, owing to reduced faecal production and absent gut sounds. The elephant was maintained on 80–100 l of rectal fluids twice daily along with intravenous glucose, lactated ringers, multivitamins, Meloxicam, Amoxycillin and Ceftriaxone with Sulbactam.

Figure 1. Endoscopic evaluation of the oesophagus.

Blood parameters continued to present severe leucocytosis and insult to the muscle, liver, and kidney consistent with anorexia and oesophageal lesions (Table 1).

The animal survived for the next four days without improvement and finally succumbed to starvation and septicaemia despite intensive treatment and care.

Postmortem

Postmortem examination revealed oesophageal ulceration with mucosal erosion at the point of blockage at the proximal and mid portions of the oesophagus with absence of any strictures throughout the lumen. Excision of ventro-lateral neck muscles revealed a large abscess draining close to 4–5 l of creamy purulent exudate that went unnoticed due to lack of a physical swelling at the time of examination and ultrasonography (Fig. 2). The pyomyositis like condition was restricted to the ventral portion of the neck invading musculature with possible involvement of the oesophagus and associated structures but could not be confirmed at the time due to severe tissue adhesions and necrosis.

Additionally, a complete torsion of the ileocaecal junction (Fig. 3) was also observed which probably occurred towards the later stages of the disease, ultimately causing death of the patient. Culture of purulent exudate revealed the presence of common Staphylococcus spp. and *E. coli* spp. bacteria.

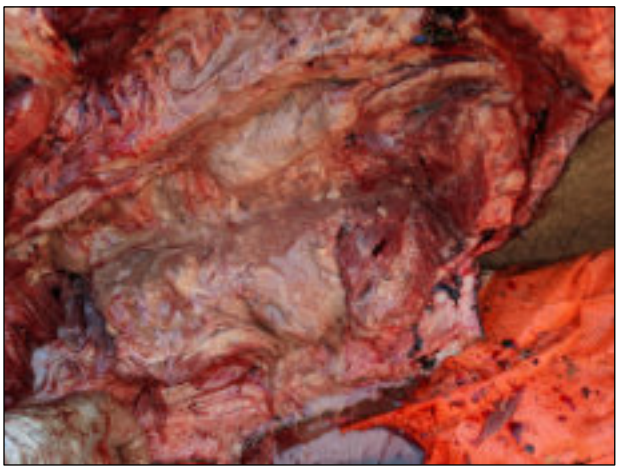

Figure 2. Purulent exudate seated deep within the ventral cervical musculature.

Table 1. Haematology and serum biochemistry values and references ranges of affected elephant collected during the course of treatment. Reference ranges represent minimum and maximum intervals for the Asian elephant as reported in the literature (Janyamethakul & Sripiboon 2017).

Parameter	Values (Day 2)	Values (Day 6)	Reference range
Total WBC (10^9/l)	100,000	77,540	7,900 – 21,800
Haemoglobin (g/dl)	15.2	17.3	9.8 – 15.2
Platelet count (10^9/l)	2.05	2.35	100 – 577
SGOT (U/l)	61.38	38.63	4 – 56
GGT (U/l)	8.2	8.49	4 – 35
Serum Creatinine (U/l)	3.19	4.17	0.7 – 2.2
Blood Urea (mg/dl)	27.54	12.3	3.1 – 27.2
Alkaline Phosphatase (U/l)	172.9	-	0 – 281.5
Total Protein (g/dl)	7.27	-	6.5 – 8.9
S. Sodium (meq/l)	-	156	98 – 115
S. Potassium (meq/l)	-	4.14	4.1 – 5.6
S. Chloride (meq/l)	-	110	-

Discussion

Oesophageal obstructions in elephants due to palm fronds, tubers and others have been sporadically reported in the past (Nath *et al*. 2006). Commonly presented symptoms are like those of domestic herbivores viz regurgitation, dysphagia, ptyalism and restlessness (Constable *et al*. 2016).

Owing to the anatomical challenges faced in clinical examination of this species, ultrasonography and physical palpations provide limited information of value in such cases. However, endoscopic visualisation continues to be the most preferred technique to identify any obstruction and evaluate the condition of associated soft tissues, but only a handful of endoscopic procedures on elephants to specific to oesophageal obstructions have been reported in literature, especially in the Indian sub-continent (Dumonceaux 2006).

Figure 3. Ilio-caecal torsion.

The elephant in this case suffered from pyomyositis and chronic abscess in the ventral neck region that contributed towards oesophageal dysmotility; pathogenesis of which is not fully understood presently but may be extrapolated from similar cases in other species. Since the animal continued to exhibit hypoglossal and swallowing reflexes throughout the course of disease, the affection may be localised caudal to the laryngeal and pharyngeal apparatus between proximal and mid oesophagus including adjoining nerves and musculature.

Although primary aim of treatment was confirmation of obstruction, its retrieval and facilitating oral feeding in the elephant as soon as possible, this elephant did not respond to therapy due to the presence of a large, undrained abscess surrounding the affected oesophageal region, coupled with significant ulceration to the mucosa and possible damage to adjoining nerves and musculature along with severe septicaemia preventing deglutition despite successful retrieval of the foreign body.

In cases where oesophageal obstruction or choke is suspected, aggressive fluid and maintenance therapy is recommended either per rectally or intravenously along with antibiotic

and pain management (Phair *et al*. 2014). Complete evaluation of the oral cavity for any dental malocclusion, laryngeal paralysis, and endoscopic evaluation of the oesophageal lumen for ulceration and foreign body obstruction should be undertaken to arrive at a comprehensive diagnosis at the earliest.

Prognosis of oesophageal obstruction is grave in elephants, despite retrieval of the foreign body even through surgical means as reported in various literatures (Phair *et al*. 2014). However, in this case, successful retrieval of the object from the oesophageal lumen may have facilitated recovery if not for the chronic pyomyositis and abscess that significantly reduced the animal's ability at oral feeding, diminishing any chances of survival. However, at this point it was unclear if the abscess contributed to the choke or vice versa due to severity of tissue adhesions and high degree of necrosis in the affected area.

This is the first reported case of oesophageal choke in India wherein endoscopic examination, and retrieval was carried out on a captive Indian elephant. It provides a description of symptoms and disease progression along with details of the anaesthetic protocol used, supportive therapy and treatment regimen employed which may facilitate successful treatment of less severe cases of oesophageal obstructions. Oesophageal choke could be considered a fast-progressing condition with a grave prognosis in elephants, especially due to the difficulty in direct visual examination of the oral cavity, inability to palpate the lodged mass sufficiently physically and to keep up with supplementing the high energy requirement of the pachyderm which may have gone off feed (Dumonceaux 2006). Additionally, obstructed masses may significantly damage surrounding tissues until the time it has been retrieved, further complicating any decent chances at survival.

Acknowledgements

We extend our thanks to the Karnataka Forest Department for their support during treatment of the elephant. We are grateful to HH Mrs. Shrutikirti Devi of the erstwhile Royal family of Mysore for undertaking all logistical responsibility and her continued encouragement through the entire duration of the procedure. Lastly, we render our heartfelt thanks to Dr. Hasneyn Mirza, head veterinarian at Aspital Equine Hospital, Bangalore for lending the endoscope at no charge and sparing his able vet for the same.

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Short Communication
Gajah 57 (2024) 34-37

Identification of Veterinary Plants for the Treatment of Common Diseases in Asian Elephants

P. Aswathi

Mahajubilee Training College, Mullookara, Thrissur, Kerala, India
Author's e-mail: aswathip101@gmail.com

Introduction

India has a rich and diverse flora that has been used for medicinal purposes for generations. Herbal medicines have been commonly used for health care in people but also in animals, and in many cases are relatively nontoxic, cheaper and eco-friendly.

Palakapya was an authority on elephant medicine in the Rigvedic period of 2000–4000 BC. The Gautham Samhita, the Ashva Ayurveda and Hasthya Ayurveda are ancient treaties on animal science. Palakapya wrote Hasthya Ayurveda dealing with elephant medicine and dedicated it to Lord Ganesha. In it, elephant medicine and surgery were divided into two parts. Maha Rogsthan or major diseases, Sudhra Rogsthan or minor diseases. He also classified various ailments of elephants into:

- Adhyatmika (physical)
- Agantuka (accidental or incidental)
- Manasa (mental diseases)
- Kapha (phlegm)

Hasthya Ayurveda also mentions about the anatomy of elephants, treatment of elephants using herbal plants and classification of elephants on the basis of a number of characteristics.

Materials and methods

Information regarding treatment of Asian elephants (*Elephas maximus*) with herbal medicine was collected by interviewing a famous traditional elephant veterinarian, the late Shri. Avanaparambu Maheshwaran Namboothiripad. A visit was also conducted to Punnathur Kotta Aanathavalam, Guruvayur (a famous elephant care centre) for interviewing mahouts.

Species of plants used in traditional medicine were collected and botanically identified by reference to the "Flora of Presidency of Madras" (Gamble & Fischer 1915–1936) and "Flowering Plants of Thrissur District" (Sasidharan & Sivarajan 1996).

Results and discussion

A total of 57 plants were identified as being used in treating elephants. They consisted of 19 herbs, 10 shrubs, 19 trees, 7 climbers and 2 aquatic species. All the plants used were angiosperms except one gymnosperm.

The 57 species belonged to a total of 32 plant families and the family with the highest representation was Poaceae with 7 species (Table 1).

Different parts of plants were used in treatment (Fig. 1, Table 1). Leaves were the most common part, being used in 27 % of treatments. Flowers were the next most commonly used, being in 18 % of treatments.

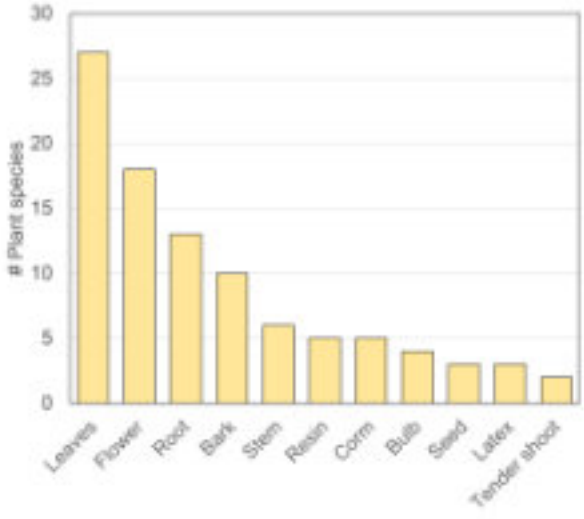

Figure 1. Different parts of plants used in treatment.

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Table 1. List of plants used to treat elephants.

Family	Scientific name	Type	Parts used	Musth	Consti-pation	Paralysis	Wound	Nail crack	Foot disease	Heel crack	Ulcer	Diarrhoea
Acanthaceae	*Hygrophila auriculata*	Herb	Whole plant	X								
Acanthaceae	*Justicia adhatoda*	Shrub	Whole plant			X						
Amaryllidaceae	*Allium sativum*	Herb	Bulb			X						
Apiaceae	*Cuminum cymium*	Herb	Fruit, Seed				X					
Apocynaceae	*Alstonia schloaris*	Tree	Root, Bark	X								
Apocynaceae	*Calotropis gigantea*	Shrub	Flower, Leaves, Bark, Latex						X			
Araceae	*Acrous calamus*	Herb	Leaves, Stem, Root					X				
Araceae	*Amorphophallus paeniifolus*	Shrub	Corm	X								
Araceae	*Borassus flabellifer*	Tree	Fruit, Leaves, Stem					X				
Arecaceae	*Cocos nucifera*	Tree	Fruit, Leaves, Flower		X							
Asteraceae	*Cyanthilium cinnereum*	Herb	Root	X								
Asteraceae	*Saussurea costus*	Herb	Root			X						
Brassicaceae	*Sinapis alba*	Herb	Fruit						X			
Callophyllaceae	*Mesua ferrea*	Tree	Fruit, Stamen, Flower				X					
Cycadaceae	*Cycas circinnalis*	Tree	Leaves		X							
Euphorbiaceae	*Jatropha gossipifolia*	Shrub	Seed							X		
Fabaceae	*Abrus precatorius*	Climber	Leaves	X								
Fabaceae	*Milletia pinnata*	Tree	Leaves, Bark, Root, Seed				X					
Lamiaceae	*Ocimum sanctum*	Herb	Leaves					X				
Malvaceae	*Sida acuta*	Herb	Leaves	X								
Meliaceae	*Azadirachta indica*	Tree	Stem, Bark, Leaves	X								
Menispermaceae	*Coscinium fenestratum*	Woody climber	Stem, Bark				X					
Menispermaceae	*Cyclea peltata*	Climbing shrub	Stem, Root						X			
Menispermaceae	*Tinospora cordifolia*	Climbing shrub	Whole plant	X								
Moraceae	*Ficus arnottiana*	Tree	Fruit				X					
Moraceae	*Ficus benghalensis*	Tree	Leaves, Bark				X					
Moraceae	*Ficus microcarpa*	Tree	Leaves, Bark, Fruit		X						X	
Moraceae	*Ficus racemosa*	Tree	Leaves, Bark, Fruit								X	
Moraceae	*Ficus religiosa*	Tree	Leaves, Root, Tender shoot			X						

Table 1. List of plants used to treat elephants (continued).

Family	Scientific name	Type	Parts used	Musth	Consti-pation	Paralysis	Wound	Nail crack	Foot disease	Heel crack	Ulcer	Diarrhoea
Moringaceae	*Moringa oleifera*	Tree	Leaves, Root, Bark, Flower	X								
Musaceae	*Musa acuminata*	Evergreen perennial	Fruit		X							
Myristicaceae	*Myristica fragrans*	Evergreen perennial	Fruit, Seed			X						
Nelumbonaceae	*Nelumbo nucifera*	Aquatic perennial	Petiole, Flower, Seed, Root							X		
Nyctaginaceae	*Boerhaavia diffusa*	Herb	Leaves, Stem, Root	X								
Nymphaeaceae	*Nymphaea stellata*	Aquatic perennial	Leaves, Flower, Rhizome									X
Oleaceae	*Jasminum grandiflorum*	Shrub	Leaves, Flower, Root	X								
Pedaliaceae	*Sesamum indicum*	Shrub	Fruit		X							
Piperaceae	*Piper betle*	Climber	Leaves					X				
Piperaceae	*Piper longum*	Climber	Fruit, Root			X						
Piperaceae	*Piper nigrum*	Climber	Fruit		X							
Plumbaginaceae	*Plumbago zeylanica*	Shrub	Root, Root bark, Seed						X			
Poaceae	*Cyperus rotundus*	Herb	Rhizome									X
Poaceae	*Bambusa bambos*	Herb	Bark, Resin, Tender shoot				X					
Poaceae	*Calamograstis rubescens*	Herb	Leaves		X			X				
Poaceae	*Cynodon dactylon*	Herb	Whole plant		X							
Poaceae	*Oryza sativa*	Herb	Seed		X							
Poaceae	*Saccharum officinarum*	Shrub	Root			X						
Poaceae	*Triticum aestivum*	Herb	Whole plant, Seed			X						
Rubiaceae	*Neolamarckia cadamba*	Tree	Leaves	X								
Rutaceae	*Aegle marmelos*	Tree	Leaves, Flower, Fruit, Bark, Seed	X								
Rutaceae	*Citrus aurantifolia*	Tree	Leaves, Fruit					X				
Rutaceae	*Murrayya koenigii*	Tree	Leaves	X	X							
Santalaceae	*Santalum album*	Tree	Wood, Oil	X								
Solanaceae	*Capsicum annum*	Shrub	Fruit		X							
Solanaceae	*Withania somnifera*	Shrub	Root, Leaves	X								
Zingiberaceae	*Elattaria cardamomum*	Herb	Fruit						X			
Zingiberaceae	*Zingiber officinale*	Herb	Rhizome		X							

For most treatments, multiple species of plants were used and the number of plant species utilised to treat an ailment varied (Table 1, Fig. 2).

Musth

To reduce the aggressiveness during musth, 16 plant species were used (Table 1, Fig. 2). The combination of plant species applied changed over the time period of treatment as below.

First month: *Cyathilium cinereum*, *Tinospora cordifolia*, *Moringa oleifera*, *Sida acuta*, *Alstonia scholaris*, *Santalum album*, *Withania somnifera* and *Hygrophila auriculata*.

Second month: *Neolamarckiana cadamba*, *Abrus precatorius*, *Amorphophallus paeniifolus* and *Santalum album*.

Third month: *Boerhaavia diffusa*, *Hygrophila auriculata*, *Abrus precatorius*, *Santalum album* and *Murrayya koenigii*.

After three months, *Jasminum grandiflorum*, *Azadirachta indica* and *Aegle marmelos* were used for treatment for another one week.

Conservation status of plants used in treatment

From the data base on "Rare, Endangered, Threatened (RET) Plants of Kerala" compiled by (KFRI) Peechi, it is seen that *Coscinium fenestratum* is critically endangered, *Cycas circinalis* and *Withania somnifera* are endangered species, *Trachyspermum ammi* and *Saussurea costus* are listed as threatened and *Santalum album* is the only vulnerable species. *Cyclea peltata* is the only endemic species.

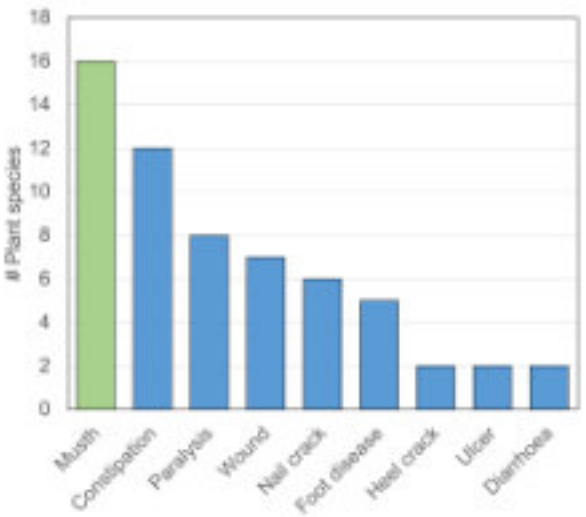

Figure 2. Number of plant species used for treating some common diseases and conditions.

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News and Briefs
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An Introduction to Addressing Linear Transportation Infrastructure in Asian Elephant Landscapes

Robert Ament*, Sandeep K. Tiwari, Melissa Butynski, Shu Chen, Jia Cherng Lim, Norris Dodd, Nilanga Jayasinghe, Aaron Laur, Gabriel Oppler, Salman Saaban, Rodney van der Ree, Yun Wang and Ee Phin Wong

Asian Elephant Transport Working Group, IUCN
**Corresponding author's e-mail: rament@largelandscapes.org*

Introduction and context

The rapid expansion of linear transportation infrastructure (LTI) in Asia – roads, railways, and canals – if not developed sensibly, has the potential to continue to further impact elephant landscapes causing increased direct mortality as well as habitat loss and fragmentation. Also, of concern, are the adverse impacts of expanding LTI on ecological connectivity and wildlife movement. All of these impacts, if poorly addressed, will exacerbate human-elephant conflict.

To address these concerns, the International Union for the Conservation of Nature (IUCN) had two of its groups – the Asian Elephant Specialist Group under its Species Survival Commission, and the Connectivity Conservation Specialist Group's Transport Working Group under its World Commission on Protected Areas, jointly form the Asian Elephant Transport Working Group (AsETWG) to address LTI issues in Asia's elephant landscapes.

The first product of the AsETWG's efforts was the publication of an introductory report that summarises the issues, policies, practices and available resources surrounding this subject. At the end of the report are 10 recommendations the experts hope will help to further address elephant- LTI conflict. Entitled, Protecting Asian Elephants from Linear Transport Infrastructure, the Asian Elephant Transport Working Group's Introduction to the Challenges and Solutions, or the Asian Elephant LTI Primer, for short, was published by the IUCN in 2021 (Fig. 1). It will be followed by a second publication, currently in production, that will be a handbook on how to effectively mitigate roads and railways in elephant landscapes.

Impacts of linear transport infrastructure

The report introduces the reader to the various direct and indirect impacts of roads, railways and canals. Such impacts include morality, aversion, movement barriers, sensory disturbances, chemical effects, habitat loss and fragmentation, and attractants. Some of these impacts by roads are illustrated in Figure 2 in the document.

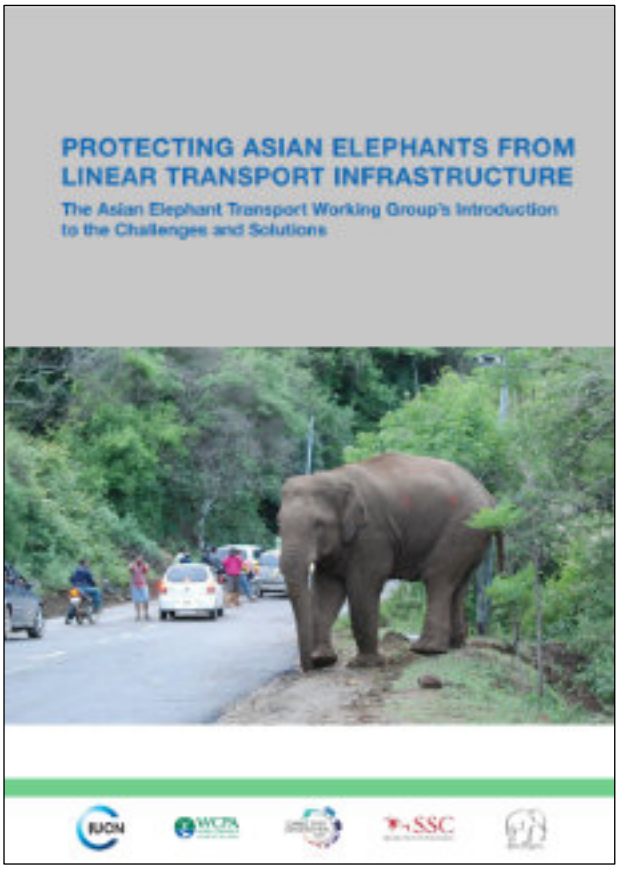

Figure 1. The cover of the first publication by the IUCN's AsETWG.

Reducing Asian elephant – transport conflict

Another section of the document is dedicated to a variety of tools that are available to diminish the impacts of transport systems on elephants. They range from published guidelines describing safeguards for biodiversity for LTI, as well as policies and laws developed by Asian countries.

Another section reviews the mitigation hierarchy and emphasises the need to practice avoidance either by route selection or to forgo LTI development if it is too impactful.

It also has a chapter dedicated to promising new technologies, such as animal detection systems. These technologies have been poorly studied regarding their ability to reduce train and vehicle strikes of elephants and many are in the early stages of research and development.

Case studies of highway and railway mitigation measures

Although there were very few projects to draw upon for case studies, the report provides some early examples of mitigation measures that were implemented for highways or railways to protect elephants in Asia. Seven case studies are highlighted from five different range states, giving the reader an opportunity to review some of the first efforts on the continent.

Recommendations for future endeavours to protect elephants from LTI

Lastly, the final section of the IUCN's introduction to reducing LTI conflict with Asian elephants enumerates future steps to be taken to facilitate improvement in policy, practices and research. The experts emphasise avoidance as a key strategy, push for the adoption of an agreed upon nomenclature for wildlife crossing structures used for mitigation to reduce confusion (e.g., viaducts, flyovers, bridges, overpasses, underpasses) and make other suggestions to improve various technical aspects of LTI mitigation. Other areas covered in their advice include economics, research and the need to develop and support a professional network across the range states.

Citation

R. Ament, S.K. Tiwari, M. Butynksi, B.S. Chen, N. Dodd, A. Gangadharan, N. Jayasinghe, A. Laur, G. Oppler, E.P. Wong, R. van der Ree & Y. Wang (2021)
Protecting Asian Elephants from Linear Transport Infrastructure: The Asian Elephant Transport Working Group's Introduction to the Challenges and Solutions
AsETWG (Asian Elephant Transport Working Group); IUCN WCPA Connectivity Conservation Specialist Group/IUCN SSC Asian Elephant Specialist Group.

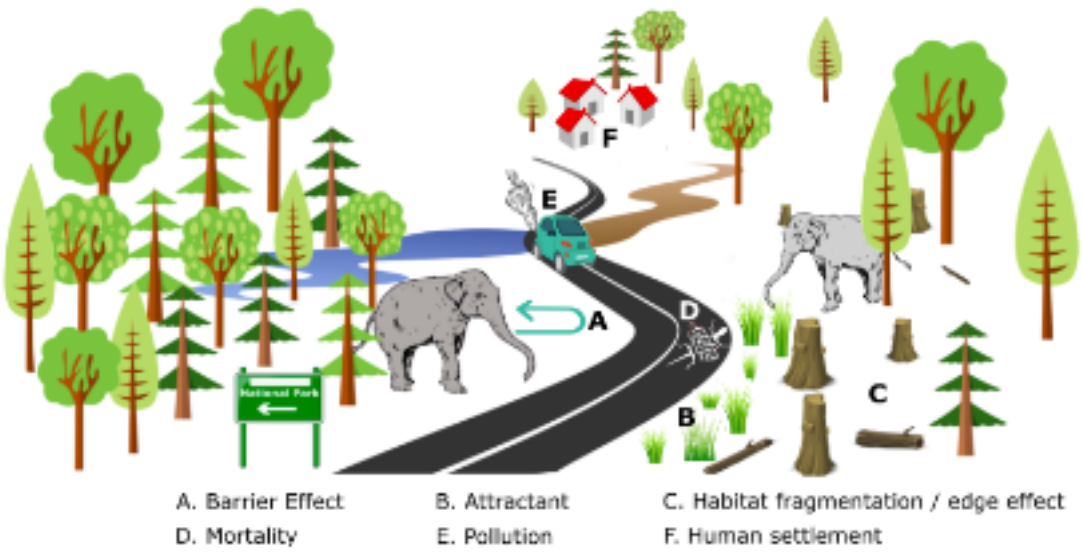

Figure 2. Summary of some key direct and indirect impacts of a highway in an elephant landscape.

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News and Briefs
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Report of the 5th Asian Elephant Endotheliotropic Herpesvirus (EEHV) Working Group Meeting

Chatchote Thitaram[1]*, Supaphen Sripiboon[2] and Sonja Luz[3]

[1]*Center of Elephant and Wildlife Health, Faculty of Veterinary Medicine, Chiang Mai University, Thailand*
[2]*Faculty of Veterinary Medicine, Kasetsart University, Kamphaengsaen, Nakornpathom, Thailand*
[3]*Mandai Nature, Singapore*
**Corresponding author's e-mail: chatchote.thitaram@cmu.ac.th*

Introduction

The Asian Elephant Endotheliotropic Herpesvirus (EEHV) Working Group was established in 2015 through a first meeting hosted by the Mandai Wildlife Group at the Singapore Zoo. The main purpose for the development of this working group was to establish a supportive network among elephant managers in Asia to improve and streamline research needs and treatment plans, as well as to build capacity with support from the western EEHV working groups. Up until 2019 the Asian EEHV Working Group met regularly with three subsequent meetings conducted again at Singapore Zoo (November 2016), as well as the Kesetsart University, Thailand (November 2017), and at the Assam Agricultural University, India (November 2019).

5th Working Group meeting

On November 13th, 2023, the 5th Asian EEHV Working Group meeting took place at the Faculty of Veterinary Medicine, Chiang Mai University, Chiang Mai, Thailand. Representatives from all Asian elephant range states (except Bhutan and Vietnam), participated, along with three representatives from non-range countries (Singapore, Japan, and Australia). The aim of the meeting was to receive updates of the EEHV situation across all Asian Elephant Range Countries, as well as to discuss and learn about new innovations and technologies developed in the last 3 years to fight this devastating disease.

As of the meeting date, a total 219 clinical endotheliotropic herpesvirus-hemorrhagic disease (EEHV-HD) cases were confirmed in Asia using molecular techniques. Notably, Thailand has reported the highest number of confirmed cases (n = 128), followed by India (n = 56) and Nepal (n = 13). The variation in the number of confirmed cases is likely linked to the availability of laboratories, public awareness, and networking. Currently, only five elephant range countries – Thailand, India, Nepal, Indonesia, and Malaysia – have functional molecular laboratories for EEHV diagnosis. The gaps and needs of each Asian elephant range countries were identified.

Diagnosis

Most countries require either equipment, technical training, or essential chemical reagents. It is noteworthy that no EEHV serological tests are presently available in Asia, highlighting an urgent need for capacity building and training. Moreover, challenges such as difficulties in obtaining CITES permission for importing and exporting elephant samples for diagnosis pose obstacles for sharing the laboratory diagnostic services across the region. To address this limitation, there continues to be a need for more training and capacity building initiatives, alongside with awareness-raising campaigns.

Treatment

Most range countries have access to anti-viral drugs, especially the oral medication e.g. acyclovir. However, stocking the medication is challenging due to shelf life and associated cost. With increasing numbers of successfully treated EEHV-HD cases it becomes clear that having anti-viral drugs readily available can signific-

antly contribute to saving the lives of elephants in range countries. Other drugs i.e. famciclovir and ganciclovir are still difficult to obtain due the availability in the country and the high cost of the drugs.

Research

The following research questions were raised during the meeting and could fulfil the gap for this fatal disease:

- Epidemiology of EEHV-HD of wild and captive elephants in each country, as well as the molecular epidemiology.
- Disease monitoring from sero-surveillance in captive elephants. Comparison of serology of EEHV-HD and sub-clinical EEHV.
- Herd immunity both cell-mediated immunity (CMI) and humeral immunity (HMI).
- Protective level / viral neutralising antibody.
- Immunity in calves vs. adults/ captive vs. wild/ calves with mother vs. calves without mother.
- Pathophysiology of this disease.
- Risk factors of this disease.
- Effective and other innovative treatment of this devastating disease.

This working group meeting has played a pivotal role in identifying existing gaps and emphasises the urgent need to prevent and manage EEHV-HD in the future, particular in the Asian elephant range countries, which could safeguard the health and well-being of elephants across the Asian region.

Acknowledgements

We would like to express our gratitude to Mandai Nature, Singapore, and the International Elephant Foundation for funding this meeting. We are also thankful to all representatives from each country who dedicated their time to join the meeting and share data from their respective country. Special thanks for the members of the EEHV Advisory Group who have consistently supported us.

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News and Briefs
Gajah 57 (2024) 42-44

Report on the Eighth Elephant Conservation Group Workshop

Jennifer Pastorini[1]* and Ee Phin Wong[2]

[1]*Centre for Conservation and Research, Tissamaharama, Sri Lanka*
[2]*University of Nottingham Malaysia Campus, Semenyih, Malaysia*
**Corresponding author's e-mail: jenny@aim.uzh.ch*

Background

The Elephant Conservation Group (ECG) was created in 2011 during a technical workshop on human-elephant conflict (HEC) management held in Sri Lanka. The purpose was to have a network to share ideas and discuss issues regarding Asian elephant (*Elephas maximus*) conservation and also to conduct research projects across the range. While the latter didn't work out so well due to time and financial constraints, we managed to hold workshops every two or three years where in-depth discussions on all kinds of topics related to elephants were held.

From 18th to 21st March 2023, we held the eighth ECG workshop at Jim Corbett National Park in Uttarakhand, India. As in the years before, we organised the workshop back-to-back with the Asian Elephant Specialist Group (AsESG) meeting, as most ECG members were also attending the AsESG meeting, making the travel expenses more worthwhile. The ECG workshop was attended by 14 people and another 2 members joined via zoom. The participants came from 8 range states (China, India, Indonesia, Malaysia - Peninsular and Sabah, Nepal, Sri Lanka, Thailand and Vietnam) and 3 non-range states (Australia, UK, USA).

Presentations from the participants

Ee Phin Wong (**Peninsular Malaysia**, MEME) talked about her team's research on the impact of roads on elephant movement, social return of investment and HEC. The Wildlife Department collared translocated elephants, giving the possibility to study their movements after translocation and also how elephants cross major roads. MEME is also working closely with plantations towards achieving coexistence with elephants since a lot of oil palm estates are affected by conflict.

Nurzhafarina Othman (**Sabah**, Seratu Aatai) shared information about her work in investigating the mysterious death of elephants in Sabah. Her team, including Sabah Wildlife Department and research organisations, are trying to bring down the number of elephants deaths due to HEC in her study area. They are working on figuring out the cause of deaths – which is very complex. Seratu Aatai also conducts outreach programs with communities, to assess damage caused by elephants and figure out how the people might get compensated for their losses via insurance.

Cheryl Cheah (**Sabah**, WWF) explained to the group about her team's efforts to evaluate the possible impacts of the new road being built from Sabah to the new capital of Indonesia, which is currently under construction in Kalimantan, on the Indonesian side of Borneo. As the new road goes through forest and elephant home ranges, some wildlife under- and overpasses are planned to ensure uninterrupted connectivity. WWF teams in Malaysia and Indonesia are working together to examine the impact of the road on elephants. Cheryl has also examined the movement of elephants in plantations and works with plantations on HEC.

Wishnu Sukmantoro (**Indonesia**, Forest and Wildlife Society) talked about reducing HEC through participatory spatial planning, habitat enrichment for elephants and agroforestry system initiatives. With proper landuse planning and elephant monitoring, his team is trying to tackle HEC. All stakeholders need to be included to make coexistence between the communities and elephants possible. He briefly

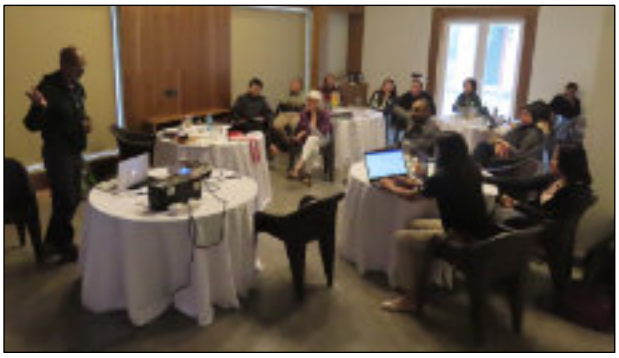
shared the results from an elephant occupancy study in Sumatra.

Ananda Kumar (**India**, NCF) updated us about his work in Hassan and Valparai. HEC is more severe in Hassan, but the patterns are quite different from Valparai. His team has set up an early warning system in Hassan – similar to what has been successfully used in Valparai since years.

Sreedhar Vijayakrishnan (**India**) studied male elephants which regularly cross the river Ganges at night to go crop raiding on its other side. When the river flow is high, they get carried about 500 m down the river before reaching the other side. He told us about elephants feeding on oil palm and rubber trees in southern India. He also informed us about captive elephants being used for various processions in Kerala.

Ahimsa Campos-Arceiz (**China**, XTBG, Chinese Academy of Sciences) talked to us about the work of the newly created "Megafauna Ecology and Conservation Group". His team studied the wanderings of the famous Chinese elephants that went way out of their normal home range. The goal was to find out why the elephants actually undertook that journey.

Aek Jitwijak (**Thailand**, WWF) gave us an update on the elephants at Kuiburi National Park. There are now around 300 elephants at Kuiburi and tourism is increasing. However, they also cause HEC in the areas surrounding the park. Various actions are being taken to mitigate the conflict, not all of them being beneficial for the elephants. There are also first efforts to plan a corridor to connect Kuiburi to other landscapes.



Mai Nguyen (**Vietnam**, Humane Society International) talked about her work on the elephants in Dong Nai. As elephant numbers in Vietnam are very low, this population is important. Thanks to camera traps it became possible to take photos of these elusive elephants and get information on their demography, health and reproductive activity. They come into conflict with the communities bordering the park, therefore Mai's team is also studying HEC.

Narendra Pradhan (**Nepal**, IUCN) presented his work on HEC around Bardia National Park. His team is trying various mitigation measures (electric fences, alternative crops, early warning system through mobile phones) to ease HEC for the communities. Raising awareness is key to better protect the elephants in that area.

Becky Shu Chen (**China**, ZSL) is currently doing a PhD on koala conservation in Australia. Her focus is mostly on communication with the communities to make people more tolerant towards koalas. The new approaches taken are very interesting and of course those communication skills could also be used for elephant conservation efforts.

Natasha Zulaikha (**Peninsular Malaysia**, MEME) gave us insight into her PhD work on human and ecological dimensions of human-elephant coexistence in Malaysia. Her work is more from a social science perspective, which for most of us was an entirely new way on how one can approach HEC issues.

Prithiviraj Fernando (**Sri Lanka**, CCR) gave an update on their team's efforts to change the way HEC is being managed in Sri Lanka. Community-based electric fencing is a very valuable non-confrontational tool to enable human-elephant coexistence. CCR helps develop and im-

plement policy and trains officers from government agencies responsible for people's welfare, to implement community-based fences. Currently several large-scale development projects are funding their implementation – which enables Sri Lanka to tackle the issue at a relevant scale.

Belinda Stewart-Cox (**UK**, Elephant Family) talked to us about a project in Myanmar which Elephant Family has been funding. They are conducting awareness programs, erecting electric fences and work on other simple HEC mitigation techniques to enable the communities to tackle the problems they face with elephants.

Discussions

The ECG group discussed continuing and promoting multi-country research efforts. For example, examining the past and presence occupancy range for wild elephants (5 km X 5 km grid, with 3 interviews within each grid) and to examine elephant body condition scores in different range countries using agreed standardised methods. However, we noted the time needed to publish the studies in individual countries first before having a combined research paper together. Additionally, there was interest in examining human dimensions in conflict and coexistence with wild elephants, to gauge tolerance towards elephants in communities. The discussions highlighted opportunities to conduct post-doctoral research that supports early career researchers, by visiting different elephant range countries and carrying out research together with the hosts. However, this will rely on individual projects to seek the funds needed.

The ECG group discussed at length on insurance and compensation for HEC, elephant behaviour, and movement analysis. We discussed possible ways to utilise field data for spatial analysis, incorporating HEC reports, field data, and GPS collar data to examine habitat connectivity together with the occurrence of conflict. It was suggested that the Smithsonian Institute should have a workshop on spatial analysis, for elephant researchers in range countries, whereby researchers can bring along their data to be analysed together during the workshop.

Lastly, the ECG group discussed membership criteria based on who can contribute and who can learn. Since this is a voluntary group, and members and the projects are mostly self-funded, the group will try to synergise with the efforts of the AsESG and channel its findings back to the AsESG.

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News and Briefs
Gajah 57 (2024) 45-47

Workshop on Preliminary Results of a Science-Based Adaptive Management Approach to the Conservation of Wild Elephants in Vietnam

Mai Thi Nguyen[12] and Hoa Thi Tran[2]

[1]*Humane Society International, Ha Noi, Vietnam*
[2]*Viet Nam Department of Forestry, Ministry of Agriculture and Rural Development, Ha Noi, Vietnam*
**Corresponding author's e-mail: maitn@hsi.org*

Introduction

A collaborative program between the Humane Society International (HSI), Viet Nam Department of Forestry (VN DOF) (under the Ministry of Agriculture and Rural Development) and Dong Nai Forest Protection Department (FPD) was launched in 2019 to obtain information that can help better conserve the elephants in Dong Nai. From 30 to 31 August 2023, HSI, VN DOF and FPD co-arranged a two-day workshop to share the key findings of the program. Ten international elephant experts from USA, India, Sri Lanka, Thailand, Cambodia and Canada, and around 50 Vietnamese researchers and conservation managers from national and provincial levels participated in the workshop.

Workshop

The workshop commenced with a ceremony to declare it open. Before the technical sessions started, the delegates had an opportunity to visit an elephant exhibition located in a nearby park. The highlight of this outdoor exhibition was a realistic life-size model of an elephant mother and baby, made of lightweight aggregated plaster foam. This part was open to the public and most were keen to take photos with the elephants. The exhibition also had large outdoor photographic panels showcasing information about individual elephants identified through the program, the natural beauty and diversity of the landscapes and ecosystems in Dong Nai, the efforts of different stakeholders to conserve elephants and a call to the public to help protect elephants, to prevent them from extinction.

At the commencement of the technical sessions, Ms. Hoa gave an introduction to elephant conservation activities in Vietnam and the importance of conserving the Vietnamese elephants. Then the program conducted in Dong Nai was introduced by Dr. Prithiviraj Fernando from the Centre for Conservation and Research (CCR) Sri Lanka, who with Dr. Jennifer Pastorini also of CCR, voluntarily provided technical guidance for the program. The program took a science-based approach and consisted of three main initiatives: (1) elephant monitoring via camera traps; (2) monitoring HEC via the Airtable app; and (3) conducting a grid-based questionnaire survey of elephant distribution. Dr. Fernando explained the basis of the methodologies and reasons why those methods were appropriate for Dong Nai and Vietnam. After

which Ms. Mai from HSI VN and Mr. Binh, a local ranger from Dong Nai FPD, briefly presented how the initiatives were implemented, the results and the challenges faced.

Camera trapping

Using camera traps to obtain photographs and identifying individuals via characteristic differences to obtain information on demography and health, was done for the first time in the country. From 13/06/2022 to 25/06/2023, 16,032 elephant photographs were captured at more than 30 locations. The photographs were analysed, and individuals identified, catalogued and named. The number of elephants in Dong Nai was previously thought to be 11–14 with 1–2 adult males and doubts had been expressed about the viability of the population. However, the presence of 25 individuals was definitively determined from camera trap pictures, with another two provisionally identified from previous photographs. The identified individuals consisted of adult males, adult females and juveniles. The M:F sex ratio was approximately 1:1. A number of the adult males were observed to come into musth. The average body condition of the elephants was quite high and on-going reproduction was confirmed. The results demonstrated the existence of a breeding population of elephants in Dong Nai that warrants in situ conservation.

This extremely encouraging data for the Dong Nai population is good news for elephant conservation in Vietnam. Applying the same methodology across all elephant range provinces in Viet Nam, especially in Dak Lak, Nghe An, Ha Tinh and Quang Nam which hold other populations, could provide detailed data for them also and help decide what actions needed to conserve elephants in those locations.

HEC monitoring

Monitoring HEC incidents showed that HEC occurred outside the perimeter electric fence, indicating that elephants crossed the fence. People mostly used confrontational methods to drive away raiding elephants, which is likely to lead to more conflict, indicating the need to adopt non-confrontational methods. With so few elephants left, even one fatality due to conflict is a disaster. Continued monitoring of HEC will help assess the effectiveness of mitigation strategies and enable the selection of appropriate strategies. An adaptive approach will enable the development of effective HEC mitigation.

Elephant distribution survey

The ongoing grid-based survey found elephant range to extend beyond the protected area boundaries, indicating the importance of 'outside' areas for elephants, hence in incorporating human-elephant coexistence in conservation planning for Dong Nai elephants.

The findings of the camera trap monitoring, human-elephant conflict monitoring and distribution survey were discussed, questioned and commented on by the participants. The officials from the Cat Tien National Park, Dong Nai Cultural and Natural Reserve, La Nga State-Owned

Forestry Enterprise and local authorities of Tan Phu, Dinh Quan and Vinh Cuu districts reiterated their commitment to conserving the elephants in Dong Nai. The sessions concluded with the awarding of certificates of recognition of the work conducted, to all hardworking dedicated experts, local officials and rangers.

Field-site visit

The second day was a field trip to the project site which was located about 100 km away from Dong Nai city. All the participants had an opportunity to visit and observe the sites related to the elephant conservation efforts that we are working on. Although, the delegates did not see elephants in the wild, they observed elephant signs such as dung, footprints, signs of feeding, and rubbing posts. A demonstration of camera trap deployment including hands-on experience in downloading data and replacing batteries from a camera trap location was conducted in the field by the rangers and Ms. Mai Nguyen.

Community event

After a long day in the forest, the participants were invited to join a community festival focussing on promoting human-elephant coexistence.

In the morning, a drawing contest titled "Elephant and humans are friends, let's coexist" was held for the children in the community, who were organised into teams with 4–5 members and prepared colourful posters depicting the theme. When the delegates arrived at the community, the posters were displayed in a traditional community long-house, with each team interpreting and explaining their creation to the delegates. The delegates then gave them a score and the winners and participants were awarded prizes and their work appreciated.

Afterward, women's, farmers' and youth associations of Phu Ly commune held a dance competition with the theme "Kindness to elephants and coexistence". The event featured both traditional and modern dances, and awards were given to outstanding groups.

The day concluded with a shared dinner with the Cho'Jo ethnic community at the community house.

Acknowledgements

We would like to thank Humane Society International, the Vietnam Department of Forestry and the Dong Nai Forest Protection Department for pioneering these conservation initiatives, opening a new chapter for Viet Nam to continue conserving elephants. A special thank to Dr. Prithiviraj Fernando and Dr. Jennifer Pastorini for their generous help with technical guidance.

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News and Briefs
Gajah 57 (2024) 48-50

Empowerment in Effective Communication Skills and Hospitality Services of Communities and Park Rangers in Human-Elephant Conflict Areas around Kui Buri National Park, Thailand

Chution Savini

Bangkok, Thailand
Author's e-mail: chution@g.swu.ac.th

A workshop related to community empowerment and human-elephant coexistence was held from June 20th to 22nd, 2023. Our aim was to empower local communities and park rangers to find best practices and sustainable solutions to reduce human-elephant conflict around Kui Buri National Park in Prachuap Khiri Khan Province, Thailand.

Kui Buri National Park has been experiencing human-elephant conflict (HEC) problems for the last 40 years. Many HEC mitigation measures have been adopted by various government agencies, private sectors, local communities, academic institutes, and NGOs. One of the successful long-term solutions for HEC, led by WWF-Thailand, was the establishment of community-based ecotourism activities through cooperation among local people, Kui Buri National Park (Department of National Park and Plant Conservation - DNP), provincial administration and NGOs. This project was later named "Kui Buri community-based ecotourism" and began actively serving tourists in 2006."

The workshop had three objectives: (1) Increasing English communication skills and knowledge in hospitality services for local communities and park rangers to support ecotourism, (2) developing effective HEC mitigation measures and management, (3) establishing a wildlife conservation network.

The target groups for the workshop included local people and park rangers involved in ecotourism, such as local guides, cooks, and tourist service park rangers. Participants were selected by the Kui Buri park chief and the head of the Kui Buri community-based ecotourism group.

The workshop content was developed from core information, gaps, and limitations identified over the last 10 years during field trips, guest visits, and wildlife research led by myself .

Academic field trips with International College for Sustainability Studies (SWUIC) were conducted annually since 2013, during which students evaluated the limitations and achievements of local community members and park rangers responsible for various aspects of ecotourism. The results indicated limitations in communication skills, including English language proficiency and hospitality services among local guides and park staff. Additionally, there was a lack of knowledge regarding elephant behaviour and wildlife conservation.

The HEC workshop was primarily conducted by university professors, with the participation of current SWUIC Thai and international students and alumni. The class assignment from the ecotourism management course to establish a guidebook for participants, which was intended to serve as a practical reference for ecotourism and hospitality services.

The first day of the workshop commenced with talks by two members of the IUCN SSC Asian Elephant Specialist Group. The plenary talk was delivered by Prof. Mostafa Feeroz. He discussed HEC on a global scale and presented a

case study from Bangladesh, featuring photos, videos, and stories. Participants were deeply impressed and gained insights into the numerous HEC sites where people encounter problems and seek solutions, much like the situation in Kui Buri.

Dr. Mattana Srikrachang provided valuable knowledge on elephant behaviour. She explained how to identify elephants that enter community areas by gender and age class and specified dos and don'ts for behaviour when tourists visit ecotourism sites.

Effective communication skills and English communication were the focus of my presentation, which highlighted words, terms, and sentences that can be used in the field, including greetings from various cultures, international etiquette, appropriate and inappropriate words and behaviours, as well as common sentences used in real-life situations related to their daily jobs.

On the second day of the workshop, we focused on the topic of 'Service Mind and Hospitality Services for Ecotourism Management.' This session was led by Dr. Talissawan Saneewong Na Ayudthaya, the former Director of Sales and Marketing at Hilton Thailand, and Dr. Thanawan Worasingha, law expert and SWUIC-HTM lecturer. The topics covered included service etiquette, table manners, bedding, and international communication. Dr. Talissawan Umpornmaha provided valuable tips and knowledge on hospitality services for the participants.

On the third day of the workshop, the focus was on English communication for ecotourism management, with instruction provided by myself and SWUIC students. The primary objective was to enhance participants' understanding of the concept of ecotourism and its operational aspects. The subjects included theory of ecotourism and sustainable tourism, mammal identification and common English words and sentences for tour guides. Participants also learned useful sentences that tour guides can use to communicate do's and don'ts to tourists in various situations.

In the final three hours of the workshop, role-play activities were introduced to evaluate participants' performance in different case studies. Participants were divided into three groups: (1) Local guides, (2) local communities and (3) park rangers. Role-play games were used to as-

sess their comprehension of the content taught in the class. This segment also featured collaborative activities between SWUIC and international students.

Finally, we received feedback from the participants, who displayed great enthusiasm for learning and enhancing their skills. Participants thoroughly enjoyed acquiring new knowledge and engaging in ice-breaking games, which were led by our former student, Ms. Irin Somsupamongkol. After the workshop, we visited the site and engaged in discussions with the participants. It was evident that they found the guidebook to be a valuable resource for their actual duties. In November 2023, we successfully edited and published a second version of the guidebook, which we subsequently distributed to tour guides and park rangers.

Acknowledgements

I sincerely appreciate the tremendous support from our workshop instructors and organizers, including Dr. Taliswan Ampornmaha, Dr. Tanawan Vorasingha, Ms. Irin Somsupamongkol, and Chutikarn Jitrareewong. I take great pride in our SWUIC students who have demonstrated excellent academic performance and a strong commitment to wildlife conservation. The production of the guidebook and workshop preparation was led by Savapat Pleangjitsatien, with valuable contributions of her friends and seniors, including Kittin Khampruangdet, Tawin Tana-atsawachot, Nannaphat Laophattaraprasit, Thitiphong Chintanawong, Nuttha Thitasiri, Suthimon Chanton, Napassorn Chuenarom, Panita Thongyotkaeo, Patcharamai Kotchapan, Phimnisa Noiwanna, Worapas Youpoh and Sem Hamans.

I am grateful to our esteemed guest speakers from the IUCN SSC Asian Elephant Specialist Group (AsESG), Professor Mohammed Mostafa Feeroz and Dr. Mattana Srikrachang. Their presence and support in sharing HEC cases from Bangladesh and other HEC sites in Thailand, as well as their insights into elephant behaviours, were highly appreciated by our participants. Special thanks to Megan English for organising part of the program. I would also like to extend my gratitude to all the members of the AsESG who have supported and become part of our conservation network, including Prof. Mostafa Feeroz, Dr. Mattana Srikrachang, Mr. John Robert and Dr. Megan English.

My thanks also go to Ms. Suporn Polphan, Ms. Prachoup Puapa, for their invaluable support. I extend a special thank you to the Dean and the administrative staff of SWUIC, Srinakarinwirot University, for their generous funding and unwavering support. Anantara Huahin Hotel generously provided the table settings and tools, with partial funding support and collaboration of Mr. John Robert.

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Obituary

Dr. A. J. T. Johnsingh (1945 – 2024)

Vivek Menon

Asian Elephant Specialist Group & Wildlife Trust of India
Author's e-mail: vivek@wti.org.in

Dr. A. J. T. Johnsingh, a distinguished conservationist and wildlife biologist and a senior member of the Asian Elephant Specialist Group, IUCN SSC passed away this month, leaving behind a rich legacy of impact on the field of wildlife conservation in India and beyond. His relentless dedication and pioneering contributions have significantly shaped the discourse and practice of wildlife preservation.

Dr. Johnsingh's work is characterised in my view through three very unique characteristics. One is his being a polymath when it came to natural sciences. He studied the elephant for a while, before he settled on the wild dog or dhole for his doctoral studies and then went back to being an expert on elephant ecology, behaviour, and habitat conservation. He has conducted seminal pieces of research on the mountain goral, sambhar, gaur and tiger and has been very involved in the conservation of these species as well as the mahseer.

The second aspect of Johnsingh's work was his ability and penchant to walk India's wilds regularly and thoroughly. He would not be contended to drive through the forests, preferring to walk through them, to study the terrain, vegetation and animals that were at the focus of his study. He was meticulous in writing and in disseminating his texts to a wide set of conservationists and researchers and his finely documented words with exhortations to conserve what was left of India's natural wonders would constantly hit our email boxes. These walks of his were not restricted to India and he contributed very valuable to the conservation of Vietnam, Myanmar and Indonesia through several trips there.

The third aspect of his work was his being an exemplary, if tough, teacher. A mentor to many aspiring conservationists, Dr. Johnsingh was at home with a crowd of eager greenhorns around him while he interpreted nature as he walked. He was a taskmaster if one did not remember what he taught, or if one did not write enough about the field.

Dr. Johnsingh leaves behind a bereft community of elephant and other mammal scientists and conservationists and a pool of students who now no longer have his wisdom to rely on. However, his contribution to Indian ecology, documentation of natural history and conservation will never be forgotten. Rest in peace my friend and senior colleague, Dr. A. J. T. Johnsingh.

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News and Briefs
Gajah 57 (2024) 52-94

Recent Publications on Asian Elephants

Compiled by Jennifer Pastorini

Department of Evolutionary Anthropology, University of Zürich, Zürich, Switzerland and Centre for Conservation and Research, Tissamaharama, Sri Lanka
E-mail: j.pastorini@icloud.com

If you need additional information on any of the articles, please feel free to contact me. You can also let me know about new (2024) publications on Asian elephants.

N.R. Anoop, S. Krishnan & T. Ganesh
Elephants in the farm – Changing temporal and seasonal patterns of human-elephant interactions in a forest-agriculture matrix in the Western Ghats, India
Frontiers in Conservation Science 4 (2023)
Abstract. Accelerating levels of human-elephant conflicts (HEC) have become a topic of major concern in conservation efforts of endangered Asian elephants throughout their range. Wayanad plateau (WP) is a key summer habitat of Asian elephants in the Brahmagri-Nilgiri Eastern Ghats elephant landscape (Nilgiris), harbouring the largest population in Asia. With the increase in human population density and consequent forest loss, HEC amplified in Wayanad. We assessed the drivers of HEC in a temporal and spatial context by integrating questionnaire surveys, compensation claims for crop loss, and individual identification of crop-raiding elephants. The oanalysis showed that season and proximity to the forest boundary were the major drivers of conflict. The conflict pattern is spatially heterogeneous, and there is peak crop depredation during the jackfruit and mango season (May–Sep), followed by paddy season (Sep–Dec). The conflict has resulted in the removal of jackfruit and mango trees from farmlands and stopped cultivation of several crops that attract elephants. This has impacted rural food supply, economic well-being, local biodiversity, and human-elephant coexistence. We discuss effective and locally appropriate conflict mitigation and management strategies which can apply in human-dominated landscapes. © 2023 The Authors.

N.R. Anoop, J. Krishnaswamy, N. Kelkar, M. Bunyan & T. Ganesh
Factors determining the seasonal habitat use of Asian elephants in the Western Ghats of India
J. of Wildlife Management 87 (2023) e22477
Abstract. Asian elephants (*Elephas maximus*) are globally endangered, and their populations persist in several meta-populations within fragmented landscapes across their distribution. Developing landscape-level management plans for elephants requires reliable information on the pattern and determinants of their distribution across relevant spatial and temporal scales. The Brahmagiri-Nilgiri-Eastern Ghats Landscape (Nilgiri landscape) of peninsular India supports the largest breeding population of Asian elephants globally. The Wayanad Plateau, a wet forest tract in the dry forest-dominated Nilgiri landscape, witnessed extensive forest fragmentation recently and evolved as a forest-agriculture matrix. We predicted that habitat use by elephants in the Wayanad Plateau would be high during summer because of the availability of numerous perennial streams and associated swamps that retain water and soil moisture for plant growth over the dry season. We also hypothesized that elephants would use areas with greater forest cover that are removed from human settlements. We used an occupancy-based approach that accounts for detection probability to understand factors influencing habitat use by elephants in summer (low rainfall, high temperature) and post-monsoon (largely rainless winter conditions but with abundant forage and water) in 2019 and 2020. As expected, the intensity of habitat use was higher during the summer than during the post-monsoon season. Elephants used habitats near perennial water sources and with greater forest cover, avoiding areas with high human disturbances. We em-

phasize the importance of areas that provide key resources for elephants during resource scarcity and the need to prevent habitat degradation for long-term persistence of elephants and mitigation of human-elephant conflict. © 2023 The Wildlife Society.

N.R. Anoop, S. Sen, P.A. Vinayan & T. Ganesh
Native mammals disperse the highly invasive *Senna spectabilis* in the Western Ghats, India
BioTropica 54 (2022) 1310-1314
Abstract. *Senna spectabilis*, a native tree of tropical America is rapidly colonizing the forests of Western Ghats. We identified the Asian elephant (*Elephas maximus*) as the major disperser of *Senna*, with the dung facilitating germination of the species. The study provides critical information for the management of *Senna* in tropical Asia. © 2021 Association for Tropical Biology and Conservation.

K. Arai, H. Qi & M. Inoue-Murayama
Age estimation of captive Asian elephants (*Elephas maximus*) based on DNA methylation: An exploratory analysis using methylation-sensitive high-resolution melting (MS-HRM)
PLoS One 18 (2023) e0294994
Abstract. Age is an important parameter for bettering the understanding of biodemographic trends – development, survival, reproduction and environmental effects – critical for conservation. However, current age estimation methods are challenging to apply to many species, and no standardised technique has been adopted yet. This study examined the potential use of methylation-sensitive high-resolution melting (MS-HRM), a labour-, time-, and cost-effective method to estimate chronological age from DNA methylation in Asian elephants (*Elephas maximus*). The objective of this study was to investigate the accuracy and validation of MS-HRM use for age determination in long-lived species, such as Asian elephants. The average lifespan of Asian elephants is between 50–70 years but some have been known to survive for more than 80 years. DNA was extracted from 53 blood samples of captive Asian elephants across 11 zoos in Japan, with known ages ranging from a few months to 65 years. Methylation rates of two candidate age-related epigenetic genes, RALYL and TET2, were significantly correlated with chronological age. Finally, we established a linear, unisex age estimation model with a mean absolute error of 7.36 years. This exploratory study suggests an avenue to further explore MS-HRM as an alternative method to estimate the chronological age of Asian elephants. © 2023 The Authors.

F. Ba, X. Li, Y. Zhang, W. Shi & P. Zhang
How human-elephant relations are shaped: A case study of integrative governance process in Xishuangbanna, China
Forest Policy and Econom. 156 (2023) e103051
Abstract. The conservation of nature is of paramount importance for preserving biodiversity. However, it can also give rise to conflicts and challenges for communities dependent on natural resources. We focus on the issue of human-elephant conflict (HEC) in Xishuangbanna National Nature Reserve, and investigate the causal linkages between governance systems and HEC. Our research presents a comprehensive case study of a village located within the Xishuangbanna National Nature Reserve, delving into the intricate dynamics of human-elephant relationships spanning a three-decade period. Drawing on the integrated governance theory and actor-centered power perspectives, we analyze the influence and interaction of three policy systems – elephant conservation, agricultural development, and forestry policy – on the governance of HECs. Through our examination of power dynamics among multiple actors involved in policy formulation and those affected by policies, we aim to identify the driving forces influencing governance performance. We have identified noteworthy patterns of synergy and conflicting interests among agricultural, forestry, and elephant conservation policies, which have evolved at different stages of governance. The interplay between these policy systems significantly influences the habitat of wild elephants, the land-use patterns of adjacent communities, and the livelihood strategies adopted by local farmers. As a result of these interactions, an adaptive governance strategy on HEC has emerged. Our findings offer novel perspectives on understanding the nuanced transitions in human-elephant relationships, providing valuable insights into the implications of policy interactions. © 2023 Reprinted with permission from Elsevier.

C. Bader, A. Delapré & A. Houssaye

Shape variation in the limb long bones of modern elephants reveals adaptations to body mass and habitat

Journal of Anatomy 242 (2023) 806-830

Abstract. During evolution, several vertebrate lineages have shown trends towards an increase in mass. Such a trend is associated with physiological and musculoskeletal changes necessary to carry and move an increasingly heavy body. Due to their prominent role in the support and movement of the body, limb long bones are highly affected by these shifts in body mass. Elephants are the heaviest living terrestrial mammals, displaying unique features allowing them to withstand their massive weight, such as the columnarity of their limbs, and as such are crucial to understand the evolution towards high body mass in land mammals. We investigate the shape variation of the six limb long bones among *Elephas maximus* and *Loxodonta africana*, to understand the effect of body mass and habitat on the external anatomy of the bones. To do so, we use three-dimensional geometric morphometrics and qualitative comparisons to describe the shape variation, at both the intraspecific and interspecific levels. Our results reveal that the two species share similar negative ontogenetic allometric patterns (i.e. becoming stouter with increased length) in their humerus and femur, but not in the other bones: the proximal epiphyses of the stylopod bones develop considerably during growth, while the distal epiphyses, which are involved in load distribution in the elbow and knee joints, are already massive in juveniles. We attribute this pattern to a weight-bearing adaptation already present in young specimens. Among adults bone robustness increases with body mass, so that heavier specimens display stouter bones allowing for a better mechanical load distribution. While this robustness variation is significant for the humerus only, all the other bones appear to follow the same pattern. This is particularly visible in the ulna and tibia, but less so in the femur, which suggests that the forelimb and hindlimb adapted differently to high body mass support. Robustness analyses, while significant for the humerus only, suggest more robust long bones in Asian elephants than in African elephants. More specifically, GMMs and qualitative comparisons indicate that three bones are clearly distinct when comparing the two species: in *E. maximus* the humerus, the ulna and the tibia display enlarged areas of muscular insertions for muscles involved in joint and limb stabilization, as well as in limb rotation. These results suggest a higher limb compliance in Asian elephants, associated with a higher dexterity, which could be linked to their habitat and foraging habits.

P. Basilia, J.J. Miszkiewicz, K. Nganvongpanit, J. Zaim, Y. Rizal, Aswan, M.R. Puspaningrum, A. Trihascaryo, G.J. Price, A.A.E. van der Geer & J. Louys

Bone histology in a fossil elephant (*Elephas maximus*) from Pulau Bangka, Indonesia

Historical Biology 35 (2023) 1356-1367

Abstract. Analyses of Pleistocene fossil proboscideans have long been used as indirect evidence for climactic and environmental shifts in the Sunda shelf of Southeast Asia. Reconstructing the biological effects of rainforest expansion at the Last Glacial Maximum on elephants can be enhanced by a better understanding of fossil proboscidean palaeobiology. We studied fragmented post-cranial fossil remains of an Asian elephant (*Elephas maximus*) from Pulau Bangka, an island to the east of Sumatra, hypothesised to be within the Late Pleistocene Sundaland savannah corridor. Bone histology of the humerus, rib, and vertebrae from the Bangka fossil were examined and compared with modern conspecifics to reconstruct remodelling. Intra-skeletally, we found that the histology of the largely weight-bearing humerus indicated slower remodelling than that of the ribs and vertebrae, which are less biomechanically constrained. Inter-skeletally, the fossil rib histology showed relatively smaller osteons and Haversian canals when compared to the modern samples. Differences in lifestyles, including range-expansion, may have influenced micromorphometric differences in elephant rib histology. Our results contribute indirect evidence of the effects of climactic variability in the Sunda palaeoenvironment on Pleistocene fauna.

M.A. Bezerra-Santos, J.A. Mendoza-Roldan, P.M. DiGeronimo, E. Ward, B. Noden, F. De Luca, E. Fanelli, D. Valenzano, R.P. Lia & D. Otranto

Into the large ears: Otitis externa associated with nematodes, mites, and bacteria in Asian elephants (*Elephas maximus*)

Parasites & Vectors 16 (2023) e87

Abstract. The Asian elephant, which is an endangered species, harbors several parasites. Among the ectoparasites that it harbors, ear mites of the genus *Loxanoetus* have the potential to cause external otitis, an inflammation that may also be associated with the presence of other microorganisms. We assessed the relationships between ear mites, nematodes, yeast, bacterial rods, and cocci sampled from the ears of captive Asian elephants in Thailand. In addition, we discuss the possibility that dust-bathing behavior may be triggered by ear mite infestation, and that this in turn may lead to contamination of the ears with soil microorganisms. Legally owned captive Asian elephants (n = 64) were sampled. Ear swabs were individually collected from both ears and microscopically examined for the presence of mites, nematodes, yeast, bacterial rods, cocci, and host cells. Mites and nematodes were identified to species level using morphological and molecular methods. *Loxanoetus lenae* mites were present in 43.8% of the animals. Nematodes of the genus *Panagrolaimus* were detected in 23.4% of the animals. In adult elephants (P = 0.0278) and female elephants (P = 0.0107), the presence of nematodes in both ears was significantly associated with the presence of mites. In addition, higher categorical burdens of nematodes were also significantly associated with the presence of mites (P = 0.0234) and epithelial cells (P = 0.0108), and marginally significantly associated with bacterial cocci (P = 0.0499). The presence of *L. lenae* mites in the ear canals of the Asian elephants was significantly associated with the occurrence of other microorganisms, such as soil nematodes, bacteria and yeasts. The presence of mites in their ears may increase the dust-bathing behavior of elephants which, if confirmed, represents a further paradigmatic example of a parasitic infestation affecting animal behavior.

T. Bo, H. Liu, M. Liu, Q. Liu, Q. Li, Y. Cong, Y. Luo, Y. Wang, B. Yu, T. Pu, L. Wang, Z. Wang & D. Wang

Mechanism of inulin in colic and gut microbiota of captive Asian elephant

Microbiome 11 (2023) e148

Abstract. Gut microbiota have a complex role on the survivability, digestive physiology, production, and growth performance in animals. Recent studies have emphasized the effects of prebiotics therapy on the gut disease, but the relationship between elephant gut-related diseases and prebiotics remains elusive. Here, a case study was undertaken to evaluate the mechanism of inulin treatment in colic in Asian elephant (*Elephas maximus*). Fecal samples were collected from a sick elephant and four healthy elephants. Analysis of microbial profile was carried out by 16S rRNA sequencing, and the short chain fatty acids were tested by gas chromatography. The physiological function of "inulin-microbiota" of elephant was verified in mice by fecal microbial transplantation (FMT). The expression of related proteins was determined by Western blotting and qPCR. Eating inulin can cure gut colic of the sick elephant and changed gut microbiota. It was found that "inulin microbiota" from the post-treatment elephants can promote the proliferation of intestinal cells, increase the utilization of short chain fatty acids (SCFAs), maintain intestinal barrier, and reduce the inflammation in mice. The mechanism was inulin—gut microbiota—SCFAs—immune barrier. Inulin contributed to rehabilitate the gut microbiota and gut immune barrier of the elephant with colic. This provides reasonable verification for using prebiotics to treat the colic in captive elephants. Prebiotics will for sure play an increasingly important role in disease prevention and treatment of captive animals in the future.

L. Brickson, L. Zhang, F.Vollrath, I. Douglas-Hamilton & A.J. Titus

Elephants and algorithms: A review of the current and future role of AI in elephant monitoring

Journal of the Royal Society Interface 20 (2023) e20230367

Abstract. Artificial intelligence (AI) and machine learning (ML) present revolutionary opportunities to enhance our understanding of animal behaviour and conservation strategies. Using elephants, a crucial species in Africa and Asia's protected areas, as our focal point, we delve into the role of AI and ML in their conservation. Given the increasing amounts of data

gathered from a variety of sensors like cameras, microphones, geophones, drones and satellites, the challenge lies in managing and interpreting this vast data. New AI and ML techniques offer solutions to streamline this process, helping us extract vital information that might otherwise be overlooked. This paper focuses on different AI-driven monitoring methods and their potential for improving elephant conservation. Collaborative efforts between AI experts and ecological researchers are essential in leveraging these innovative technologies for enhanced wildlife conservation, setting a precedent for numerous other species.

K. Budd, J.C. Gunn, L.L. Sullivan & L.S. Eggert

Identification of conservation priority units in the Asian elephant, *Elephas maximus*

Conservation Genetics 24 (2023) 827-837

Abstract. No permission to print abstract.

K. Budd, D. Suddychan, M. Tyson, C.N.Z. Coudrat, A. McWilliam, C.D. Hallam, A. Johnson & L.S. Eggert

Effects of a hydropower project on a high-value Asian elephant population

Ecology and Evolution 13 (2023) e10353

Abstract. Habitat loss and fragmentation are leading contributors to the endangered status of species. In 2006, the Nakai Plateau contained the largest known Asian elephant population in the Lao People's Democratic Republic (Lao PDR), and the population was among those with the highest genetic diversity reported for Asian elephants. In 2008, completion of the Nam Theun 2 hydroelectric dam inundated much of the Plateau, resulting in the loss of 40% of elephant habitat. We studied elephant presence, movements, and the incidence of human-elephant conflict (HEC) on the Nakai Plateau and surrounding areas from 2004 to 2020, before and for 12 years after dam completion. To examine contemporary population dynamics in the Nakai elephants, we used genetic sampling to compare minimum population numbers, demography, and levels of genetic diversity from the wet and dry seasons in 2018/2019, 10 years after dam completion, with those reported in a pre-dam-completion genetic survey. After dam completion, we found a major increase in HEC locally and the creation of new, serious, and persistent HEC problems as far as 100 km away. While we were unable to compare estimated population sizes before and after dam completion, our data revealed a decrease in genetic diversity, a male-biased sex ratio, and evidence of dispersal from the Plateau by breeding-age females. Our results raise concerns about the long-term viability of this important population as well as that of other species in this region. Given that hydropower projects are of economic importance throughout Laos and elsewhere in southeast Asia, this study has important implications for understanding and mitigating their impact.

S. Budhathoki, J. Gautam, S. Budhathoki & P.P. Jaishi

Predicting the habitat suitability of Asian elephants (*Elephas maximus*) under future climate scenarios

Ecosphere 14 (2023) e4678

Abstract. This study aimed to predict the habitat suitability of Asian elephants in Madhesh Province, Nepal, by using maximum entropy (MaxEnt) modeling based on the occurrence data and environmental variables, including bioclimatic, topographic, vegetation-related, and anthropogenic variables. The study was conducted under current and future climate scenarios for the year 2100. Among the districts of Madhesh Province, the largest suitable habitats for elephants are located in Rautahat district (30%) followed by Bara district (21%), with Dhanusha district having the smallest suitable area (1%). Elevation, slope, annual precipitation, precipitation of the driest quarter, and temperature seasonality were identified as the most important variables affecting habitat suitability. A total of 1037.3 km^2 was identified as the current highly suitable habitat for elephants, primarily in grasslands and shrublands. The results of the study depict a slight increase in highly suitable areas under the emission scenarios shared socioeconomic pathways (SSP) 2–4.5 and SSP 5–8.5 but a severe decrease in suitable habitats and a drastic increase in unsuitable habitats. The research emphasizes the possible influence of human activities and land use on the living environment of elephants. The study, therefore, suggests that the authorities should prioritize future land use management to lessen the potential harm to the habitats of ele-

phants and other endangered species in Nepal. It is also imperative to identify how elephants utilize their spatial habitat within their range to help park authorities devise efficient management strategies. © 2023 The Authors.

J. Caballero-Gómez, D.C. Terriza, J. Pujols, E. Martínez-Nevado, M.D. Carbonell, R. Guerra, J. Recuero, P. Soriano, J. Barbero & I. García-Bocanegra

Monitoring of bluetongue virus in zoo animals in Spain, 2007–2019

Transboundary and Emerging Diseases 69 (2022) 1739-1747

Abstract. Bluetongue (BT) is an emerging and re-emerging communicable vector-borne disease of animal health concern. A serosurvey was performed to assess exposure to BT virus (BTV) in zoo animals in Spain and to determine the dynamics of seropositivity in longitudinally sampled individuals during the study period. Serum samples were collected from 241 zoo animals belonging to 71 different species in five urban zoos (A-E) in Spain between 2007 and 2019. Twenty-four of these animals were longitudinally surveyed at three of the sampled zoos (zoos B, C and E) during the study period. Anti-BTV antibodies were found in 46 (19.1%; 95% CI: 14.1–24.1) of the 241 captive animals analysed by commercial ELISA. A virus neutralization test confirmed specific antibodies against BTV-1 and BTV-4 in 25 (10.7%; 95% CI: 6.7–14.6) and five (3.0%; 95% CI: 0.3–4.0) animals, respectively. Two of the 24 longitudinally sampled individuals (one African elephant (*Loxodanta africana*) and one aoudad (*Ammotragus lervia*)) showed anti-BTV antibodies at all samplings, whereas seroconversions were detected in one mouflon (*Ovis aries musimon*) in 2016, and one Asian elephant (*Elephas maximus*) in 2019. This is the first large-scale survey on BTV conducted in both artiodactyl and non-artiodactyl zoo species worldwide. The results confirm BTV exposure in urban zoo parks in Spain, which could be of animal health and conservation concern. Circulation of BTV was detected in yearling animals in years when there were no reports of BTV outbreaks in livestock. Surveillance in artiodactyl and non-artiodactyl zoo species could be a valuable tool for epidemiological monitoring of BTV. © 2021 Wiley-VCH GmbH.

S.J. Cabral de Mel, S. Seneweera, R.K. de Mel, A. Dangolla, D.K. Weerakoon, T. Maraseni & B.L. Allen

Welfare impacts associated with using aversive geofencing devices on captive Asian elephants

Applied Animal Behaviour Science 265 (2023) e105991

Abstract. Animal-borne aversive geofencing devices (AGDs, or satellite-linked shock collars) are commercially available and used on livestock to restrict their movement within a virtual boundary. This technology has potential application as a human-wildlife conflict mitigation tool, where problem animals might be conditioned to avoid human-dominated habitats by associating an audio warning with a subsequent electric shock, which is delivered if the audio warning is ignored. Ensuring that high standards of animal welfare are maintained when implementing such tools is important for acquiring manager and community acceptance of such approaches. We conducted two pilot experiments with eight captive Asian elephants using mild electric shocks from a modified dog-training collar fitted around the neck, as part of an ongoing effort to develop AGDs suitable for mitigating human-elephant conflict. As part of these experiments, we assessed elephants' behavioural and physiological stress before, during and after our experiments. During the experiments elephants wore collars up to 9 consecutive days and received a small number of electric shocks on 1–3 consecutive days. Bootstrapped principal component analysis showed that daily activity budgets of individual elephants on experiment days were not different to the pre-experiment days. Generalised linear mixed-effect model (GLMM) showed that anxiety/stress behaviours increased on the first day of acclimatising to the collar and on testing days (i.e. days they received shocks) of the first experiment, but not during the second experiment relative to pre-experiment days. Analysis of faecal cortisol metabolite (FCM) concentrations using GLMM showed that FCM concentrations were higher in samples collected ~24 hrs and ~48 hrs after testing days compared to baseline levels as expected given the lag time for excretion of cortisol metabolites. These elevated anxiety/stress behaviours and FCM concentrations returned to baseline levels shortly after the experiment.

Therefore, we conclude that AGDs did not produce lasting behavioural or physiological stress effects in elephants during this short term study but recommend further studies with a larger sample of elephants to confirm the transferability of these findings. © 2023 The Authors.

S.J. Cabral de Mel, S. Seneweera, R.K. de Mel, M. Medawala, N. Abeysinghe, A. Dangolla, D.K. Weerakoon, T. Maraseni & B.L. Allen

Virtual fencing of captive Asian elephants fitted with an aversive geofencing device to manage their movement

Applied Animal Behaviour Science 258 (2023) e105822

Abstract. Aversive Geofencing Devices (AGDs) are designed to emit audible warning signals followed by electric shocks when animals reach virtual fences (VFs) with the intent that animals will learn to turn away at audio warnings and thereby avoid receiving shocks. AGDs are a potentially useful tool for mitigating human-elephant conflict, but a greater understanding of captive elephant responses to AGDs is required before they might be confidently used on wild elephants. We conducted experiments with eight, female captive Asian elephants using a modified dog-training collar to deliver mild electric shocks (4 kV) of varying strength (pulse frequencies) to determine the ideal location on the neck to deliver the stimuli and the optimum strength of the shock required to generate desired aversive responses. Ten shocks (<1 s duration) of different strengths were delivered during a 10 min session (i.e., one shock per minute) at two positions on one side of the elephant's neck. Results indicated that elephants were more likely to display desirable aversive behaviours at the upper position tested on the neck ($P = 0.018$) and at higher stimuli strengths ($P \leq 0.001$). A conditioning experiment was then conducted several months later with five of the same elephants. These were individually trained to walk along a ~100 m path to a food reward on three consecutive days, wearing a dummy collar. On the next three days and on one other day few months later, the elephants were fitted with a similar shock collar (positioned at the upper neck location, and with the highest strength tested earlier) to determine if the AGD could prevent the elephants from accessing the food reward. Three VFs were established at ~30 m, ~50 m and ~60 m points along the path. As the elephant approached the food, a mild audio warning, a more aggressive audio warning, and an electric shock was administered at the first, second and third VFs respectively. Warnings and shocks were not delivered if elephants heeded earlier warnings. A maximum of five such trials were attempted. The VFs successfully kept elephants from reaching the food 77.8% of the time, with elephants responding to the audio warnings and avoiding electric stimulation 47.2% of the trials. These findings suggest that AGDs are a promising method to manage elephant movement, but further research is needed to develop a reliable approach for wild elephants. © 2022 Reprinted with permission from Elsevier.

Y. Chen, L. Atzeni, L. Gibson, Y. Sun, Z. Yang, K. Shi & D. Dudgeon

Urban expansion and infrastructure development reduce habitat suitability for Asian elephants in southwestern China

Wildlife Management 86 (2022) e22204

Abstract. Conservation interventions for threatened species must be based on accurate assessments of the effects of anthropogenic pressures on habitat suitability. We used multiscale multivariable species-distribution modeling to evaluate habitat suitability for an Asian elephant (*Elephas maximus*) population in Shangyong Reserve, Yunnan Province, southwestern China. We investigated the scales at which measurements of environmental variables best reflected elephant habitat selection, and examined whether these responses changed over 2 decades (2000–2010 and 2011–2020) in response to 20 environmental variables, including 14 variables reflecting landscape fragmentation, the extent of buildings, and transport infrastructure. Elephant presence was sensitive to the scale of each variable, and the effects differed among variables within and between decades. More than half of the variables influenced elephant presence at coarse scales of 8 or 16 km, including 12 variables reflecting anthropogenic pressures in 2000–2010 and 10 in 2011–2020. Overall, multivariate models with variables at their optimal scales had higher discrimination than models at uniformly fine scales of 1 km or 2 km. The extent of suitable habitat for elephants declined by 24% over 2 decades. Less

than half of elephant habitat was located within Shangyong Reserve (49% in 2000–2010, 40% in 2011–2020), indicating the importance of managing suitable habitat beyond reserve boundaries. Roads and buildings reduced the probability of elephant presence, with effects that extended beyond their immediate footprint. We advocate that infrastructure be planned with buffers, ≥8 km wide, between roads or buildings and core elephant habitat. Multiscale multivariable species-distribution modeling should be employed to ensure that all suitable habitat for the remaining fragmented elephant populations in Yunnan is identified, mapped, and protected.

Y. Chen, Y. Sun, L. Atzeni, L. Gibson, M. Hua, K. Li, K. Shi & D. Dudgeon

Anthropogenic pressures increase extinction risk of an isolated Asian elephant (*Elephas maximus*) population in southwestern China, as revealed by a combination of molecular- and landscape-scale approaches

Integrative Zoology 17 (2022) 1078-1094

Abstract. Identification of the effect of anthropogenic threats on ecosystem is crucial. We used molecular tools and remote sensing to evaluate the population status of an isolated Asian elephant population in southwestern China in response to changes in habitat suitability between 1989 and 2019. A total of 22 unique genotypes were identified from 117 dung samples collected between March and June 2018 using microsatellite DNA analysis, including 13 males and 9 females. Based on the size of fecal boli, 1 animal was a juvenile, 9 were subadults, and 12 were adults, indicating that recruitment was limited. The effective population size was small (15.3) but there was no signature of a recent population bottleneck. We observed a low genetic diversity (H_e = 0.46 ± 0.05) and a high level of inbreeding (F_{is} of 0.43 ± 0.11), suggesting low population viability and high risk of extinction. In total, these elephants lost nearly two thirds (62%) of their habitat in 3 decades. The expansion of agriculture and rubber plantations followed by an increase in human settlements after 1989 increased the isolation of this population. We recommend that resettlement of 800 inhabitants of 2 villages and the abandonment of associated farmland and rubber plantations would make an additional 20 km^2 of suitable habitat available. This could allow a population increase of 14 elephants, possibly by translocating individuals from elsewhere in China. Our findings can be applied to the management and conservation of other fragmented populations in China or in other range countries of Asian elephants. © 2021 International Society of Zoological Sciences.

Y. Chen, Y. Sun, M. Hua, K. Shi & D. Dudgeon

Using genetic tools to inform conservation of fragmented populations of Asian elephants (*Elephas maximus*) across their range in China

Integrative Zoology 18 (2023) 453-468

Abstract. A herd of 15 Chinese elephants attracted international attention during their 2021 northward trek, motivating the government to propose establishment of an Asian elephant national park. However, planning is hampered by a lack of genetic information on the remaining populations in China. We collected DNA from 497 dung samples from all five populations encompassing the entire range of elephants in China and used mitochondrial and microsatellite markers to investigate their genetic and demographic structure. We identified 237 unique genotypes (153 females, 84 males), representing 81% of the known population. However, the effective population size was small (28, range 25–32). Historic demographic contraction appeared to account for low haplotype diversity (H_d = 0.235), but moderate nucleotide and nuclear diversity (π = 0.6%, H_e = 0.55) was attributable to post-bottleneck recovery involving recent population expansion plus historical gene exchange with elephants in Myanmar, Lao PDR and Vietnam. The five populations fell into three clusters, with Nangunhe elephants differing consistently from the other four populations (F_{ST} = 0.23); elephants from Mengyang, Simao and Jiangcheng belonged to a single population (henceforth, MSJ), and differed from the Shangyong population (F_{ST} = 0.11). Interpopulation genetic variation reflected isolation by distance and female-biased dispersal. Chinese elephants should be managed as two distinct units: Nangunhe and another combining Shangyong and MSJ, their long-term viability will require restoring gene flow between Shangyong and MSJ, and between elephants in China and neighboring countries. Our results

have the potential to inform conservation planning for an iconic megafaunal species. © 2022 International Society of Zoological Sciences.

S.E. Childs-Sanford, A.J. Makowski, R.L. Hilliard & J.J. Wakshlag

Experimental cholecalciferol supplementation in a herd of managed Asian elephants (*Elephans maximus*)

J. of Zoo and Wildlife Med. 54 (2023) 219-230

Abstract. Vitamin D supplementation may pose a significant health risk in species where levels of deficiency, sufficiency, and toxicity have not been clearly established, and species-specific research on vitamin D supplementation should be performed. This study documented the effect of vitamin D supplementation on serum vitamin D metabolites and other analytes of Ca homeostasis in Asian elephants. Six adult Asian elephants received PO supplementation with cholecalciferol at 300 IU/kg of body weight (BW) once a week for 24 wk. Serum was analyzed every 4 wk for 25-hydroxyvitamin D_2/D_3 [25(OH)D]; 24,25-dihydroxyvitamin D_2/D_3 [24,25$(OH)_2$D]; 1,25-dihydroxyvitamin D [1,25$(OH)_2$D]; parathyroid hormone (PTH); total Ca; ionized Ca (iCa); P; and Mg. After the supplement was discontinued, serum 25$(OH)D_2/D_3$ was measured every 4 wk until levels returned to baseline. At the start of the study, the average serum 25$(OH)D_3$ was non-detectable (<1.5 ng/ml). With cholecalciferol supplementation, 25$(OH)D_3$ increased at an average rate of 2.26 ng/ml per month and reached an average concentration of 12.9 6 3.46 ng/ml at 24 wk. Both 24,25$(OH)_2D_3$ and 1,25$(OH)_2$D increased over time with supplementation from an average of ,1.5 to 12.9 ng/ml and from 9.67 to 36.4 pg/ml, respectively. PTH, iCa, Ca, P, and Mg remained within reported normal ranges throughout supplementation. After the supplement was discontinued, serum 25$(OH)D_3$ demonstrated a slow decline to baseline, taking an average of 48 wk. Elephants demonstrated significant individual variation in response to supplementation and subsequent return to baseline. Supplementation with a weekly dose of 300 IU/kg BW cholecalciferol for 24 wk appears to be effective and safe. Additional clinical studies would be necessary to investigate the safety of other routes of administration, dosages, and duration of vitamin D supplementation, as well as associated health benefits. © 2023 American Assoc. of Zoo Veterinarians.

P.C. Chu, K. Wierucka, D. Murphy, H.B. Tilley & H.S. Mumby

Human interventions in a behavioural experiment for Asian elephants (*Elephas maximus*)

Animal Cognition 26 (2023) 393-404

Abstract. No permission to print abstract.

D.E. Chusyd, J.L. Brown, L. Golzarri-Arroyo, S.L. Dickinson, V.B. Kraus, J. Siegal-Willott, T.M. Griffin, J.L. Huebner, K.L. Edwards, D.B. Allison & S.N. Austad

Relationship between reproductive and bone biomarkers and osteoarthritis in zoo Asian (*Elephas maximus*) and African (*Loxodonta africana*) elephants

J. of Zoo and Wildlife Med. 53 (2023) 801-810

Abstract. Osteoarthritis (OA) is common in zoo Asian (*Elephas maximus*) and African (*Loxodonta africana*) elephants. This study investigated the relationship between confirmed or suspected OA with ovarian cyclicity, gonadotropins, progestagens, luteinizing hormone (LH), follicle-stimulating hormone (FSH), and collagen type I (CTX-I) in zoo elephants. In Asian elephants, odds of having confirmed or suspected OA decreased with cycling (OR = 0.22, P = 0.016; OR = 0.29, P = 0.020, respectively), however, not when adjusted for age (odds ratio [OR] = 0.31, P = 0.112; OR = 0.58, P = 0.369, respectively). In African elephants, none of the models between confirmed OA and cycling status were significant (P > 0.060), while the odds of having suspected OA decreased with cycling (OR = 0.12, P = 0.001), even after adjusting for age (OR = 0.15, P = 0.005). Progestagens (Asian elephants P > 0.096; African elephants P > 0.415), LH (Asian P > 0.129; African P > 0.359), and FSH (Asian P > 0.738; African P > 0.231) did not differ with confirmed or suspected OA status, unadjusted. CTX-I concentrations were not related to OA status (P > 0.655). This study concluded hormonal changes may not have a strong impact on OA, so additional investigation into other serologic biomarkers is warranted. © 2022 American Association of Zoo Veterinarians.

R. De, R. Sharma, P. Nigam, A.C. Williams, B. Habib & S.P. Goyal

Identifying sex and individual from faecal DNA of the Asian elephant using a single multiplex PCR for population monitoring
Conservation Genetics Resources 15 (2023) 163-173
Abstract. No permission to print abstract.

N. Deiringer, U. Schneeweiß, L.V. Kaufmann, L. Eigen, C. Speissegger, B. Gerhardt, S. Holtze, G. Fritsch, F. Göritz, R. Becker, A. Ochs, T. Hildebrandt & M. Brecht
The functional anatomy of elephant trunk whiskers
Communications Biology 6 (2023) e591
Abstract. Behavior and innervation suggest a high tactile sensitivity of elephant trunks. To clarify the tactile trunk periphery we studied whiskers with the following findings. Whisker density is high at the trunk tip and African savanna elephants have more trunk tip whiskers than Asian elephants. Adult elephants show striking lateralized whisker abrasion caused by lateralized trunk behavior. Elephant whiskers are thick and show little tapering. Whisker follicles are large, lack a ring sinus and their organization varies across the trunk. Follicles are innervated by ~90 axons from multiple nerves. Because elephants don't whisk, trunk movements determine whisker contacts. Whisker-arrays on the ventral trunk-ridge contact objects balanced on the ventral trunk. Trunk whiskers differ from the mobile, thin and tapered facial whiskers that sample peri-rostrum space symmetrically in many mammals. We suggest their distinctive features—being thick, non-tapered, lateralized and arranged in specific high-density arrays—evolved along with the manipulative capacities of the trunk. © 2023 The Authors.

D.B. Dundi, I. Praet & G. Marvin
Good, quarrelsome, bad: Animal agency and human-elephant interactions in the Western Ghats, India
Frontiers in Conservation Science 4 (2023) e1142333
Abstract. Ecological breakdowns are posing many serious threats to the lives of both humans and wild animals in the spaces where those lives are shared. Today the intensification of conservation-related conflict is one of the main ecological challenges faced in the Western Ghats of India. This article explores some of the complex interactions between different groups of people, such as wealthy farmers, small-scale farmers, and Adivasi (indigenous) people, and Asian elephants and suggests potentially non-conflictual approaches to sharing spaces with these elephants. The study used a multispecies ethnographic approach as a primary research method and focused on detailed stories and anecdotes narrated by the inhabitants of the study area who had long experience of living with these elephants and who frequently encountered them. Based on insights offered by the stories and anecdotes, the article argues that the lives of elephants and those of people are deeply and intimately interconnected and co-constructed in the study area; such 'naturecultures' of elephants and humans constitute a complex whole. The stories highlight that most people in the study area know that elephants have agency and are intelligent, emotional beings, and can subvert human attempts to control them. According to local people, each individual elephant possesses a distinct personality: some are good, some are quarrelsome, and some are bad. People believe that, just as human beings do, elephants also perceive and respond to individual humans differently; such beliefs, and the stories created out of them, are non-anthropocentric in nature. Overall, this article explores how understanding, and treating seriously, the concepts, beliefs, and experiences of multidimensional elephant agency can be beneficial for envisioning possible new ways for human-elephant coexistence. © 2023 The Authors.

X. Feng, R. Hua, W. Zhang, Y. Liu, C. Luo, T. Li, X. Chen, H. Zhu, Y. Wang & Y. Lu
Comparison of the gut microbiome and resistome in captive African and Asian elephants on the same diet
Frontiers in Veterinary Science 10 (2023) e986382
Abstract. Elephants are endangered species and threatened with extinction. They are monogastric herbivorous, hindgut fermenters and their digestive strategy requires them to consume large amounts of low quality forage. The gut microbiome is important to their metabolism, immune regulation, and ecological adaptation. Our study investigated the structure and function of the gut microbiota as well as the antibiotic resistance genes (ARGs) in captive

African and Asian elephants on the same diet. Results showed that captive African and Asian elephants had distinct gut bacterial composition. MetaStats analysis showed that the relative abundance of *Spirochaetes* (FDR = 0.00) and *Verrucomicrobia* (FDR = 0.01) at the phylum level as well as *Spirochaetaceae* (FDR = 0.01) and *Akkermansiaceae* (FDR = 0.02) at the family level varied between captive African and Asian elephants. Among the top ten functional subcategories at level 2 (57 seed pathway) of Kyoto Encyclopedia of Genes and Genomes (KEGG) database, the relative gene abundance of cellular community-prokaryotes, membrane transport, and carbohydrate metabolism in African elephants were significantly lower than those in Asian elephants (0.98 vs. 1.03%, FDR = 0.04; 1.25 vs. 1.43%, FDR = 0.03; 3.39 vs. 3.63%; FDR = 0.02). Among the top ten functional subcategories at level 2 (CAZy family) of CAZy database, MetaStats analysis showed that African elephants had higher relative gene abundance of Glycoside Hydrolases family 28 (GH 28) compared to Asian elephants (0.10 vs. 0.08%, FDR = 0.03). Regarding the antibiotic resistance genes carried by gut microbes, MetaStats analysis showed that African elephants had significantly higher relative abundance of vanO (FDR = 0.00), tetQ (FDR = 0.04), and efrA (FDR = 0.04) than Asian elephants encoding resistance for glycopeptide, tetracycline, and macrolide/rifamycin/fluoroquinolone antibiotic, respectively. In conclusion, captive African and Asian elephants on the same diet have distinct gut microbial communities. Our findings established the ground work for future research on improving gut health of captive elephants.

C. Fernando, M.A. Weston, R. Corea, K. Pahirana & A.R. Rendall

Asian elephant movements between natural and human-dominated landscapes mirror patterns of crop damage in Sri Lanka

Oryx 57 (2023) 481-488

Abstract. Wildlife movements within a landscape are influenced by environmental factors such as food availability and, as human-modified landscapes continue to expand, the risks associated with encountering people. For Asian elephants *Elephas maximus*, human-dominated landscapes can be a risky but also rewarding habitat. When elephants share space with people, negative human–elephant interactions are common, sometimes resulting in injuries or deaths of both people and elephants. We monitored elephant movements in and out of a forest reserve in central Sri Lanka to test four predictions regarding elephant behaviour: (1) visits to agricultural areas occur at times of the year when crops are plentiful, (2) elephants exploit these areas by night to avoid interactions with people, (3) increased nocturnal illumination reduces use of agricultural areas, and (4) males make greater use of anthropogenic food sources than family groups. Analysis of camera-trap data confirmed that elephants visited human-dominated areas mostly at night. The frequency of such incursions was not influenced by moon phase for males, but there was a weak effect of moon phase for family groups. Males moved more frequently into human-dominated landscapes than family groups, and their movements showed a distinct seasonal pattern, peaking at times of rice and fruit harvest. Our findings suggest that elephants primarily venture into human-dominated areas to consume crops. Encouraging farmers in areas frequented by elephants to adapt land-use practices (e.g. guarding crops, fencing villages, planting orange/citrus fences) and establish early warning systems could help limit the damage caused by elephants. © 2022 The Authors.

Jonas Gamso

Aiding animals: Does foreign aid reduce wildlife crime?

Journal of Environment & Development 32 (2023) 34-60

Abstract. The illegal wildlife trade has come to the forefront of global politics, driven by concerns about biodiversity loss, illicit markets, and animal-borne infectious diseases. Yet, poaching remains common in many countries. The persistence of illegal hunting is attributable to (among other factors) poverty and poor labor market opportunities, which leave individuals in some communities with few viable alternatives to wildlife crime. Foreign aid that alleviates poverty and unemployment may, therefore, lead to a reduction in illegal hunting. However, cross-national research on aid and economic development offers mixed findings, suggesting a conditional effect. Against this backdrop, I the-

orize that aid reduces the economic pressures that contribute to poaching, but only in countries with representative political institutions. I test a corresponding hypothesis using data on elephant poaching in African and Asian countries. My findings show that aid is accompanied by a reduction in elephant poaching in democracies, but not in authoritarian countries. © 2022 The Author.

S.H. Gallini, P.M. DiGeronimo, E. Ward, W. Thepapichaikul, K. Tachampa, N. Di Girolamo & J. Brandão

Evaluation of plasma cardiac troponin I in Asian elephants (*Elephas maximus*) using two clinical analyzers

J. of Zoo and Wildlife Med. 53 (2023) 654-660

Abstract. Cardiac troponin I (cTnI) is specific to myocardial tissue, highly conserved across taxa, and a reliable indicator of myocardial disease in human and veterinary medicine. Biomarkers, like cTnI, may be useful for cardiac evaluation of elephants because the application of other modalities is complicated by the size of the animal. The goal of this study was to establish observed ranges for plasma cTnI in Asian elephants (*Elephas maximus*) measured by two point-of-care analyzers. Blood was collected from captive juvenile (≤15 yr; n = 9), adult (16–50 yr; n = 42), and geriatric (>50 yr; n = 16) elephants. Following centrifugation, heparinized plasma was stored at 5°C prior to and in between analyses on iSTAT (Abbott Point of Care Inc, Princeton, NJ 08540, USA) and HUBI-QUANpro (Humiasis Co, Ltd, Anyangsi 14042, South Korea) analyzers. With the exception of two results, plasma concentrations of cTnI were below the limit of quantification (LOQ < 0.05 ng/ml) for the HUBI-QUANpro (n = 64), which prohibited comparison between the two analyzers. Observed ranges were determined for plasma cTnI concentrations reported by the iSTAT for the entire population sampled (n = 58; mean 0.011 ng/ml; SD ± 0.013 ng/ml; range 0.00–0.07 ng/ml) and with outliers excluded (n = 50; mean 0.007 ng/ml; SD ± 0.007 ng/ml; range 0.00–0.02 ng/ml). No significant differences were observed between age classes (P = 0.70) or sexes (P = 0.34). Higher cTnI concentrations were significantly correlated with increasing age (Pearson's r = 0.426; P = 0.002). Future studies are warranted to investigate the diagnostic potential of plasma cTnI in Asian elephants. © 2022 American Association of Zoo Veterinarians.

H. Gautam & T.N.C. Vidya

Do food distribution and competitor density affect agonistic behaviour within and between clans in a high fission-fusion species?

Royal Society Open Science 10 (2023)

Abstract. According to the ecological model of female social relationships (EMFSR), within-group competition and between-group competition in female-bonded species are shaped by food distribution. Strong between-group contests are expected over large, monopolizable resources and high population density, but not when low-quality food is distributed across large, undefended home ranges. Within-group contests are expected to be more frequent with increasing heterogeneity among feeding sites and with group size. We tested these predictions in female Asian elephants, which show traits associated with infrequent contests—graminivory, high fission–fusion and overlapping home ranges. We examined how food distribution and competitor density affected agonistic interactions within and between female elephant clans (social groupings) in the Kabini grassland, southern India. We found stronger between-clan contest in the grassland than that known from neighbouring forests, and more frequent agonism between females between clans than within clans. Such strong between-clan contest was attributable to the grassland being a food-rich habitat patch, thus supporting the EMFSR. Within-clan agonism was also frequent, but did not increase with food heterogeneity, contradicting the EMFSR. Contrary to recent claims, increasing within-clan agonism with group size suggested ecological constraints on large groups despite high fission–fusion. High population density may explain such frequent contests despite graminivory and fission–fusion. © 2023 The Authors.

T.D. Gunawansa, K. Perera, A. Apan & N.K. Hettiarachchi

The human-elephant conflict in Sri Lanka: History and present status

Biodiversity and Conservation 32 (2023) 3025-3052

Abstract. Human-elephant conflict (HEC) is a severe conservation, socio-economic and environmental issue of forests and ecosystems in elephant inhabiting countries, including Sri Lanka. Due to the rapid growth of human and elephant populations, both struggles to share limited land resources. The major causes and contexts of HEC in Sri Lanka include land use change, habitat loss due to human population growth, crop raiding behavior, problem elephants, and changes in agriculture practices. Since 2019, 125 people and 370 elephants have killed annually on average due to the conflict. Also, Sri Lanka has recorded the highest annual elephant deaths and second-highest human deaths due to HEC. The human death rate has increased by approximately 42% over previous three decades. The Sri Lankan government provides compensation for death and disability of the human caused by elephants and for elephant-damaged houses or properties. The Sri Lankan elephant's home range is restricted to 50–150 km^2 and depends on the availability of food, water, and shelter of the habitat in which they live. Various management strategies have been developed by the government and villagers to prevent and mitigate HEC. Today, Sri Lankan elephants are protected under Sri Lankan law, with punishment by fines and jail terms. This article reviews the history, present status, and traditional conflict management of HEC in Sri Lanka. We suggest a satellite data fusion approach with GIS modeling to identify risk zones of HEC to develop further protective measures for humans and elephants. © 2023 The Authors.

T.D. Gunawansa, K. Perera, A. Apan, N.K. Hettiarachchi & D.Y. Bandara

Greenery change and its impact on human-elephant conflict in Sri Lanka: A model-based assessment using Sentinel-2 imagery

International Journal of Remote Sensing 44 (2023) 5121-5146

Abstract. Human-elephant conflict (HEC) is a significant conservation issue for Asian elephants (*Elephas maximus*) and an environmental and socioeconomic crisis in elephant range countries, including Sri Lanka. Approximately 14,897 HEC incidents were recorded in Sri Lanka between 2015 and 2021. In this study, we present a Sri Lanka-wide analysis to explore the impact of greenery change on HEC. Our sources were official government data, and land use and land cover maps developed using Sentinel-2 satellite imagery. We applied the support vector machine (SVM), random forest (RF), and object-based image analysis classifications to classify land cover into six categories. This classification scheme also considered the differences observed in Sri Lanka's woody vegetation, consisting of forest, open forest, paddy fields, homestead gardens, and other crops. Analysis of the accuracies of the three types of classifiers confirmed that the supervised classification with two machine learning algorithms, RF and SVM, delivered a higher level of precision in land cover classification. RF was the best option, with a 97.34% overall accuracy and a 0.94 kappa coefficient, while SVM recorded a 94.68% overall accuracy and a 0.89 kappa coefficient. According to the findings, most HEC incidences were recorded in open forests (54%), while 62% were recorded within 2 km of the forest edge. Results indicated that HEC coincides with the human-occupied changed landscape adjacent to forest reservations and patches. The findings could be valuable for HEC management by identifying areas where elephants are most likely to conflict with humans, and the government may declare these as protected areas. Also, we propose an early warning system as an effective approach that helps detect and monitor elephant herds' movement. Therefore, implementing long-term land use planning is crucial for protecting the forest and natural habitats, restoring elephant habitats, and mitigating HEC by minimizing human encroachment and promoting sustainable land use practices. © 2023 The Authors.

T. Guntawang, T. Sittisak, S. Srivorakul, K. Photichai, P. Aiumurai, C. Thitaram, N. Sthitmatee, W.-L. Hsu, N. Sookrung & K. Pringproa

Development of an immunochromatographic strip test for antigen detection of elephant endotheliotropic herpesvirus in Asian elephants (*Elephas maximus*)

J. of Virological Methods 311 (2023) e114627

Abstract. Elephant endotheliotropic herpesvirus (EEHV) is the causative agent of EEHV-hemorrhagic disease (EEHV-HD) in elephants worldwide. This disease is highly virulent and a predominant cause of fatalities in young Asian elephants. Rapid diagnosis and aggressive ther-

apies have been determined to be a key strategy in the successful treatment of this disease. Herein, we have developed the immunochromatographic strip test for EEHV detection. Accordingly, 31.2 kDa of partial EEHV DNA polymerase (DNApol) protein was expressed in Escherichia coli and used to generate rabbit polyclonal anti-EEHV DNApol antibodies. These were then used to develop an ICS test for EEHV antigen detection using the double-antibody sandwich colloidal gold method. Anti-EEHV DNApol antibodies conjugated with 40 nm colloidal gold solution were used as a detector, while rabbit anti-EEHV DNApol and goat anti-rabbit IgG antibodies immobilized on the nitrocellulose membrane were used as the test and control lines, respectively. The test had a detection limit of 1.25 ×105 viral genome copies (vgc)/mL of EEHV obtained from blood samples. Moreover, no specialized equipment or laboratory infrastructure was required in the administration of this test. This developed ICS test for EEHV antigen detection can be used in field application for the rapid detection of EEHV in resource-limited environments. © 2022 Reprinted with permission from Elsevier.

M.A. Imron, D.M. Glass, M. Tafrichan, R.D. Crego, J.A. Stabach & P. Leimgruber

Beyond protected areas: The importance of mixed-use landscapes for the conservation of Sumatran elephants (*Elephas maximus sumatranus*)

Ecology and Evolution13 (2023) e10560

Abstract. Elephants were once widely distributed across the Indonesian island of Sumatra but now exist in small, isolated populations. Using the best data available on elephant occurrence, we aimed to (a) predict potential habitat suitability for elephants across the island of Sumatra and (b) model landscape connectivity among the extant elephant populations. We used direct sightings and indirect observations of elephant signs, as well as six remotely sensed proxies of surface ruggedness, vegetation productivity and structure, and human land use and disturbance, to model habitat suitability in a Google Earth Engine (GEE) environment. We validated the habitat suitability prediction using 10-fold spatial block cross validation and by calculating the area under the precision-recall curve (AUC-PR), sensitivity, and specificity for each model iteration. We also used a geolocation dataset collected from global positioning system (GPS) collars fitted on elephants as an independent validation dataset. Models showed good predictive performance with a mean AUC-PR of 0.73, sensitivity of 0.76, and specificity of 0.68. Greater than 83% of the independent GPS collar geolocations were located in predicted suitable habitat. We found human modification, surface ruggedness, and normalized difference vegetation index to be the most important variables for predicting suitable elephant habitat. Thirty-two percent, or 135,646 km2, of Sumatra's land area was predicted to be suitable habitat, with 43 patches of suitable habitat located across Sumatra. Areas with high connectivity were concentrated in the Riau and North Sumatra provinces. Though our analysis highlights the need to improve the quality of data collected on Sumatran elephants, more suitable habitat remains on Sumatra than is used by known populations. Targeted habitat conservation, especially of the suitable habitat in and around the Lamno, Balai Raja, Tesso Tenggara, Tesso Utara, Bukit Tigapuluh, Seblat, Padang Sugihan, and Bukit Barisan Selatan ranges, may improve the long-term viability of this critically endangered species. © 2023 The Authors.

Akira Ito

Two new *Raabena* species and a new *Pararaabena* species (Ciliophora, Entodiniomorphida) with redescriptions of *Raabena bella* and *Pararaabena dentata*

European J. of Protistology 89 (2023) e125986

Abstract. The genera *Raabena* and *Pararaabena* (Ciliophora, Entodiniomorphida, Blepharocorythidae) were monospecific, and their type species are *Raabena bella* and *Pararaabena dentata*. They have been found in Asian elephants and closely resemble each other: ovoid and laterally compressed body; non-retractable adoral ciliary zone; funnel-shaped vestibulum; three non-retractable somatic ciliary arches. Furthermore, the positional relationship between the vestibular ciliary zone and the anterior dorsal ciliary zone identifies *Raabena* and *Pararaabena*: these two ciliary zones are connected in *Raabena* while they are separated in *Pararaabena*. While investigating entodinio-

morphid ciliates of Asian elephants, the author often encountered ciliates similar to *Raabena bella* but with a sinuous body or with a small body and ciliates similar to *Pararaabena dentata* but with a slender body or with no or two caudal lobes. In this study, their general morphology and infraciliature were compared to *R. bella* and *P. dentata* to know whether they are new species or morphological variations in a species. As a result, the present study re-described *R. bella* and *P. dentata*, and described *R. sinuosa* n. sp., *R. bellafilia* n. sp., *P. gracilis* n. sp., and morphotypes of *P. dentata*.

S.L. Jacobson, J. Dechanupong, W. Horpiencharoen, M. Yindee & J.M. Plotnik

Innovating to solve a novel puzzle: Wild Asian elephants vary in their ability to problem solve

Animal Behaviour 205 (2023) 227-239

Abstract. An animal's capacity for innovation or solving novel problems likely has important implications for how quickly they can adapt to environmental change. Asian elephants living in zoos have previously demonstrated a capacity to innovate, but problem solving has never been studied experimentally in a wild elephant population. We installed puzzle boxes with multiple possible solutions inside a protected area in western Thailand to determine individual variation in innovation, as well as other behavioural traits associated with elephants' problem solving, including persistence, exploratory diversity and neophilia. We recorded 77 elephants approaching the puzzle box, with 44 interacting with the box in their first exposure. Individuals varied widely in their success opening the doors of the puzzle box. Such success was influenced by persistence and exploratory diversity in both the first interaction as well as across multiple interactions. However, when considering each individual's overall innovation scores, which represented how many different doors elephants were able to open across all of their interactions with the puzzle box, only greater persistence and interaction number were associated with reaching a higher innovation score. We observed that elephants who interacted with the box multiple times learned to open a door of any type more quickly as their interactions increased, but we did not see evidence of learning to open specific door types over time. Overall, this study about how innovation and its associated behaviours vary in wild elephants not only informs our understanding of how a capacity for problem solving is expressed, but also how well elephants may be able to adapt to, overcome or avoid increasingly frequent interactions with humans within their habitat.

A. Jambari, T. Hosaka, M. Nakabayashi, M.S. Yahya & B. Azhar

Conservation planning in national parks may benefit from site occupancy and detection estimates of native animal species

J. for Nature Conservation 75 (2023) e126463

Abstract. Protected areas are the best strategy to conserve native biodiversity around the world. In Southeast Asia, most of the pristine tropical forest habitats are limited to protected areas such as national parks and wildlife reserves. Endau Rompin National Park (ERNP) is one of undisturbed biodiversity-hotspots in the southern region of Peninsular Malaysia but surrounded by industrial oil palm plantations and threatened by habitat fragmentation. Little is known about the distribution and habitat requirement of wildlife, including those conservation priority species in the ERNP. This study aims to investigate the mammal distribution in the ERNP by estimating the probability of occurrence of a species among sampled sites. At 24 sites, we used camera traps to detect the forest wildlife. We estimated wildlife occupancy by using single-season occupancy analysis while considering of imperfect detection and relating it to stand- and landscape-level variables. We detected 26 species of native wild animals in the study area including several conservation priority species such as Asian elephant, Asian tapir, and Malayan tiger. The site occupancy of conservation-priority species attests to ERNP's status as an important regional biodiversity hotspot. The detection probabilities of wildlife species were highly sensitive to specific ecological variables at stand- and landscape-level. Our data indicated that tree canopy cover, forest edges, adjacent human settlements, and riparian habitats (e.g., stream and river) are crucial for the persistence of the native wildlife species. Our results suggest that pristine forest habitat such as those typical to

the ERNP are critical for wildlife conservation. We suggest that the stand- and landscape-level ecological variables are considered in conservation planning to protect forest biodiversity and ecological integrity of the national park and other terrestrial protected areas in the tropics.

L.V. Kaufmann, R. Becker, A. Ochs & M. Brecht

Elephant banana peeling

Current Biology 33 (2023) R257-R258

Abstract. Elephants are large mammals that rely on their trunk to acquire huge quantities of food. Complex muscles and motor control structures mediate dexterous and lateralized trunk behaviors, but our understanding of elephants' haptic abilities is limited. Here we describe the banana-peeling behavior of the female Asian elephant Pang Pha at the Berlin Zoo. Like other elephants, Pha consumes green or yellow bananas as a whole. She rejects brown bananas but, unlike other elephants, when on her own she peels yellow-brown bananas. Pha peels faster than humans by a partially stereotyped sequence of behaviors: she breaks the banana, shakes out and collects the pulp, and discards the peel. When yellow-brown bananas are offered to a group of elephants, she changes her behavior and consumes all bananas as a whole with exception of the last banana, which she retains for later peeling. Banana peeling appears to be rare in elephants and none of the other Berlin elephants engage in peeling, raising the question why only Pha peels bananas. Pha was handraised by human caretakers in the Berlin Zoo, who fed her peeled bananas, but never conditioned her to peel them: we suggest she acquired peeling through observational learning from humans. African elephants appear to be able to interpret human pointing gestures6 and to classify human ethnic groups7, but complex human-derived manipulation behaviors like the banana peeling reported here appear to have only rarely been observed.

L.V. Kaufmann, U. Schneeweiss, E. Maier, T. Hildebrandt & M. Brecht

Elephant facial motor control

Science Advances 8 (2022) eabq2789

Abstract. We studied facial motor control in elephants, animals with muscular dexterous trunks. Facial nucleus neurons (~54,000 in Asian elephants, ~63,000 in African elephants) outnumbered those of other land-living mammals. The large-eared African elephants had more medial facial subnucleus neurons than Asian elephants, reflecting a numerically more extensive ear-motor control. Elephant dorsal and lateral facial subnuclei were unusual in elongation, neuron numerosity, and a proximal-to-distal neuron size increase. We suggest that this subnucleus organization is related to trunk representation, with the huge distal neurons innervating the trunk tip with long axons. African elephants pinch objects with two trunk tip fingers, whereas Asian elephants grasp/wrap objects with larger parts of their trunk. Finger "motor foveae" and a positional bias of neurons toward the trunk tip representation in African elephant facial nuclei reflect their motor strategy. Thus, elephant brains reveal neural adaptations to facial morphology, body size, and dexterity.

J.J. Kilburn, D. Schmitt, W. Kiso, M.G. Papich & K.A. Backues

Pharmacokinetics of rectally and orally administered levofloxacin in Asian elephants (*Elephas maximus*)

J. of Zoo and Wildlife Med. 53 (2022) 670-678

Abstract. Appropriate and effective antibiotic use is a critical component of veterinary medicine, but there are variations across species regarding dosage and administration of these drugs. Oral or rectal routes of administration are typically used in elephants, but not all medications can achieve adequate concentrations rectally. The fluoroquinolone antimicrobials are used in elephants because of their favorable antimicrobial spectrum and pharmacokinetics compared with other oral agents. They are commonly used as part of multiple antibiotic regimens for the treatment of tuberculosis. The objective of this study was to determine the pharmacokinetic profile of levofloxacin after oral and rectal administration in Asian elephants. Dosages of 5 mg/kg orally and 15 mg/kg rectally were evaluated in 13 Asian elephants. Blood was collected at various time points from 0 to 72 h for pharmacokinetic analysis. Pharmacokinetic parameters were determined and reached concentrations above minimum inhibitory concentrations of various bacterial organ-

isms via both routes. A pharmacokinetic-pharmacodynamic assessment was used to estimate appropriate minimal inhibitory concentrations for bacteria that could be potentially treated with this antimicrobial. Based on these findings, levofloxacin may be a consideration for administration orally (5 mg/kg) and rectally (15 mg/kg) in Asian elephants. Antimicrobial stewardship principles, culture and susceptibility of suspected pathogens, and blood level monitoring should be used to tailor administration of levofloxacin in this species. © 2022 American Association of Zoo Veterinarians.

W. Klinsawat, P. Uthaipaisanwong, P. Jenjaroenpun, S. Sripiboon, T. Wongsurawat & K. Kusonmano

Microbiome variations among age classes and diets of captive Asian elephants (*Elephas maximus*) in Thailand using full-length 16S rRNA nanopore sequencing

Scientific Reports 13 (2023) e17685

Abstract. Asian elephant (*Elephas maximus*) is the national symbol of Thailand and linked to Thai history and culture for centuries. The elephant welfare improvement is one of the major components to achieve sustainable captive management. Microbiome inhabiting digestive tracts have been shown with symbiotic relations to host health. This work provided high-resolution microbiome profiles of 32 captive elephants at a species level by utilizing full-length 16S rRNA gene nanopore sequencing. Eleven common uncultured bacterial species were found across elephants fed with solid food. We observed microbiome shifts along the age classes of baby (0–2 years), juvenile (2–10 years), and adult (> 10 years). Interestingly, we found distinct microbiome profiles among adult elephants fed with a local palm, *Caryota urens*, as a supplement. Potential beneficial microbes have been revealed according to the age classes and feed diets. The retrieved microbiome data could be provided as good baseline microbial profiles for monitoring elephant health, suggesting further studies towards dietary selection suitable for each age class and the use of local supplementary diets. © 2023 The Authors.

S. Köpke, S.S. Withanachchi, R. Pathiranage, C.R. Withanachchi, D.U. Gamage, T.S. Nissanka, C.C. Warapitiya, B.M. Nissanka, N.N. Ranasinghe, C.D. Senarathna, H.R. Dissanayake, E.N.C. Perera, C. Schleyer & A. Thiel

Human-elephant conflict in the Sri Lankan dry zone: Investigating social and geographical drivers through field-based methods

GeoJournal 88 (2023) 5153-5172

Abstract. Human-elephant conflict (HEC) in Sri Lanka has escalated over the recent years, with, on average, 300 elephant deaths annually and human casualties of around 90 per year. Employing field-based qualitative methods, this contribution identifies causes and contexts of HEC in those parts of the Sri Lankan dry zone most severely affected. We have used field observations as well as semi-structured interviews with experts and affected villagers as primary data collection techniques. The findings show that (a) HEC is the result of land-use decisions, encroachment on elephant corridors, changes in agricultural production systems, and commercialization of land, and that (b) there is a deep division between the environmental knowledge and practices of rural people and the conservation governance provided by government authorities. Furthermore, both traditional and modern mitigation approaches fail to reign in HEC effectively. The insufficient implementation of HEC mitigation measures, and a severe disconnect between the needs and anxieties of rural people and conservation policies, render the management of human-wildlife interactions ineffective. This suggests a need for fundamental reform of elephant conservation policy in Sri Lanka. © 2023 The Authors.

W. Kosaruk, J.L. Brown, P. Towiboon, K. Pringproa, V. Punyapornwithaya, P. Tankaew, N. Kittisirikul, W. Toonrongchang, T. Janyamathakul, P. Muanghong & C. Thitaram

Seasonal patterns of oxidative stress markers in captive Asian elephants in Thailand and relationships to elephant endotheliotropic herpesvirus shedding

Frontiers in Veterinary Science 10 (2023) e1263775.

Abstract. Oxidative stress refers to an imbalance between oxidant and antioxidant activity and accumulation of reactive oxygen species, which can have detrimental effects on animal health. Annual fluctuations in oxidative stress status can occur, increasing disease susceptibil-

ity during certain time periods. However, a full understanding of factors related to oxidative stress in Asian elephants and how to mitigate the negative consequences is lacking. This study measured six serum oxidative stress markers (reactive oxygen species [ROS], malondialdehyde [MDA], 8-hydroxydeoxyguanosine [8-OHdG], albumin, glutathione peroxidase [GPx], and catalase) and two stress markers (serum cortisol and fecal glucocorticoid metabolites [fGCM]) in 23 captive Asian elephants in Thailand over a 12-month period to examine relationships with age and season. Annual variations were observed, with several markers exhibiting significantly higher concentrations in the summer (ROS, MDA, 8-OHdG, albumin) and lower values during the rainy/winter seasons (MDA, 8-OHdG, albumin, catalase). By contrast, GPx was the only marker to be highest during the rainy season. For the stress markers, higher fGCM concentrations were noted during the rainy season, which contrasts with earlier studies showing more activity in the winter (tourist season). Positive correlations were found between THI and ROS, GPx, and fGCM, while a negative correlation was observed with serum albumin. Elephant endotheliotropic herpesvirus (EEHV) shedding events were associated with higher concentrations of ROS and MDA, although only in some elephants. A moderate negative correlation was observed between 8-OHdG and the PCR threshold cycle of EEHV shedding (Ct), indicating DNA damage may be involved in EEHV shedding in elephants. Results revealed significant age and seasonal effects on several oxidative stress markers, indicating those factors should be considered in study design and data interpretation. There also may be physiological adaptations in oxidative stress conditions in relation to environmental changes that could impact health outcomes.

V. Krishnaswamy, N. Singh, M. Sharma, N. Verma & A. Verma

Application of CRISP-DM methodology for managing human-wildlife conflicts: An empirical case study in India

Journal of Environmental Planning and Management 66 (2023) 2247-2273

Abstract. Human-wildlife conflict (HWC) is a major concern for protected area management. Managing HWC around protected areas requires structured and replicable processes to reduce subjectivity and promote adherence to good governance principles. The Cross-Industry Standard Process for Data Mining (CRISP-DM) is a widely-used process model for structured decision-making. This study demonstrates the novel application of CRISP-DM to HWC related decision-making. We apply CRISP-DM and conduct hotspot and temporal (monthly) analysis of HWC data from Ramnagar Forest Division, India. Based on the patterns of crop loss, livestock loss, and human loss, we propose conflict-type and species-specific preventive strategies. A qualitative assessment of the initial outcomes of the ongoing implementation finds the preventive strategies to be effective. We suggest a participatory approach, localization of strategy, and need for data management as opportunities for improvement. © 2022 Newcastle University.

M.J. Kurz & J.R. Hutchinson

Visual feedback influences the consistency of the locomotor pattern in Asian elephants (*Elephas maximus*)

Biology Letters 19 (2023) e20230260

Abstract. Elephants are atypical of most quadrupeds in that they maintain the same lateral sequence footfall pattern across all locomotor speeds. It has been speculated that the preservation of the footfall patterns is necessary to maintain a statically stable support polygon. This should be a particularly important constraint in large, relatively slow animals. This suggests that elephants must rely on available sensory feedback mechanisms to actively control their massive pillar-like limbs for proper foot placement and sequencing. How the nervous system of elephants integrates the available sensory information for a stable gait is unknown. Here we explored the role that visual feedback plays in the control of the locomotor pattern in Asian elephants. Four Asian elephants walked with and without a blindfold as we measured their stride time intervals. Coefficient of variation was used to assess changes in the overall variability of the stride time intervals, while approximate entropy was used to measure the stride-to-stride consistency of the time intervals. We show that visual feedback plays a role in the stride-to-stride consistency of the locomotor

pattern in Asian elephants. These results suggest that elephants use visual feedback to correct and maintain proper sequencing of the limbs during locomotion. © 2023 The Authors.

C.A. LaDue, K.E. Hunt, W.K. Kiso & E.W. Freeman

Hormonal variation and temporal dynamics of musth in Asian elephants (*Elephas maximus*) are associated with age, body condition and the social environment

Conservation Physiology 11 (2023) coad019

Abstract. The sustainability of endangered Asian elephants in human care is threatened in part by low breeding success and concerns over individual animal wellbeing. Male elephants have received less research attention compared to females, yet males deserve special consideration due to their unique reproductive biology (particularly the sexual state of "musth") and the complex interaction of physiological, environmental, and social pressures they face. We measured fecal androgen metabolites (FAMs), fecal glucocorticoid metabolites (FGMs), and fecal triiodothyronine metabolites (FT3s) collected weekly over approximately 12 months from 26 male Asian elephants housed in zoos across the US, hypothesizing that FAM, FGM, and FT3 concentrations would be associated with temporal correlates of musth and would vary further with intrinsic (musth status, age, body condition) and extrinsic (social environment) factors. The duration of each musth episode was positively associated with exposure to male conspecifics and negatively associated with body condition. Further, elevated FAM concentrations were associated with social exposure, age, and body condition, and FGM concentrations also varied with age and body condition. FT3 concentrations were not associated with any factor we measured. We also identified periods of lower FAM concentration than confirmed musth episodes (but still higher than baseline FAM concentrations) that we termed "elevated FAM episodes." The durations of these episodes were negatively correlated with exposure to other male elephants. Together, these results provide evidence that hormone profiles (including those that are predicted to change around musth) vary significantly between male Asian elephants in a way that may be attributed to intrinsic and extrinsic factors. Studies like these serve to enhance the sustainability of ex-situ populations by providing wildlife managers with information to enhance the health, welfare, and reproduction of threatened species like Asian elephants. © 2023 The Authors.

C.A. LaDue & R.J. Snyder

Asian elephants distinguish sexual status and identity of unfamiliar elephants using urinary odours

Biology Letters 19 (2023) e20230491

Abstract. Despite the ubiquity of odours in mammals, few studies have documented the natural olfactory abilities of many 'non-model' species such as the Asian elephant. As Asian elephants are endangered, we may apply odours to more effectively manage threatened populations. We implemented a habituation–discrimination paradigm for the first time in Asian elephants to test the ability of elephants to discriminate between unfamiliar male elephant urine, hypothesizing that elephants would successfully distinguish non-musth from musth urine and also distinguish identity between two closely related individuals. We conducted two bioassay series, exposing three female and three male zoo-housed elephants to the same urine sample (non-musth urine in the first series, and urine from an unfamiliar individual in the second) over 5 days. On the sixth day, we simultaneously presented each elephant with a novel sample (either musth urine or urine from a second unfamiliar individual) alongside the habituated urine sample, comparing rates of chemosensory response to each sample to indicate discrimination. All elephants successfully discriminated non-musth from musth urine, and also urine from two unfamiliar half-brothers. Our results further demonstrate the remarkable olfactory abilities of elephants with promising implications for conservation and management. © 2023 The Authors.

P. Lakshmi, M. Karikalan, G.K. Sharma, K. Sharma, C.S. Mohan, R.K. Kumar, K. Miachieo, A. Kumar, M.K. Gupta, R.K. Verma, N. Sahoo, G. Saikumar & A.M. Pawde

Pathological and molecular studies on elephant endotheliotropic herpesvirus haemorrhagic disease among captive and free-range Asian elephants in India

Microbial Pathogenesis 175 (2023) e105972

Abstract. In the present research pathology and molecular diagnosis of elephant endotheliotropic herpes virus-haemorrhagic disease (EEHV-HD) among Asian elephants was studied. Out of 76 cases, 20 were positive for EEHV infection in PANPOL and POL1 based seminested PCR. Out of 20 samples, 10 samples were fatal cases of EEHV-HD while 10 were of either subclinical or latent infection. Acute onset haemorrhagic disease with EEHV-HD had anorexia, facial and neck swelling, cyanotic buccal mucosa and tongue, nasal and ocular discharge, and colic. The hallmark of gross finding in all cases were severe haemorrhagic lesions in the internal organs viz. cyanosis of tongue with multifocal petechial haemorrhages, diffuse epicardial and endocardial haemorrhages, swollen liver (rounded edges) with parenchymal haemorrhages, serosal and mucosal haemorrhages in gastrointestinal tract, congested kidneys with corticomedullary haemorrhages, highly congested meninges, and brain capillaries with haemorrhages. Microscopic findings in all the cases had severe vascular changes in the visceral organs. Microthrombi was present in the vasculature of tongue, heart, lung, liver, kidney, and brain. The endothelial lining of most of the blood vessels were swollen with apoptotic changes. Amphophilic to basophilic intranuclear inclusion bodies were observed in the endothelial cells. Immunostaining using anti-EEHV DNAPOL hyperimmune sera revealed intense positive signals in the endothelium of blood vessels and their walls. Quantification of viral load in necropsy tissue samples revealed highest in the heart and least in the brain. The PCR amplicons from EEHV1 specific genes (POL1(U38) and TER were subjected to partial genome sequencing which had 99.9% similarity with the EEHV1A subtype. It was concluded that Asian elephants in India are latently infected for EEHV1 and in all the fatal EEHV-HD cases, EEHV1A subtype was the causative agent with characteristic pathomorphological changes in visceral organs.

L.D. Lalande, V. Lummaa, H.H. Aung, W. Htut, U.K. Nyein, V. Berger & M. Briga

Sex-specific body mass ageing trajectories in adult Asian elephants

Evolutionary Biology 35 (2022) 752-762

Abstract. In species with marked sexual dimorphism, the classic prediction is that the sex which undergoes stronger intrasexual competition ages earlier or quicker. However, more recently, alternative hypotheses have been put forward, showing that this association can be disrupted. Here, we utilize a unique, longitudinal data set of a semi-captive population of Asian elephants, a species with marked male-biased intrasexual competition, with males being larger and having shorter lifespans, and investigate whether males show earlier and/or faster body mass ageing than females. We found evidence of sex-specific body mass ageing trajectories: adult males gained weight up to the age of 48 years old, followed by a decrease in body mass until natural death. In contrast, adult females gained body mass with age until a body mass decline in the last year of life. Our study shows sex-specific ageing patterns, with an earlier onset of body mass declines in males than females, which is consistent with the predictions of the classical theory of ageing.

W. Li, P. Liu, N. Yang, H. Pan, S. Chen & L. Zhang

Spatio-temporal trend and mitigation of human-elephant conflict in Xishuangbanna, China

J. of Wildlife Management 87 (2023) e22485

Abstract. With strict enforcement of the legal protection for Asian elephants (*Elephas maximus*) in China, the elephant population has steadily increased from 146 elephants in 1976 to over 300 elephants in 2023. More elephants occur in highly fragmented and human-dominated landscapes, resulting in serious human–elephant conflicts (HEC). We investigated the temporal and spatial aspects of HEC in Xishuangbanna Prefecture, China, from 2011–2015 and 2016–2020. We analyzed the characteristics of crop raiding, property damage, and human injury and death by elephants. Then, we employed a multi-model ensemble forecasting framework to perform a risk assessment, and compared the changes in HEC hotspots to explore the factors influencing conflict. Our data revealed that 91,311 HEC compensations were recorded from 2011–2020 with a total compensation amount of 127.01 million yuan (17.40 million

USD), 89.75% of which was crop compensation. Areas of risk in 2011–2015 and 2016–2020 were 2,505 km^2 and 3,157 km^2, respectively, with an increase in area of 26.01%. The HEC risk areas were mainly distributed in nature reserves and surrounding areas, and >65% of the risk areas were located in land-use types dominated by artificial planting. Distance to farmland, distance to sparse wood, and slope had the greatest relative importance in the risk model evaluation. The mitigation measures that we recommend include strengthening the monitoring system for Asian elephants in areas with current and potential HEC risks; improving compensation mechanisms, such as determining accurate annual premiums, establishing a shared loss compensation mechanism, and ensuring a fair, transparent, and timely compensation process; and proposing habitat conservation measures, such as restoring suitable habitats for Asian elephants, establishing ecological corridors between nature reserves, and creating a nature reserve system based on the Asian Elephant National Park to enhance the habitat of Asian elephants. © 2023 The Wildlife Society.

X. Li, P. Wang, Q. Pan, G. Liu, W. Liu, O. Omotoso, J. Du, Z. Li, Y. Yu, Y. Huang, P. Zhu, M. Li & X. Zhou

Chromosome-level Asian elephant genome assembly and comparative genomics of long-lived mammals reveal the common substitutions for cancer resistance

Aging Cell 22 (2023) e13917

Abstract. The naked mole rat (*Heterocephalus glaber*), bats (e.g., genus *Myotis*), and elephants are known as long-lived mammals and are assumed to be excellent cancer antagonists. However, whether there are common genetic changes underpinning cancer resistance in these long-lived species is yet to be fully established. Here, we newly generated a high-quality chromosome-level Asian elephant genome and identified that the expanded gene families in elephants are involved in Ras-associated and base excision repair pathways. Moreover, we performed comparative genomic analyses of 12 mammals and examined genes with signatures of positive selection in elephants, naked mole rat, and greater horseshoe bat. Residues at positively selected sites of CDR2L and ALDH6A1 in these long-lived mammals enhanced the inhibition of tumor cell migration compared to those in short-lived relatives. Overall, our study provides a new genome resource and a preliminary survey of common genetic changes in long-lived mammals. © 2023 The Authors.

L.L. Longren, L. Eigen, A. Shubitidze, J.A. Nyakatura, T. Hildebrandt & M. Brecht

Dense reconstruction of elephant trunk musculature

Current Biology 33 (2023) 4713-4720

Abstract. The elephant trunk operates as a muscular hydrostat and is actuated by the most complex musculature known in animals. Because the number of trunk muscles is unclear, we performed dense reconstructions of trunk muscle fascicles, elementary muscle units, from microCT scans of an Asian baby elephant trunk. Muscle architecture changes markedly across the trunk. Trunk tip and finger consist of about 8,000 extraordinarily filigree fascicles. The dexterous finger consists exclusively of microscopic radial fascicles pointing to a role of muscle miniaturization in elephant dexterity. Radial fascicles also predominate (at 82% volume) the remainder of the trunk tip, and we wonder if radial muscle fascicles are of particular significance for fine motor control of the dexterous trunk tip. By volume, trunk-shaft muscles comprise one-third of the numerous, small radial muscle fascicles; two-thirds of the three subtypes of large longitudinal fascicles (dorsal longitudinals, ventral outer obliques, and ventral inner obliques); and a small fraction of transversal fascicles. Shaft musculature is laterally, but not radially, symmetric. A predominance of dorsal over ventral radial muscles and of ventral over dorsal longitudinal muscles may result in a larger ability of the shaft to extend dorsally than ventrally and to bend inward rather than outward. There are around 90,000 trunk muscle fascicles. While primate hand control is based on fine control of contraction by the convergence of many motor neurons on a small set of relatively large muscles, evolution of elephant grasping has led to thousands of microscopic fascicles, which probably outnumber facial motor neurons. © 2023 The Authors.

M. Macías-Rioseco, J. Ochoa & F.A. Uzal

Salmonellosis in elephants in managed care: Report of 2 cases and literature review

Journal of Veterinary Diagnostic Investigation 35 (2023) 295-299

Abstract. In animals, salmonellosis is seen typically as enteritis and/or septicemia. Subclinical infection also occurs, and outwardly healthy animals can serve as reservoirs of infection. Reports of salmonellosis in elephants are rare, limited to a few serovars, and the gross and microscopic lesions of enteric salmonellosis in this species have not been described in detail. We present here, in 2 elephants in managed care settings, cases of salmonellosis that resulted from infection by *Salmonella enterica serovar* and *S. enterica serovar*, serovars that have not been described previously as the cause of salmonellosis in elephants, to our knowledge. We also review the literature on salmonellosis in elephants. Animal A, an adult Asian elephant that was euthanized because of gastrointestinal hemorrhage, had multifocal, necrotizing, suppurative enterocolitis, and necrotizing gastritis. Animal B, an adult African elephant with chronic, recurrent colic, followed by death, had necrotizing typhlocolitis. The origin of infection was not determined in either case. The animals came from different facilities and did not have a common feed source. Previously reported cases of salmonellosis in elephants were caused by *Salmonella* Dublin, *Salmonella* Typhimurium, or *Salmonella* Enteritidis. The definitive diagnosis of salmonellosis is made based on compatible gross and microscopic lesions, coupled with the detection of *Salmonella* spp. in the affected tissues. Effective biosecurity should be adopted to minimize the risk of salmonellosis in elephants in managed care. © 2023 The Authors.

R. Manuel, P.M. Deepa, A. Unni, L. John & C.K. Deepa

Lipoarabinomannan (LAM) – A potential biomarker for the diagnosis of tuberculosis from the urine of infected elephants

European J. of Wildlife Research 69 (2023) e13

Abstract. No permission to print abstract.

D. Milda, K. Ashish, T. Ramesh, R. Kalle & M. Thanikodi

Evaluation of anthropogenic pressure on the occupancy patterns of large mammals in the Western and Eastern Ghats

Landscape Ecology 38 (2023) 409-422

Abstract. No permission to print abstract.

K. Mizuno, A.D.G. Ranjeewa, N. Kutsukake & K.U.K.G. Padmalal

Collective movements during visits to water bodies in wild Asian elephants

Journal of Ethology 41 (2023) 223-230

Abstract. No permission to print abstract.

F.M. Molenaar, M. Rowcliffe & A. Lakey

Adaptation of a point-of-care canine progesterone test for use of parturition prediction in captive Asian elephants (*Elephas maximus*): Proof of concept

J. of Zoo and Wildlife Med. 53 (2023) 791-796

Abstract. In the Asian elephant the levels of progesterone products 5α-pregnane, 3α-hydroxypregnane, and 17α-progesterone are elevated during pregnancy. Detection of a sudden decrease in blood progesterone product levels in the final days of pregnancy is considered an objective way of predicting impending parturition. Point-of-care (POC) tests eliminate the cost involved in transporting samples to an external laboratory and provide an almost instant result, facilitating decision-making for animal monitoring and management. This proof-of-concept study aims to investigate the ability of the Ag-Plus POC immunoassay system to measure 4-pregnen-3,20-dione in pregnant elephant serum samples and adapt the method for detection of the preparturient progesterone decrease. Frozen serum samples of two pregnant elephants (N = 82) and fresh serum samples of one pregnant elephant (N = 10) were analyzed using both the POC method and a radioimmunoassay in a reference laboratory. Statistical analysis of the data showed that there was no significant difference between the two methods for detection of the progesterone drop, indicating that the POC method can be considered appropriate for use in elephant parturition prediction. Refinement of the methodology, an increase of sample size, and temporal tandem radioimmunoassay would be required to further validate this method for use in elephant reproductive management. © 2022 American Assoc. of Zoo Veterinarians.

P. Monaghan & E.R. Ivimey-Cook

No time to die: Evolution of a post-reproductive life stage

Journal of Zoology 321 (2023) 1-21

Abstract. In some species, permanent curtailment of reproduction part-way through the

lifespan of adult females is a feature of their evolved life history. The existence of such a post-reproductive life stage is apparently rare; reasonably robust evidence for this is confined to only six species (humans, Asian elephants and four whales). That it occurs at all appears to contradict our view of natural selection operating to maximize fitness and special circumstances must exist to explain its occurrence. We evaluate the main hypotheses posited to explain the evolution of this life stage, why it occurs in a restricted group of animals, and why only in females. We bring together literature from multiple biological disciplines and levels of enquiry, ranging through evolutionary ecology, developmental biology, physiology, neuroscience, molecular biology, and human medicine. We conclude that while time-limited fertility is not in itself adaptive, the duration of subsequent survival is likely to be linked to inclusive fitness benefits. We present a new hypothesis which posits that the duration of female fertility in certain long-lived, highly encephalised species, with no post-natal oogenesis, is limited by the need for intense screening of oocyte mitochondria. This is required to support endothermy coupled with the very high energy requirement for the development and maintenance of the exceptionally large brain size required for complex social living. This limits the number and shelf-life of oocytes, creating an antagonistically pleotropic effect that is beneficial to the production of high performing offspring but carries the later life cost of time-limited female fertility. But the end of the fertile period is no time to die. Inclusive fitness benefits arising from protracted parental care of offspring, overlapping generations, and kin group structures means that continued survival of post-reproductive females is favoured by selection. We suggest further lines of research to test these ideas.

S. Montero-De La Torre, S.L. Jacobson, M. Chodorow1, M. Yindee & J.M. Plotnik

Day and night camera trap videos are effective for identifying individual wild Asian elephants

PeerJ 11 (2023) e15130

Abstract. Regular monitoring of wild animal populations through the collection of behavioral and demographic data is critical for the conservation of endangered species. Identifying individual Asian elephants, for example, can contribute to our understanding of their social dynamics and foraging behavior, as well as to human-elephant conflict mitigation strategies that account for the behavior of specific individuals involved in the conflict. Wild elephants can be distinguished using a variety of different morphological traits—e.g., variations in ear and tail morphology, body scars and tumors, and tusk presence, shape, and length—with previous studies identifying elephants via direct observation or photographs taken from vehicles. When elephants live in dense forests like in Thailand, remote sensing photography can be a productive approach to capturing anatomical and behavioral information about local elephant populations. While camera trapping has been used previously to identify elephants, here we present a detailed methodology for systematic, experimenter differentiation of individual elephants using data captured from remote sensing video camera traps. In this study, we used day and night video footage collected remotely in the Salakpra Wildlife Sanctuary in Thailand and identified 24 morphological characteristics that can be used to recognize individual elephants. A total of 34 camera traps were installed within the sanctuary as well as crop fields along its periphery, and 107 Asian elephants were identified: 72 adults, 11 sub-adults, 20 juveniles, and four infants. We predicted that camera traps would provide enough information such that classified morphological traits would aid in reliably identifying the adult individuals with a low probability of misidentification. The results indicated that there were low probabilities of misidentification between adult elephants in the population using camera traps, similar to probabilities obtained by other researchers using handheld cameras. This study suggests that the use of day and night video camera trapping can be an important tool for the long-term monitoring of wild Asian elephant behavior, especially in habitats where direct observations may be difficult.

A.M. Moore, A. Hartstone-Rose & D. Gonzalez-Socoloske

Review of sensory modalities of sirenians and the other extant Paenungulata clade

Anatomical Record 305 (2022) 715-735

Abstract. Extant members of Paenungulata (sirenians, proboscideans, and hyracoideans) form a monophyletic clade which originated in Africa. While paenungulates are all herbivorous, they differ greatly in size, life history, and habitat. Therefore, we would expect both phylogenetically related similarities and ecologically driven differences in their use and specializations of sensory systems, especially in adaptations in sirenians related to their fully aquatic habitat. Here we review what is known about the sensory modalities of this clade in an attempt to better elucidate their sensory adaptations. Manatees have a higher frequency range for hearing than elephants, who have the best low-frequency hearing range known to mammals, while the hearing range of hyraxes is unknown. All paenungulates have vibrissae assisting in tactile abilities such as feeding and navigating the environment and share relatively small eyes and dichromatic vision. Taste buds are present in varying quantities in all three orders. While the olfactory abilities of manatees and hyraxes are unknown, elephants have an excellent sense of smell which is reflected by having the relatively largest cranial nerve related to olfaction among the three lineages. Manatees have the relatively largest trigeminal nerve—the nerve responsible for, among other things, mystacial vibrissae—while hyraxes have the relatively largest optic nerve (and therefore, presumably, the best vision) among the Paenungulata. All three orders have diverged significantly; however, they still retain some anatomical and physiological adaptations in common with regard to sensory abilities.

A. Nath, B.P Lahkar, N. Brahma, P. Sarmah, A.K. Das, S. Das, T. Basumatary, R. Islari & A. Swargowari

Breaking dawn: Factors influencing mammalian habitat usage in western Assam following socio-political instability

J. for Nature Conservation 72 (2023) e126357

Abstract. The impacts of conflict on nature are devastatingly adverse but differ widely in different socio-economic-political regimes. Armed conflict often facilitates illegal plunder and unsustainable use of natural resources. We studied the response of mammals in Ripu (605.27 km^2, westernmost part of Manas Tiger Reserve) Reserved Forest (RF) in Assam, India that suffers prolonged anthropogenic pressures due to armed conflict instigated by social unrest. We used standard single-season occupancy models using sign survey to assess factors affecting the space use of mammals. Our study revealed that Ripu RF has a high proportion of area occupied by prey species of large carnivores. Asian elephant, barking deer, and wild pig occupied most of the habitat, whereas gaur, sambar and spotted deer restricted themselves to selected patches. The probability of a site being occupied by the majority of ungulates declines with an increase in anthropogenic activities, including distance to human settlement (measure of prolonged disturbance) and an increase in the proportion of secondary degraded forest. Common leopard was found to be positively associated with prey occupancy and increase in semievergreen and moist-mixed deciduous forest. Our ground efforts to strengthen community patrolling and operational execution of various alternative livelihoods has helped to improve the economic condition of patrolling staff. Strategic implementation of law enforcement could support dispersal of tigers from Phibsoo Wildlife Sanctuary (Bhutan), potentially linked to the larger tiger and elephant landscape far west (Buxa Tiger Reserve in West Bengal) in the Terai region of India. Various community-based conservation initiatives and strategies with sustained support from various agencies, including national, international, and local bodies, is required to restore this critical habitat.

M. Nayak & P.K. Swain

Human-elephant interaction: Community perspectives on conflict mitigation and conservation mechanisms

Journal of Public Affairs 23 (2023) e2820

Abstract. The instances of human-elephant conflict (HEC) are becoming pervasive in elephant range areas across the globe. One of the primary reasons is the exclusion and under-representation of local communities in the planning and implementation of mitigation strategies. However, engaging with local communities and considering their viewpoints are vital for the success of conflict mitigation and conservation efforts. This qualitative study was undertaken to gain a reasonably comprehensive understanding

of the local community's perspectives concerning elephants in the Balasore district of Odisha, a state along the Eastern coast of India. Qualitative data obtained primarily through focus group discussions were analyzed using MAXQDA 2020 to perform thematic analysis of participants' narratives. Six common themes emerged from the study: exposure and experiences with elephants, the efficacy of deterrents, compassionate payment provisions, reasons for tolerance, and expectations. Attempts were made to understand the community viewpoints and offer implementable recommendations to improve human–elephant interactions by adopting more inclusive and participatory conservation practices.

V.V. Nguyen, H.T.T. Nguyen, T.T.T. Phan & C.-H. Lee

Determinants of locals' willingness to participate in human-elephant conflict management: Evidence from Dong Nai Biosphere Reserve, Vietnam

Trees, Forests and People 14 (2023) e100435

Abstract. Human-elephant conflict (HEC) poses a significant threat to the conservation of Asian elephants and the well-being of local communities in the tropical forests of Asia. As local communities play a crucial role in HEC reduction, their engagement is essential for the success and sustainability of HEC management strategies. This study employs exploratory factor analysis and a logistic regression model to examine the key determinants influencing the participation of locals in HEC management within the Dong Nai Biosphere Reserve (DNBR). The findings indicate that improvements in elephant habitat and land use have the most substantial positive impact on locals' participation in HEC management, followed by policies for HEC reduction, local perception of the benefits associated with elephants, and measures for HEC prevention and mitigation. In terms of demography, individuals' education levels exhibit the highest positive influence on their involvement in HEC management, followed by income, and occupation. These research findings contribute to a broader understanding of human-wildlife conflicts and underscore the significance of community engagement in conservation efforts. By identifying the factors that influence local participation in HEC management, this study aims to inform future initiatives and policies aimed at mitigating conflicts between humans and elephants, while promoting coexistence and sustainable development in the DNBR. © 2023 The Authors.

T.D. Nguyen, H. Li, Y. Zhuang, B. Chen, K. Kinoshita, M.A. Jamal, K. Xu, J. Guo, D. Jiao, K. Tanabe, Y. Wei, Z. Li, W. Cheng, Y. Qing, H.-Y. Zhao & H.-J. Wei

In vitro and in vivo development of interspecies Asian elephant embryos reconstructed with pig enucleated oocytes

Animal Biotechnology 34 (2023) 1909-1918

Abstract. Interspecies somatic cell nuclear transfer (iSCNT) has an immense potential to rescue endangered animals and extinct species like mammoths. In this study, we successfully established an Asian elephant's fibroblast cell lines from ear tissues, performed iSCNT with porcine oocytes and evaluated the in vitro and in vivo development of reconstructed embryos. A total of 7780 elephant-pig iSCNT embryos were successfully reconstructed and showed in vitro development with cleavage rate, 4-cell, 8-cell and blastocyst rate of 73.01, 30.48, 5.64, and 4.73%, respectively. The total number of elephant-pig blastocyte cells and diameter of hatched blastocyte was 38.67 and 252.75 μm, respectively. Next, we designed species-specific markers targeting EDNRB, AGRP and TYR genes to verify the genome of reconstructed embryos with donor nucleus/species. The results indicated that 53.2, 60.8, and 60.8% of reconstructed embryos (n = 235) contained elephant genome at 1-cell, 2-cell and 4-cell stages, respectively. However, the percentages decreased to 32.3 and 32.7% at 8-cell and blastocyst stages, respectively. Furthermore, we also evaluated the in vivo development of elephant–pig iSCNT cloned embryos and transferred 2260 reconstructed embryos into two surrogate gilts that successfully became pregnant and a total of 11 (1 and 10) fetuses were surgically recovered after 17 and 19 days of gestation, respectively. The crown-rump length and width of elephant–pig cloned fetuses were smaller than the control group. Unfortunately, none of these fetuses contained elephant genomes, which suggested that elephant embryos failed to develop in vivo. In conclusion, we successfully obtained elephant–pig reconstructed embryos for the first time and

these embryos are able to develop to blastocyst, but the in vivo developmental failure needs further investigation. © 2022 Taylor & Francis Group, LLC.

J.S. Nordin, N.K. Matthew & C.L. Puan

Public willingness to pay for an entrance fee to National Elephant Conservation Center (NECC), Peninsular Malaysia

Sage Open 13 (2023) e4

Abstract. Wildlife especially large mammals such as elephants are an important part of an ecosystem providing various ecological functions and services, although they are often involved in human-wildlife conflict. The National Elephant Conservation Center (NECC) in the Pahang state of Peninsular Malaysia was established to ensure that the survival of the Asian elephant (*Elephas maximus*) in Peninsular Malaysia through direct management, as well as educational and public awareness activities. However, no entrance fee has been imposed since the establishment of the center in 1989 (32 years). This study aimed to determine public willingness to pay for an entrance fee in the NECC. By using the open-ended contingent valuation method (CVM), the mean public willingness to pay for an entrance fee in the NECC during the non-peak season amounted to RM4.65/person/visit whereas it was RM7.09/person/visit during the peak season. The study would serve as a reference for entrance fee implementation for a conservation center as a form of financial aid to sustain the center as well as highlight the importance of public engagement in elephant conservation. © 2023 The Authors.

L. Ong, K.R. McConkey & A. Campos-Arceiz

The ability to disperse large seeds, rather than body mass alone, defines the importance of animals in a hyper-diverse seed dispersal network

Journal of Ecology 110 (2022) 313-326

Abstract. Large-bodied animals play irreplaceable roles in seed dispersal, partly due to their capacity to disperse large seeds. Understanding this role at a community level has been limited by the paucity of network studies that include large vertebrates, and the almost complete absence of studies including synzoochoric dispersers. Synzoochoric dispersers can disperse seeds disproportionately large for their body size, potentially overlapping the roles of large-bodied animals. A comprehensive network, inclusive of large vertebrates and synzoochorous dispersers, is imperative to understand seed dispersal at a community level. Here, we analysed the seed dispersal network of a hyper-diverse Sundaic forest in Malaysia using local ecological knowledge and including multiple forms of endozoochorous and synzoochorous dispersal. We evaluated the extent to which three disperser traits: body mass, seed-handling ability (size of the largest seed dispersed) and diet explained the importance of animals in the network. We evaluated dispersers' relative importance using four network metrics—degree of specialisation (nested rank), species strength, within-module connectivity (z-value) and between-modules connectivity (c-value). We found that seed-handling ability had the biggest effect on a disperser's importance, with strong effects on three network metrics (species strength, ecological specialisation and z-value) and moderate effects on connectivity between modules. Body mass was important in defining interactions within modules, and dietary differences defined the ecological specialisation of species in seed dispersal. Important dispersers in our network were large-seed dispersers (e.g. rats, gibbons), large-bodied animals, in particular the Asian elephant, and animals with frugivorous diets such as hornbills. Our work uncovers the significance of seed-handling ability in identifying pivotal seed dispersal roles in tropical rainforests. Key dispersers include large-bodied herbivores and medium-sized frugivores that could disperse large seeds by endozoochory, and smaller rodents that dispersed similar-sized seeds by synzoochory. Many of the species that emerged as particularly important for the seed dispersal network are currently threatened (e.g. the Asian elephant, gibbons and hornbills). Their protection or reintroduction should be a top conservation priority. © 2021 British Ecological Society.

L. Ong, W.H. Tan, L.C. Davenport, K.R. McConkey, M.K.A.b.M. Amin, A. Campos-Arceiz & J.W. Terborgh

Asian elephants as ecological filters in Sundaic forests

Frontiers in Forests and Global Change 6 (2023) e1143633

Abstract. Megaherbivores exert strong top-down influence on the ecosystems they inhabit, yet little is known about the foraging impacts of Asian elephants on the structure of Southeast Asia's rainforests. Our goal was to document elephants' dietary composition, selectivity, and foraging impacts in a Sundaic rainforest and test whether these differed between habitats. We conducted controlled direct observations of five wild-born captive elephants feeding on six plant types (bamboo, grass, monocot herbs, palms, lianas, and trees) of different age classes in two habitats (mature vs. early successional forest) in Krau, Peninsular Malaysia. Palms, trees, and lianas formed the bulk of the elephants' diet. In the mature forest, elephants showed a strong preference for monocots (preference ratio, PR = 5.1), particularly large palms (PR = 5.4), while trees were negatively selected (PR = 0.14). Conversely, in early successional habitats, large tree saplings were positively selected (PR = 1.6). Elephants uprooted (30%) and broke the main stem (30%) of the dicot trees, mainly large saplings, that they handled. Tree saplings broken by elephants had an average diameter of 1.7 ± 1.1 cm (up to 7 cm), with breaks happening at 1.1 ± 0.5 m of height. We estimated that, in a year, an elephant could damage around 39,000 tree saplings if it fed entirely in mature forest, and almost double the number (73,000) if it fed solely in early successional habitats. Assuming a density of 0.05–0.18 elephants/km^2, elephant foraging could damage 0.2–0.6% of the tree sapling population per year. Slow growth rates of understory plants in mature forests could result in negative feedbacks, whereby elephants suppress palms, other monocots, and highly preferred tree species. Alternatively, elephants may initiate positive feedbacks by impeding succession along forest edges and in semi-open environments, thereby increasing the size of gaps and the availability of their preferred food plants. Overall, our results show that Asian elephants act as ecological filters by suppressing the plants they prefer in Southeast Asia's rainforests. © 2023 The Authors.

S. Osorio, J. Soto, D. Schmitt, W. Kiso & C. Cray

Preliminary assessment of serum capillary zone electrophoresis in the Asian elephant (*Elephas maximus*)

Frontiers in Vet. Science 10 (2023) e1204880

Abstract. Serum protein electrophoresis has been demonstrated to have utility in diagnostic workup, wellness exams, and prognosis. Agarose gel electrophoresis (AGE) has previously been described for use with serum from Asian elephants. As the newer method of capillary zone electrophoresis (CZE) is becoming more commonplace in veterinary diagnostic laboratories, serum samples from Asian elephants were examined using this method. CZE allowed for a reproducible definition of two beta fractions and, overall, showed a low coefficient of variation for fraction quantitation. Preliminary reference intervals were generated using samples primarily from an older population of 22 female elephants. Albumin levels determined by CZE were also compared with those determined by the bromocresol green method on a chemistry analyzer. It was found that the latter method overestimated the level of albumin with a mean positive bias of 11.6% or 0.38 g/dl, thus method-specific reference intervals should be used. Significant negative correlations were observed between A/G ratio determined by CZE and serum amyloid A levels ($p < 0.001$) and haptoglobin ($p < 0.001$); both APP were significantly correlated with the alpha 2 globulin fraction ($p < 0.001$). CZE reflects an overall picture of changes in acute phase proteins and immunoglobulins and accurate quantitation of albumin and thus should be considered as an adjunct tool to the use of other measures of the acute phase response in patient monitoring. © The Authors.

U. Panja & B. Mistri

Appraisal on human-elephant conflict in multifunctional landscape of the mayurjharna elephant reserve in India

GeoJournal 88 (2023) 4717-4740

Abstract. No permission to print abstract.

B. Pant, H.P. Sharma, B.R. Dahal, S. Regmi & J.L. Belant

Spatio-temporal patterns of human-wildlife conflicts and effectiveness of mitigation in Shuklaphanta National Park, Nepal

PLoS One 18 (2023) e0282654

Abstract. Human-wildlife interactions occur where human and wildlife coexist and share common resources including food or shelter. In-

creasing wildlife populations within protected areas also can increase interactions with humans living adjacent to these areas, resulting in conflicts including human casualty, livestock depredation, crop damage, and property loss. We analyzed six years human-wildlife conflict data from 2016–2021 in the buffer zone of Shuklaphanta National Park and conducted questionnaire survey to investigate factors influencing human-wildlife conflicts. Nineteen people were attacked by wildlife, primarily wild boar. Ninety-two livestock were killed by leopard, and among these most were sheep or goats killed near ShNP during summer. Crops were most frequently damaged by Asian elephants, followed by wild boar. Greatest economic losses were from damage to rice, followed by sugarcane and wheat. Asian elephant was the only reported species to cause structural damage to property (e.g., homes). Majority of respondents (83%) considered that the mitigation techniques that are currently in practice are effective to reduce the conflicts. However, the effectiveness of the mitigation techniques are the species specific, we recommend use of more efficacious deterrents (e.g., electric fencing) for large herbivores and mesh wire fencing with partially buried in the ground. Effective collaboration among different tiers of government, NGOs, civil societies and affected communities are important to share the best practices and continue to apply innovative methods for impactful mitigation of human-wildlife conflicts in the region.

S.S. Pokharel & J.L. Brown

Physiological plasticity in elephants: Highly dynamic glucocorticoids in African and Asian elephants

Conservation Physiology 11 (2023) coad088

Abstract. Slowly reproducing and long-lived terrestrial mammals are often more at risk from challenges that influence fitness and survival. It is, therefore, important to understand how animals cope with such challenges and how coping mechanisms translate over generations and affect phenotypic plasticity. Rapidly escalating anthropogenic challenges may further diminish an animal's ability to reinstate homeostasis. Research to advance insights on elephant stress physiology has predominantly focused on relative or comparative analyses of a major stress response marker, glucocorticoids (GCs), across different ecological, anthropogenic, and reproductive contexts. This paper presents an extensive review of published findings on Asian and African elephants from 1980 to 2023 (May) and reveals that stress responses, as measured by alterations in GCs in different sample matrices, often are highly dynamic and vary within and across individuals exposed to similar stimuli, and not always in a predictable fashion. Such dynamicity in physiological reactivity may be mediated by individual differences in personality traits or coping styles, ecological conditions, and technical factors that often are not considered in study designs. We describe probable causations under the 'Physiological Dynamicity Model', which considers context–experience–individuality effects. Highly variable adrenal responses may affect physiological plasticity with potential fitness and survival consequences. This review also addresses the significance of cautious interpretations of GCs data in the context of normal adaptive stress versus distress. We emphasize the need for long-term assessments of GCs that incorporate multiple markers of 'stress' and 'well-being' to decipher the probable fitness consequences of highly dynamic physiological adrenal responses in elephants. Ultimately, we propose that assessing GC responses to current and future challenges is one of the most valuable and informative conservation tools we have for guiding conservation strategies.

C. Pongma, S. Songthammanuphap, S. Puthong, A. Buakeaw, T. Prammananan, S. Warit, W. Tipkantha, E. Kaewkhunjob, W. Jairak, P. Kongmakee, C. Pabutta, S. Sripiboon, W. Yindeeyoungyeon & T. Palaga

Using whole blood cultures in interferon gamma release assays to detect *Mycobacterium tuberculosis* complex infection in Asian elephants (*Elephas maximus*)

PLoS ONE 18 (2023) e0288161

Abstract. Elephants are susceptible to *Mycobacterium tuberculosis* (*M. tb*) complex (MTBC) infections. Diagnosis of tuberculosis (TB) in elephants is difficult, and most approaches used for human TB diagnosis are not applicable. An interferon gamma release assay (IGRA) to diagnose TB in Asian elephants (*Elephas maximus*) using peripheral blood mono-

nuclear cells (PBMCs) has been previously developed. Although the assay is shown to be valid in determining MTBC infection status, the laborious PBMC isolation process makes it difficult to use. In this study, we simplified the method by using whole blood cultures (WC) as the starting material. Using PBMC cultures for IGRA, the MTBC infection status of 15 elephants was first confirmed. Among these animals, one has been previously confirmed for *M. tb* infection by both TB culture and PCR and the other was confirmed for MTBC infection in this study by droplet digital PCR (ddPCR) method. WC for IGRA consisted of an unstimulated sample, a mitogen stimulated sample, and sample stimulated with recombinant *M. tb* antigens, ESAT6 and CFP10. Using WC for IGRA in the 15 enrolled elephants, the results showed that 7 out of 15 samples yielded MTBC infection positive status that were completely concordant with those from the results using PBMCs. To test this method, WC for IGRA were applied in another elephant cohort of 9 elephants. The results from this cohort revealed a perfect match between the results from PBMC and WC. Responses to ESAT6 or CFP10 by PBMC and WC were not completely concordant, arguing for the use of at least two *M. tb* antigens for stimulation. Given the ease of sample handling, smaller blood sample volumes and equivalent efficacy relative to the PBMC approach, using WC for IGRA provides a novel, rapid, and user-friendly TB diagnostic method for determining the MTBC infection in elephants.

N.A. Prado, E.E. Armstrong, J.L. Brown, S.Z. Goldenberg, P. Leimgruber, V.R. Pearson, J.E. Maldonado & M.G. Campana

Genomic resources for Asian (*Elephas maximus*) and African savannah elephant (*Loxodonta africana*) conservation and health research

Journal of Heredity 114 (2023) 529-538

Abstract. We provide novel genomic resources to help understand the genomic traits involved in elephant health and to aid conservation efforts. We sequence 11 elephant genomes (5 African savannah, 6 Asian) from North American zoos, including 9 de novo assemblies. We estimate elephant germline mutation rates and reconstruct demographic histories. Finally, we provide an in-solution capture assay to genotype Asian elephants. This assay is suitable for analyzing degraded museum and noninvasive samples, such as feces and hair. The elephant genomic resources we present here should allow for more detailed and uniform studies in the future to aid elephant conservation efforts and disease research.

Raweewan Proyrungroj

Motivations of international volunteer tourists working with elephants in Thailand

Tourism Recreation Res. 48 (2023) 432-448

Abstract. This study examines the motivations of Western volunteer tourists at Elephants-World, Kanchanaburi Province, Thailand. An interpretive paradigm utilizing a qualitative research approach was adopted. The informants included 24 volunteer participants. Data were collected through a combination of semi-structured interviews and participant observation, and were analysed by thematic analysis. The findings of the research identify six main motivations: (i) to have close interactions with elephants; (ii) to gain in-depth understanding of local culture; (iii) to have new experiences; (iv) to relax; (v) a good match between the project/objective of the host organization and the tourists' needs and conditions; and (vi) the image and attractiveness of Thailand. These six motivations represent the co-existence of altruistic and self-interested motivations and their roles in influencing the decisions of animal-related volunteer tourists. They also indicate that while some volunteer respondents were driven by motivational factors related to the protection and well-being of the elephants (which is the objective of the volunteer tourism project), others were motivated by other, more self-interested factors that were not related to the main objective of the project.

D.A. Rahman, R. Herliansyah, B. Subhan, D. Hutasoit, M.A. Imron, D.B. Kurniawan, T. Sriyanto, R.D. Wijayanto, M.H. Fikriansyah, A.F. Siregar & N. Santoso

The first use of a photogrammetry drone to estimate population abundance and predict age structure of threatened Sumatran elephants

Scientific Reports 13 (2023) e21311

Abstract. Wildlife monitoring in tropical rainforests poses additional challenges due to species often being elusive, cryptic, faintly colored, and preferring concealable, or difficult to access habitats. Unmanned aerial vehicles (UAVs) prove promising for wildlife surveys in different ecosystems in tropical forests and can be crucial in conserving inaccessible biodiverse areas and their associated species. Traditional surveys that involve infiltrating animal habitats could adversely affect the habits and behavior of elusive and cryptic species in response to human presence. Moreover, collecting data through traditional surveys to simultaneously estimate the abundance and demographic rates of communities of species is often prohibitively time-intensive and expensive. This study assesses the scope of drones to non-invasively access the Bukit Tigapuluh Landscape (BTL) in Riau-Jambi, Indonesia, and detect individual elephants of interest. A rotary-wing quadcopter with a vision-based sensor was tested to estimate the elephant population size and age structure. We developed hierarchical modeling and deep learning CNN to estimate elephant abundance and age structure. Drones successfully observed 96 distinct individuals at 8 locations out of 11 sampling areas. We obtained an estimate of the elephant population of 151 individuals (95% CI [124, 179]) within the study area and predicted more adult animals than subadults and juvenile individuals in the population. Our calculations may serve as a vital spark for innovation for future UAV survey designs in large areas with complex topographies while reducing operational effort.

R.M. Rajbhandari, R. Napit, P. Manandhar, R. Raut, A. Gurung, A. Poudel, N. Shrestha, A. Sadaula, D. Karmacharya, C. Gortázar, P.C. Alves, J. de la Fuente & J. Queirós

Phylogenomic analysis supports *Mycobacterium tuberculosis* transmission between humans and elephants

Frontiers in Veterinary Science 10 (2023)

Abstract. Tuberculosis is an infectious disease caused by a group of acid-fast bacilli known as *Mycobacterium tuberculosis* complex (MTC), which has a major impact on humans. Transmission of MTC across the human-animal interface has been demonstrated by several studies. However, the reverse zoonotic transmission from humans to animals (zooanthroponosis) has often been neglected. In this study, we used Nanopore MinION and Illumina MiSeq approaches to sequence the whole genome of *M. tuberculosis* strains isolated from two deceased Asian elephants and one human in Chitwan, Nepal. The evolutionary relationships and drug resistance capacity of these strains were assessed using the whole genome data generated by the stand-alone tool Tb-Profiler. Phylogenomic trees were also constructed using a non-synonymous SNP alignment of 2,596 bp, including 94 whole genome sequences representative of the previously described *M. tuberculosis* lineages from elephants worldwide (lineages 1 and 4) and from humans in Nepal (lineages 1, 2 and 3). The new genomes achieved an average coverage of 99.6%, with an average depth of 55.67x. These M. tuberculosis strains belong to lineage 1 (elephant DG), lineage 2 (elephant PK) and lineage 4 (human), and none of them were found to have drug-resistant variants. The elephant-derived isolates were evolutionarily closely related to human-derived isolates previously described in Nepal, both in lineages 1 and 2, providing additional support for zooanthroponosis or bidirectional transmission between humans and elephants. The human-derived isolate clustered together with other published human isolates from Argentina, Russia and the United Kingdom in the lineage 4 clade. This complex multi-pathogen, multi-host system is challenging and highlights the need for a One Health approach to tuberculosis prevention and control at human-animal interface, particularly in regions where human tuberculosis is highly endemic.

L. Raviv, S.L. Jacobson, J.M. Plotnik h& A. Benítez-Burraco

Elephants as an animal model for self-domestication

PNAS 120 (2023) e2208607120

Abstract. Humans are unique in their sophisticated culture and societal structures, their complex languages, and their extensive tool use. According to the human self-domestication hypothesis, this unique set of traits may be the result of an evolutionary process of self-induced domestication, in which humans evolved to be less aggressive and more cooperative. However, the only other species that has been argued to be

self-domesticated besides humans so far is bonobos, resulting in a narrow scope for investigating this theory limited to the primate order. Here, we propose an animal model for studying self-domestication: the elephant. First, we support our hypothesis with an extensive cross-species comparison, which suggests that elephants indeed exhibit many of the features associated with self-domestication (e.g., reduced aggression, increased prosociality, extended juvenile period, increased playfulness, socially regulated cortisol levels, and complex vocal behavior). Next, we present genetic evidence to reinforce our proposal, showing that genes positively selected in elephants are enriched in pathways associated with domestication traits and include several candidate genes previously associated with domestication. We also discuss several explanations for what may have triggered a self-domestication process in the elephant lineage. Our findings support the idea that elephants, like humans and bonobos, may be self-domesticated. Since the most recent common ancestor of humans and elephants is likely the most recent common ancestor of all placental mammals, our findings have important implications for convergent evolution beyond the primate taxa, and constitute an important advance toward understanding how and why self-domestication shaped humans' unique cultural niche. © 2023 The Authors.

M. Rendana, W.M.R. Idris, S.A. Rahim, H.G. Abdo, H. Almohamad & A.A.A. Dughairi

Habitat suitability analysis in a natural peat swamp forest on Sumatran elephants using remote sensing and GIS

Forest Science and Technol. 19 (2023) 221-231

Abstract. It is essential to assess the suitable habitat for elephants in order to mitigate the effects of forest fragmentation on conservation. This study aimed to estimate the potential suitable habitats for Sumatran elephants in the fragmented forest in the Padang Sugihan wildlife reserve area in southern Sumatra, Indonesia. The habitat suitability was analyzed using some environmental factors such as slope, elevation, land cover, distance to rivers, and distance to agricultural areas. The remote sensing, geographic information system (GIS), and MaxEnt model were used to determine the potential habitat suitability for Sumatran elephants. This study revealed areas of suitable habitat were evenly distributed throughout the study area, with the composition being suitable (45%), highly suitable (5%), and less suitable (50%). This study revealed the most suitable habitats were found in dense forest areas (gelam or Melaleuca cajuputi forest), which were highly affected by river adjacency, whereas agricultural areas resulted in constrained suitability and fragmentation of forested areas. As a whole, the estimation of elephant habitat using remote sensing and GIS may guide the development of conservation strategies for elephant conservation in this region. © 2023 The Authors.

Jessica Bell Rizzolo

Wildlife tourism and consumption

J. of Sustainable Tourism 31 (2023) 1181-1194

Abstract. The scant existent literature on the link between wildlife tourism and consumption relies on case studies and does not directly measure attitudes towards wildlife tourism or consumption. This paper uses empirical survey data (N = 12,378) from 12 countries in Europe, Asia, and the Americas to examine the links between wildlife tourism and wildlife consumption, with a particular focus on evaluating forms of wildlife tourism typically considered "non-consumptive." The first set of analyses looked at the full sample and examined the relationships between wildlife tourism participation and (a) acceptability of wildlife consumption and (b) wildlife consumption behavior. The second set of analyses divided the sample by country and by location of the wildlife tourism activity (abroad or at home) and focused on the associations between participation in live animal encounters and wildlife consumption behavior. Models were built for two forms of wildlife consumption: eating/drinking wildlife and purchasing products/souvenirs made from animal parts. The results indicate that participation in entertainment-based live animal encounters is a strong correlate of increased wildlife consumption. Implications for wildlife tourism policies, wildlife consumption research, and wildlife crime prevention are discussed. © 2021 Informa UK Limited.

P. Saengsawang, M. Desquesnes, S. Yangtara, P. Chalermwong, N. Thongtip, S. Jittapalapong & T. Inpankaew

Molecular detection of *Loxodontofilaria* spp. in Asian elephants (*Elephas maximus*) from elephant training camps in Thailand

Comparative Immunology, Microbiology and Infectious Diseases 92 (2023) e101910

Abstract. Filarial infection is an important disease in human and animal medicine. Several filarial worms are of importance, especially nematodes in the Onchocercidae. The Asian elephant is an endangered animal and is very important from several socio-economic and ecological aspects in Thailand. Various parasites can be found in elephants; however, data related to filarial infections in elephants is limited. The objective of this study was to detect filaria in the blood of Asian elephants in Thailand, based on a polymerase chain reaction (PCR) technique. Blood samples were collected from 208 Asian elephants and detected for filaria using PCR, targeting the region of the internal transcribed spacer 2 (ITS2), the cytochrome c oxidase subunit 1 (cox1), and the RNA polymerase II large subunit (rbp1). In total, 4.33% (9 out of 208) of the sampled elephants had *Loxodontofilaria* spp. DNA with 100% query coverage. In addition, the obtained cox1 and rbp1 sequences matched with *Loxodontofilaria* sp., *Onchocerca* sp., and *Dirofilaria* sp. There were no identified risk factors (sex, age, location, and packed cell volume) related to *Loxodontofilaria* infection in elephants. The analyses of the phylogeny of ITS2 sequences demonstrated that the *Loxodontofilaria*-positive sequences were closely related to *Onchocerca dewittei japonica* and *O. d. dewittei* with 100% query coverage. Notably, the concatenated phylogenetic trees of ITS2 and the cox1 and rbp1 genes were closely similar to *Loxodontofilaria* sp. To describe in detail the genomic DNA of *Loxodontofilaria* spp., other genes should be additionally studied using a more discriminatory technique, such as DNA barcoding or whole genome sequencing. © 2022 Reprinted with permission from Elsevier.

L. Scherer, L. Bingaman Lackey, M. Clauss, K. Gries, D. Hagan, A. Lawrenz, D.W.H. Müller, M. Roller, C. Schiffmann & A.-K. Oerke

The historical development of zoo elephant survivorship

Zoo Biology 42 (2023) 328-338

Abstract. In the discussion about zoo elephant husbandry, the report of Clubb *et al*. (2008, Science 322: 1649) that zoo elephants had a "compromised survivorship" compared to certain non-zoo populations is a grave argument, and was possibly one of the triggers of a large variety of investigations into zoo elephant welfare, and changes in zoo elephant management. A side observation of that report was that whereas survivorship in African elephants improved since 1960, this was not the case in Asian elephants. We used historical data (based on the Species360 database) to revisit this aspect, including recent developments since 2008. Assessing the North American and European populations from 1910 until today, there were significant improvements of adult (≥10 years) survivorship in both species. For the period from 1960 until today, survivorship improvement was significant for African elephants and close to a significant improvement in Asian elephants; Asian elephants generally had a higher survivorship than Africans. Juvenile (<10 years) survivorship did not change significantly since 1960 and was higher in African elephants, most likely due to the effect of elephant herpes virus on Asian elephants. Current zoo elephant survivorship is higher than some, and lower than some other non-zoo populations. We discuss that in our view, the shape of the survivorship curve, and its change over time, are more relevant than comparisons with specific populations. Zoo elephant survivorship should be monitored continuously, and the expectation of a continuous trend towards improvement should be met. © 2022 The Authors.

C. Schiffmann, L. Hellriegel, M. Clauss, B. Stefan, K. Knibbs, C. Wenker, T. Hård & C. Galeffi

From left to right all through the night: Characteristics of lying rest in zoo elephants

Zoo Biology 42 (2023) 17-25

Abstract. Despite increased research during the past years, many characteristics of resting behavior in elephants are still unknown. For example, there is only limited data suggesting elephants express longer lying bouts and increased total nightly lying durations on soft substrates as compared to hard surfaces. Additionally, it has not been investigated how frequently elephants change body sides between lying bouts. Here we present these characteristics based on observations of nighttime lying behavior in 10 zoo

elephants (5 African and 5 Asian elephants) living in five different European facilities. We found that elephants housed on soft substrates have significantly increased total lying durations per night and longer average lying bouts. Furthermore, at 70%–85% of all bouts, a consistently higher frequency of side change between lying bouts occurred on soft substrates, leading to an overall equal laterality in resting behavior. Deviations from this pattern became evident in elephants living on nonsand flooring or/and in nondominant individuals of nonfamily groups, respectively. Based on our findings, we consider elephants to normally have several lying bouts per night with frequent side changes, given an appropriate substrate and healthy social environment. We encourage elephant-keeping facilities to monitor these characteristics in their elephants' nighttime behavior to determine opportunities for further improvements and detect alterations putatively indicating social or health problems in elephants at an early stage.

A.L. Schreier, T.S. Readyhough, A. Moresco, M. Davis & S. Joseph

Social dynamics of a newly integrated bachelor group of Asian elephants (*Elephas maximus*): Welfare implications

Journal of Applied Animal Welfare Science 26 (2023) 229-246

Abstract. Male associations are a typical component of elephant society, allowing bulls to practice appropriate social behavior. To improve zoo elephant welfare, it is important to provide bulls with social opportunities. In fall 2018, Denver Zoo added two bull Asian elephants to its existing all-male group of three bulls, offering the opportunity to conduct a systematic behavioral study of the integration of the new bulls into the resident group. We recorded aggressive and affiliative behaviors before, during, and after the introduction of the new males. The proportion of aggressive behavior was significantly higher during the five-month introduction period compared to before their introduction. By the end of the study period, the elephants engaged in significantly more affiliative behavior and less aggressive behavior than during the introduction period, suggesting they had formed a new stable social dynamic. These results suggest group compatibility and positive elephant welfare resulting from housing male elephants together and can be used to inform management plans for bull elephants that prioritize their welfare.

Asmita Sengupta

Animal-mediated seed dispersal in India: Implications for conservation of India's biodiversity

BioTropica 54 (2022) 1320-1330

Abstract. Effective seed dispersal is critical for forest regeneration and recruitment as well as the restoration of degraded lands. Most tropical tree species depend on frugivorous animals to disperse their seeds; frugivore-mediated seed dispersal is thus crucial for biodiversity conservation in megadiverse tropical systems such as India. The fauna in India are increasingly threatened due to anthropogenic interventions such as deforestation and hunting. Thus, it is imperative to have an understanding of plant–frugivore interactions across the country to curb further biodiversity loss by ensuring the maintenance of these ecological processes. In this paper, I reviewed the literature on seed dispersal by animals in India to identify important groups that disperse many plant species and/or are the only recorded dispersers of certain plant species. Hornbills, bulbuls, bears, cattle, deer, civets, elephants, macaques, nilgais, Old World fruit bats, and wild pigs meet these criteria; overall 18 species were included in this list. Six of these species are currently "Threatened" on the IUCN Red List and their loss can lead to limited dispersal for at least 86 plant species. I suggest ensuring the protection of the important seed dispersers identified in this paper, irrespective of their conservation status, to prevent further biodiversity loss. The review reveals that plant–animal interactions in India are understudied and a major knowledge gap exists with regard to seed dispersal networks within the country.

K. Shahi, G. Khanal, R.R. Jha, A.K. Joshi, P. Bhusal & T. Silwal

Characterizing damages caused by wildlife: Learning from Bardia National Park, Nepal

Human Dim. of Wildlife 27 (2022) 173-182

Abstract. Understanding damages caused by wildlife is critical in developing strategies to mitigate human-wildlife conflict. We conducted

135 household surveys and group discussions in three villages around Bardia National Park. Of the 222 total wildlife damage incidents in 2017, crop damage was the most frequent conflict (72%) followed by livestock depredation (24%). While elephants and deer were the main species implicated in crop loss, leopards and tigers were responsible for livestock depredation. Livestock depredation resulted in an average annual monetary loss of US$32 ($19–$442) per household. On average, each household lost 11% of their total annual potential crop production to wildlife damage. Poor households experienced noticeably disproportionate losses. Only 32% of respondents experiencing wildlife damage received compensation from the park. We recommend simplifying the compensation process and focusing on elephant and leopard damages while working to improve mitigation measures.

S. de Silva, K. Ruppert, J. Knox, E.O. Davis, U.S. Weerathunga & J.A. Glikman

Experiences and emotional responses of farming communities living with Asian elephants in southern Sri Lanka

Trees, Forests and People 14 (2023) e100441

Abstract. Individuals' tolerance toward wildlife can be based on a combination of tangible benefits and costs (e.g. economic gains and losses) as well as intangible benefits and costs (e.g. shared values and risk perceptions). Asian elephants potentially present both types of benefits and costs for rural communities. We examined which factors were associated with emotional responses toward wild Asian elephants among agriculturalists using a questionnaire survey of 300 households situated around the Wetahirakanda Sanctuary connecting Udawalawe and Lunugamwehera National Parks, Sri Lanka. Respondents were all from the Sinhala-Buddhist ethno-religious majority with average annual household incomes of Rs. 339,335 LKR (~$2610 USD). We found that none of the surveyed households derived any economic benefits from tourism despite the proximity of two national parks, whereas 171 (57%) had experienced crop damage by elephants. Though the median annual income lost due to elephants was Rs.50,000 LKR (4%), 21 households (7%) had losses exceeding 100%. Only six individuals (2%) recollected any human fatalities in their communities. Only three individuals reported positive feelings toward elephants, whereas all others had negative or neutral feelings. Economic factors were not significant predictors of feelings toward elephants, whereas fear of elephants and worry about crop damage had the largest and most significant negative effects. Our findings suggest that it might not be sufficient to reduce losses solely at an individual level, but that human-elephant coexistence interventions should target communities as a whole to reduce the spill-over effects of worry and anxiety by association with others who have experienced loss.

S. de Silva, T. Wu, P. Nyhus, A. Weaver, A. Thieme, J. Johnson, J. Wadey, A. Mossbrucker, T. Vu, T. Neang, B.S. Chen, M. Songer & P. Leimgruber

Land-use change is associated with multi-century loss of elephant ecosystems in Asia

Scientific Reports 13 (2023) e5996

Abstract. Understanding historic patterns of land use and land cover change across large temporal and spatial scales is critical for developing effective biodiversity conservation management and policy. We quantify the extent and fragmentation of suitable habitat across the continental range of Asian elephants based on present-day occurrence data and land-use variables between 850 and 2015 A.D. We found that following centuries of relative stability, over 64% (3.36 million km^2) of suitable elephant habitat across Asia was lost since the year 1700, coincident with colonial-era land-use practices in South Asia and subsequent agricultural intensification in Southeast Asia. Average patch size dropped 83% from approximately 99,000–16,000 km^2 and the area occupied by the largest patch decreased 83% from ~ 4 million km^2 (45% of area) to 54,000 km^2 (~ 7.5% of area). Whereas 100% of the area within 100 km of the current elephant range could have been considered suitable habitat in the year 1700, over half was unsuitable by 2015, driving potential conflict with people. These losses reflect long-term decline of non-forested ecosystems, exceeding estimates of deforestation within this century. Societies must consider ecological histories in addition to proximate threats to develop more just and sustainable land-use and conservation strategies.

A. Singh, H.N. Kumara & S. Mahato

Mayurjharna Elephant Reserve is just a gateway for elephants: Changes in the range use pattern by Asian elephants over seven decades

Mammal Study 48 (2023) 283-288

Abstract. Persistent use of the Mayurjharna forest by elephants led to its declaration as "Mayurjharna Elephant Reserve (MER)" in 2002; however, the usage changed over time. We describe the elephant movement pattern and the quality forage availability in the MER. We collected past and current sightings of elephants from people and records of the Forest Department and constructed the range used from 1950 to 2018. Initially, the range of elephants in the reserve was ~80 km^2 in 1950–1959 that increased to ~572 km^2 by 1990–1999 but later decreased to ~152 km^2 in 2010–2018. The high human settlements, alteration, and overexploitation of the forest might lead the elephants to the rich agricultural lands outside the reserve, making the reserve just a gateway for elephants to move to other parts of the South Bengal landscape.

A. Singh, H.N. Kumara, S. Mahato & A.D. Velankar

Anthropogenic driven range expansion of Asian elephant *Elephas maximus* in an agricultural landscape and its consequences in South West Bengal, India

J. for Nature Conservation 73 (2023) e126374

Abstract. Alterations of the geographical ranges of animals have become a reason for interactions with humans, leading to various consequences. We describe the pattern of range expansion of Asian elephants and implications for human-elephant interactions in the agricultural landscape of South West Bengal, India. We enquired about past and current sightings of Asian elephants from local people to gather information on range expansion from the 1950 s to 2018. We also collected the records of human deaths and injuries by elephants from 2010 to 2018. We employed an occupancy framework to understand the probability of the occurrence of elephants in the landscape from 2010 to 2018. The range of elephants in the landscape increased from ~ 1200 km^2 in the 1950–60 s to ~ 13,200 km^2 by 2010–18. The calculated probability of use of grid cells was 36 % and the forest edge had a high influence on the space usage by the elephants. Elephants occurred in an average of 26 grid cells per month, and the number of grid cells with elephants did not differ between the months. A total of 640 attacks on humans occurred, which significantly varied between the years. The probability of elephant occurrence in a grid cell was the major determinant factor for the elephant attacks on humans. Although people respect elephants, there is a sense of intolerance towards them if they enter the crop fields, owing to the small land holdings and the incapacity to endure the monetary losses of the farmers.

T. Sittisak, T. Guntawang, S. Srivorakul, K. Photichai, K. Boonprasert, S. Khammesri, P. Chuammitri, C. Thitaram, W.-L. Hsu, R. Thanawongnuwech & K. Pringproa

Response of elephant peripheral blood mononuclear cells when stimulated with elephant endotheliotropic herpesvirus glycoprotein B (EEHV-gB)

Veterinary Immunology and Immunopathology 258 (2023) e110577

Abstract. Elephant endotheliotropic herpesvirus-hemorrhagic disease (EEHV-HD) is the most highly fatal infectious disease among young Asian elephants. Despite the fact that antiviral therapy has been widely used, its therapeutic outcomes remain uncertain. Additionally, the virus has yet to be successfully cultivated in vitro in the process of develop viral envelope glycoproteins for vaccine design. The present study aims to investigate and evaluate EEHV1A glycoprotein B (gB) antigenic epitopes as potential candidates for further vaccine development. Epitopes of EEHV1A-gB were employed in in silico predictions and designed by using online antigenic predicting tools. Candidate genes were then constructed, transformed and expressed in the *E. coli* vectors prior to examine their potential for acceleration elephant immune responses in vitro. Elephant peripheral blood mononuclear cells (PBMCs) isolated from 16 healthy juvenile Asian elephants were investigated for their proliferative capability and cytokine responses after being stimulated with EEHV1A-gB epitopes. Exposure of elephant PBMCs to 20 μg/mL of gB for 72 h resulted in a significant proliferation of CD3 + cells

when compared with the control group. Furthermore, proliferation of CD3 + cells was associated with a marked up-regulation of cytokine mRNA expression, involving IL-1β, IL-8, IL-12 and IFN-γ. It remains to be determined whether these candidate EEHV1A-gB epitopes could activate immune responses in animal models or elephants in vivo. Our potentially promising results demonstrate a degree of feasibility for the use of these gB epitopes in expanding EEHV vaccine development. © 2023 Reprinted with permission from Elsevier.

K. Takehana, M. Adachi, S. Ishikawa & N. Yamagishi

Agarose gel electrophoresis pattern of serum creatine kinase and lactate dehydrogenase isoenzymes in zoo-managed Asian elephants (*Elephas maximus*)

J. of Vet. Medical Science 85 (2023) 578-583

Abstract. Serum levels of creatine kinase (CK) and lactate dehydrogenase (LDH) isoenzymes were evaluated in nine zoo-managed Asian elephants (*Elephas maximus*) using a commercial agarose gel electrophoresis (AGE) kit. CK was separated into two major fractions, CK-BB and CK-MM, along with a small fraction of macroenzyme-CK type 2 (mCK2); CK-MM was the largest fraction. LDH was separated into five fractions (LDH1–5); LDH3 was the largest fraction. Age was negatively and positively correlated with the percentages of CK-BB and CK-MM, respectively, and negatively correlated with CK-BB and mCK2 activities. These results indicate that an AGE kit can be used to evaluate CK and LDH isoenzymes. Routine isoenzyme testing may enable early detection of disease and physiological changes. © 2023 The Japanese Society of Veterinary Science.

K. Takehana, M. Adachi, S. Ishikawa & N. Yamagishi

The serum activities of alkaline phosphatase isoenzymes measured using two approved methods in zoo-managed Asian elephants (*Elephas maximus*)

J. of Vet. Medical Science 85 (2023) 232-235

Abstract. The approved Japanese measurement method of circulating alkaline phosphatase (ALP) has changed from that of the Japan Society of Clinical Chemistry (JSCC) to that of the International Federation of Clinical Chemistry and Laboratory Medicine (IFCC). We measured the serum levels of total ALP (t-ALP) and those of the isoenzymes ALP2 and ALP3 in 50 Asian elephant specimens using both methods. The activities determined by the IFCC method were roughly one-third lower than those determined by the JSCC method. We present conversion formulae. Our results enable comparisons of historical and current data on serum ALP activities in endangered, zoo-managed Asian elephants. © 2023 The Japanese Society of Veterinary Science.

K. Takehana & K. Matsuno

Direct detection of elephant endotheliotropic herpesvirus 1 (EEHV1) DNA in heparinized plasma by loop-mediated isothermal amplification

J. of Vet. Medical Science 85 (2023) 459-462

Abstract. Elephant endotheliotropic herpesvirus (EEHV) causes a fatal hemorrhagic disease and is a significant cause of mortality in juvenile Asian elephants. A loop-mediated isothermal amplification (LAMP) method was developed to rapidly diagnose EEHV viremia. However, extracting DNA from whole blood samples to perform LAMP hampers diagnosis in a field setting. Here, we established the Direct-LAMP method, using heparinized plasma without extracting the DNA to speed up and simplify the test. EEHV-positive specimens were tested using the Direct-LAMP. The detection limit was calculated to be 101.3 copies/μL using the mimetic samples, which was almost identical to the value determined in LAMP in which DNA was extracted. Hence, the Direct-LAMP provided a more rapid diagnosis to save, which could prevent elephant deaths. © 2023 The Japanese Society of Veterinary Science.

N.R. Talukdar, P. Choudhury & F. Ahmad

Assessment of spatio-temporal distribution of human-elephant conflicts: A study in Patharia Hills Reserve Forest, Assam, India

GeoJournal 88 (2023) 383-396

Abstract. No permission to print abstract.

Z.M. Thant, P. Leimgruber, A.C. Williams, Z.M. Oo, E. Røskaft & R. May

Factors influencing the habitat suitability of wild Asian elephants and their implications for human-elephant conflict in Myanmar

Global Ecology and Conserv. 43 (2023) e02468
Abstract. Anthropogenic disturbances are key factors affecting the distribution and ranging behaviour of wild elephants. Such disturbances exaggerate threats to the survival and population decline of wild elephants, and they have negative consequences for the livelihood of local people. We aimed to identify which factors influence the spatial movement, distribution, and suitable habitats of wild Asian elephants, to examine the relationship between elephant habitat use and human-elephant conflict (HEC) incidents, and to explore whether HEC is caused by habitats preferred by elephants or by human predictors. We used presence-only data from 25 GPS-collared elephants from the southern Rakhine State, Ayeyawady, and Yangon Regions of Myanmar. The study identified 11,524 km^2 of suitable habitat for wild elephants in southwest Myanmar. Results indicated that elevation, distance to water sources, and mean annual precipitation contribute most to the distribution and suitability of wild elephant habitats. Disturbed and degraded forests were highly utilised by elephants. Elephants in less suitable habitats were aggressive leading to intense HEC. This suggests that human encroachment into elephant habitats has intensified HEC. We recommend that areas, where larger croplands exist at the lower altitudes near degraded forests and/or water bodies, should be prioritized to monitor and minimize HEC. Elephant habitats in forested areas should be restored and replenished, with water holes and suitable plants provided for the most severely degraded habitats. © 2023 The Authors.

Z.M. Thant, R. May & E. Røskaft
Effect of human-elephant conflict on local attitudes toward the conservation of wild Asian elephants in Myanmar
Human Dimensions of Wildlife 28 (2023) 547-563
Abstract. The study of attitudes toward wild elephants and human-elephant conflict (HEC) is vital to understanding what attitudes are held by local people and how to incorporate them into wild elephant conservation. This study investigated the interlinkages between the HEC experience and local people's attitudes toward the conservation of wild elephants and which exploratory factors influence these attitudes. We used a Bayesian Belief Network (BBN) framework to highlight the interlinkages between HEC and people's attitudes. The basic BBN model indicated that HEC was central in determining the attitudes of local people. Although people generally hold positive attitudes toward elephants, people support having elephants in the country but not in their own regions. Conservation willingness was not obvious due to the lack of deliberate assistance from the government to the affected communities. We suggest implementing education programs to promote local awareness of conflict mitigation techniques. © 2022 The Authors.

S.J. Thevarajah, T.S. Readyhough, M. Davis, A. Moresco, S. Joseph & A.L. Schreier
Nighttime behavior and the length of social relationships in male Asian elephants
Journal of Applied Animal Welfare Science 26 (2023) 447-462
Abstract. To evaluate elephant welfare, it is important to understand their use of time both during day and night. The length of social relationships can influence how much time they spend in different activities. We assessed daytime and nighttime activity budgets of male Asian elephants at Denver Zoo and examined how length of relationships influenced nighttime behavior. Using scan sampling we investigated activity budget and proximity to a conspecific, and used General Estimating Equations to compare them across day and night and across new and established dyads at night. During daytime, elephants spent significantly more time exhibiting affiliative and agonistic behaviors, and in proximity to a conspecific, and less time resting, compared to night. Overnight, the odds of resting were significantly lower in new social dyads compared to established dyads, and new dyads spent more time exhibiting agonistic behavior and in proximity to a conspecific compared to established dyads. Our study suggests that male elephants at Denver Zoo have developed strong relationships and highlights the importance of systematically observing elephants overnight so that managers make decisions that improve animal welfare. © 2021 Informa UK Limited.

Y. Tsuchiya, M. Yayota, Y. Kashima & Y. Shiota

Nutritional effect of feeding enrichment using bamboo *Pleioblastus* spp. in zoo-kept Asian elephants *Elephas maximus*

Journal of Zoo and Aquarium Research 11 (2023) 267-273

Abstract. Many zoos use browse and other roughage as feed ingredients and enrichment tools for elephants. Amongst these are bamboo species (e.g. *Pleioblastus* spp.), which belong to the family of grasses. Bamboo is used in zoos worldwide as a dietary item for many herbivores. The fibrous attributes of bamboo are potentially beneficial in reducing diet digestibility and overnutrition in captive elephants. This study aimed to determine the effect of feeding bamboo on nutritional intake, digestibility and blood condition in Asian elephants. Four elephants aged 4 to 8 years, fed in two groups of two animals, received a conventional diet (CON) or a diet with bamboo (BAM; 4.5 kg bamboo/animal as fed). In CON, animals were fed sudangrass and timothy hay, rice straw, fresh Italian ryegrass, zoo pellets, carrots, sweet potatoes, steamed potatoes and apples. In BAM, a part of the sudangrass hay, accounting for approximately 20% of the diet on a dry matter basis, was replaced with bamboo *Pleioblastus* spp. Dry matter, crude protein, and neutral and acid detergent fibre digestibility were similar between the treatments. The concentrations of serum components, including total cholesterol, albumin, glucose, Ca and P, did not differ between the treatments and were almost within the range of previously reported values. These results suggest that feeding bamboo has no negative impacts on the nutritional status and health of captive Asian elephants.

A. Turner, N. Masters, T. Pfau, J.R. Hutchinson & R. Weller

Development and evaluation of a standardized system for the assessment of locomotor health in elephants under human care

J. of Zoo and Wildlife Med. 54 (2023) 529-537

Abstract. Although lameness is a common problem in elephants (Asian elephant *Elephas maximus* and African elephants *Loxodonta africana* and *Loxodonta cyclotis*) under human care, there has not been a standardized lameness assessment system to date. This study developed and evaluated a standardized system for the assessment of locomotion in elephants under human care regardless of husbandry system. In total, 72 elephants out of a possible 73 in the United Kingdom and Ireland were filmed from behind, from in front, and from both sides. Using a questionnaire and a select panel of elephant specialists, a zoo veterinarian, and a locomotion expert, a numerical rating scoring (NRS) system was proposed. Locomotion was scored on a 4-point scale with numerical values 0–4 corresponding to specific criteria as follows: 0 = clinically sound, 1 = stiffness, 2 = abnormal tracking, and 4 = reluctance to bear weight. The intra- and interobserver repeatability of five veterinary surgeons using this system was determined and compared with a visual analog scale (VAS) expressed as a 100-mm line. Overall intraobserver reliability was moderate (Cohen's kappa [$\varkappa$] = 0.676) and interobserver reliability was fair ($\varkappa = 0.37$) for the presence of lameness. Interobserver agreement improved from the first scoring to second scoring from slight agreement to fair agreement for stiffness and reluctance to bear weight. Abnormal tracking had moderate intraobserver agreement for both scoring sessions. There were wide widths of agreement for the VAS interobserver (67 mm); however, they were narrower for the intraobserver (33 mm). The developed NRS can be used on freely moving elephants to evaluate elephant locomotion, regardless of husbandry methods, and has been shown to be more reliable than a VAS.

S. Ukonaho, V. Berger, D.J. Franco dos Santos, W. Htut, H.H. Aung, UK. Nyeing, S. Reichert & V. Lummaa

Seasonal variation in molecular and physiological stress markers in Asian elephants

Conservation Physiology 11 (2023) coad029

Abstract. Free-living species exhibit seasonal variation in various life history traits, including vital rates such as birth and death patterns. Different physiological mechanisms are thought to underlie the expression of life history traits that contribute to lifetime fitness. However, although the broad impacts of seasonality on life history traits and trade-offs is well established in many systems, the exact physiological mechanisms responsible for driving differences within and between individuals are poorly understood. Among them, molecular and

physiological stress pathways, such as stress hypothalamic-pituitary-adrenal axis and oxidative stress, have potential to mediate relationships between individual survival, reproduction and environmental seasonality. Here, we determine how different physiological markers of stress including faecal cortisol metabolites (FCMs), heterophils/lymphocytes (H/L) ratio, two markers indicating oxidative balance including a marker of oxidative damage (reactive oxygen metabolites, ROM) and a marker of antioxidant defences (superoxide dismutase, SOD) and body weight vary in a large semi-captive population of Asian elephants exposed to extreme seasonality (e.g. elevated temperatures). Individuals showed higher FCM levels and H/L ratios during cold season, indicating increased stress, and the lowest FCM levels during monsoon season and H/L ratios during hot and dry season, but we found no pattern in oxidative stress (ROM and SOD) levels. Hot season also associated with a decline in body weight. The present study shows how different physiological parameters (FCM levels and H/L ratio), molecular (oxidative stress) and body condition vary with seasonal changes, and how these parameters might allow individuals to adapt to such variations. Our results on an endangered long-lived species are crucial in indicating the most productive timing for conservation efforts, predicting how individuals cope with environmental changes, and allow for a more accurate representation of how animal physiology operates in nature. © 2023 The Authors.

D. Vasudev, R.J. Fletcher Jr., N. Srinivas, A.J. Marx & V.R. Goswami

Mapping the connectivity-conflict interface to inform conservation

PNAS 120 (2022) e2211482119

Abstract. Balancing the competing, and often conflicting, needs of people and wildlife in shared landscapes is a major challenge for conservation science and policy worldwide. Connectivity is critical for wildlife persistence, but dispersing animals may come into conflict with people, leading to severe costs for humans and animals and impeding connectivity. Thus, conflict mitigation and connectivity present an apparent dilemma for conservation. We present a framework to address this dilemma and disentangle the effects of barriers to animal movement and conflict-induced mortality of dispersers on connectivity. We extend random-walk theory to map the connectivity–conflict interface, or areas where frequent animal movement may lead to conflict and conflict in turn impedes connectivity. We illustrate this framework with the endangered Asian elephant *Elephas maximus*, a species that frequently disperses out of protected areas and comes into conflict with humans. We mapped expected movement across a human-dominated landscape over the short- and long-term, accounting for conflict mortality. Natural and conflict-induced mortality together reduced expected movement and connectivity among populations. Based on model validation, our conflict predictions that explicitly captured animal movement better explained observed conflict than a model that considered distribution alone. Our work highlights the interaction between connectivity and conflict and enables identification of location-specific conflict mitigation strategies that minimize losses to people, while ensuring critical wildlife movement between habitats. By predicting where animal movement and humans collide, we provide a basis to plan for broad-scale conservation and the mutual well-being of wildlife and people in shared landscapes. © 2022 The Authors.

J. Wang, Y. Chen, Y. Sun, Z. Lyu & K. Shi

Inferring human-elephant coexistence based on characteristics of human-elephant interactions in Nangunhe of Yunnan, China

Chinese Geogr. Science 33 (2023) 363-376

Abstract. No permission to print abstract.

P. Wattananit1, Y. Yingchutrakul, K. Kornkaewrat, S. Mahasawangkul, S. Roytrakul & A. Pinyopummin

Non-targeted proteomic analysis of Asian elephant (*Elephas maximus*) seminal plasma using an in-solution digestion technique and liquid chromatography tandem-mass spectrometry

Frontiers in Vet. Science 10 (2023) e1174078

Abstract. Seminal plasma proteins have recently been reported to play a significant role as valuable materials for understanding male reproductive biology, identifying causes of fertility problems, and developing reproductive biomarkers. Proteomic analysis of seminal plasma holds promise in advancing the understanding

of male Asian elephant reproductive biology. This study aims to explore seminal plasma proteins of Asian elephants and their probable functions to provide fundamental information about male reproduction in this species. The protein solution from pooled seminal plasma from 10 bulls (a total of 33 ejaculates) was digested into peptides and identified using LC-MS/MS. Out of 986 proteins, 597 were mapped and matched with 58 species in UniProt databases, including *Elephas maximus*. These mapped proteins were mostly involved in binding function, catalytic activity, cellular process, and metabolic process. Only 29 mapped proteins were recognized to be related in reproductive process, mainly associated in spermatogenesis and sperm capacitation. Additionally, several seminal plasma proteins related to fertility or semen quality in other mammals were also found in Asian elephant semen, such as keratin type I, aldose reductase, thrombospondon-1, fibronectin 1, platelet-activating factor acetyl hydrolase, mannosidase, and semenogelin-2. This discovery clearly reveals the beneficial protein profile in seminal plasma of the Asian elephant and serves as a crucial step in investigating infertility and poor semen quality in this valuable species.

M. Wettasin, R. Chaiyarat, N. Youngpoy, N. Jieychien, R. Sukmasuang & P. Tanhan

Environmental factors induced crop raiding by wild Asian elephant (*Elephas maximus*) in the Eastern Economic Corridor, Thailand

Scientific Reports 13 (2023) e13388

Abstract. Crop raiding are an increasing concern in wildlife conservation. This study identified the environmental factors that cause wild Asian elephants to enter sub-urban and rural areas and share resources with humans in the Eastern Economic Corridor (EEC) in the eastern part of Thailand. The snowball method was used to interview villagers that had crop raiding experienced in seven provinces of the EEC and adjacent provinces in the eastern part of Thailand in 2020, and data from 183 households indicated that crop raiding had increased continuously from 2000 to 2020, especially in Chonburi, Chachoengsao, and Prachinburi provinces, which have seen increases in damaged agricultural areas. MaxEnt analysis showed an increase in incidents of crop raiding, while the elephants distribution area decreased from 9534 km^2 in 2000 to 5199 km^2 in 2010 and 4850 km^2 in 2020. The study area has had land use changes in the low elevations from croplands of cassava and sugar cane to eucalyptus, para rubber, and fruits. These mixed crop plantations provide a pseudo-habitat for wild Asian elephants. The results from this study provide evidence that changes in land use and reduction of suitable habitat are factors that influenced the movement of wild Asian elephants to the rural agricultural areas and increased the incidents of crop raiding.

W.K.N.C. Withanage, M.D.K.L. Gunathilaka, P.K. Mishra, W.M.D.C. Wijesinghe & S. Tripathi

Indexing habitat suitability and human-elephant conflicts using GIS-MCDA in a human-dominated landscape

Geography and Sustainability 4 (2023) 343-355

Abstract. Concerns for biodiversity loss, wildlife conservation, and habitat destruction have dominated the policy agenda worldwide for decades. Unsustainable human-induced development and negative interaction between humans and wildlife have emerged as predominant issues globally. The present study deals with human and elephant conflicts (HEC) in the Polpitigama Divisional Secretariat, Sri Lanka, which is located in the Kahalla-Pallekele elephant corridor and connects Wilpattu and Kaudulla wildlife sanctuaries. The research objectives are identifying spatial patterns of elephant habitat suitability and probable risk zones for HEC. The elephant habitat suitability and HEC risk zones were identified on spatial and temporal scales using Geographic Information System integrating Multi-Criteria Decision Analysis. Different factors, including habitat suitability, distance to roads, distance to croplands, distance to forests and protected areas, settlements, and population density, were considered to determine HEC risk zones in the area. Topography, water, and vegetation criteria are considered when determining elephant habitat suitability. The results of the Analytic Hierarchy Process run the spatially explicit model. The results revealed that of the total area, 15.3% is very highly suitable for elephant habitats, while the least suitable areas contribute only 4%. About 33.8% of the area is moderately suit-

able for elephants. The risk map indicates that 23.7% of the total area is under very high risk for HEC, and the least risk areas only account for 5.4%. About 26.2% of the area falls under the moderate risk zone for HEC. Since the model considered three aspects of HEC, it will help policymakers in wildlife conservation to avoid and minimize the HEC. © 2023 The Authors.

P. Xiaoxu, S. Yakuan, C. Ying, A. Norris & S. Kun

Diet analysis of Asian elephants using next-generation sequencing

J. of Resources and Ecology 14 (2023) 616-630

Abstract. Understanding the diet composition and preferences of large herbivores not only provides insights into their ecological role, but also helps to assess the viability of elephant populations and their habitats. This study was performed to determine the diet preferences of a small population of Asian elephants in Nangunhe National Nature Reserve in Yunnan, China, during the annual dry season. The next-generation sequencing of the rbcL gene from non-invasively collected fecal samples was conducted in addition to transect surveys and camera-trapping along known elephant trails. With the transect survey, we identified 31 plant species foraged by elephants. The next-generation sequencing analysis identified a total of 90 plant species from the elephant dung samples. Only nine species were detected at rates greater than 1% in all the samples. Poaceae (47.69%), Moraceae (21.25%), and Musaceae (11.24%) were detected to have the highest rates at the family level. We also examined whether differences existed between sexes, age groups, and individuals; however, significant differences were found only between individuals. This study provides useful insights into the foraging preferences of Asian elephants, which could help in further understanding the interactions between elephants and their habitat in the reserve and inform future management decisions in related areas. The detected core plant species with relatively high abundance could provide guidance for habitat restoration and cultivation of food bases. The local plantations where the elephants prefer to feed could be moved farther away, making them inaccessible to the elephants.

J. Yang, Y. Chen, Z. Dong, W. Zhang, L. Liu, W. Meng, Q. Li, K. Fu, Z. Zhou, H. Liu, Z. Zhong, X. Xiao, J. Zhu & G. Peng

Distribution and association of antimicrobial resistance and virulence characteristics in *Enterococcus* spp. isolates from captive Asian elephants in China

Frontiers in Microbiology 14 (2023) e1277221

Abstract. *Enterococcus* spp., as an opportunistic pathogen, are widely distributed in the environment and the gastrointestinal tracts of both humans and animals. Captive Asian elephants, popular animals at tourist attractions, have frequent contact with humans. However, there is limited information on whether captive Asian elephants can serve as a reservoir of antimicrobial resistance (AMR). The aim of this study was to characterize AMR, antibiotic resistance genes (ARGs), virulence-associated genes (VAGs), gelatinase activity, hemolysis activity, and biofilm formation of *Enterococcus* spp. isolated from captive Asian elephants, and to analyze the potential correlations among these factors. A total of 62 *Enterococcus* spp. strains were isolated from fecal samples of captive Asian elephants, comprising 17 *Enterococcus hirae* (27.4%), 12 *Enterococcus faecalis* (19.4%), 8 *Enterococcus faecium* (12.9%), 7 *Enterococcus avium* (11.3%), 7 *Enterococcus mundtii* (11.3%), and 11 other *Enterococcus* spp. (17.7%). Isolates exhibited high resistance to rifampin (51.6%) and streptomycin (37.1%). 50% of *Enterococcus* spp. isolates exhibited multidrug resistance (MDR), with all *E. faecium* strains demonstrating MDR. Additionally, nine ARGs were identified, with tet(M) (51.6%), erm(B) (24.2%), and cfr (21.0%) showing relatively higher detection rates. Biofilm formation, gelatinase activity, and α-hemolysin activity were observed in 79.0, 24.2, and 14.5% of the isolates, respectively. A total of 18 VAGs were detected, with gelE being the most prevalent (69.4%). Correlation analysis revealed 229 significant positive correlations and 12 significant negative correlations. The strongest intra-group correlations were observed among VAGs. Notably, we found that vancomycin resistance showed a significant positive correlation with ciprofloxacin resistance, cfr, and gelatinase activity, respectively. In conclusion, captive Asian elephants could

serve as significant reservoirs for the dissemination of AMR to humans. © 2023 The Authors.

N. Yang, X. Dai, B. Wang, M. Wen, Z. Gan, Z. Li & K.J. Duffy

Mapping potential human-elephant conflict hotspots with UAV monitoring data

Global Ecology and Conserv. 43 (2023) e02451

Abstract. Human-elephant conflicts (HECs) threaten both elephants and humans globally. Many modern techniques have been adopted to mitigate HECs, including remote sensing with unmanned aerial vehicles (UAVs). Based on the UAV monitoring data of wild Asian elephants in China, we mapped the potential HEC hotspots and identified the possible related environmental factors. Our results indicated that there were six clusters of UAV-monitored elephant positions, and these corresponded to the previously known elephant subpopulations. According to the local Getis-Ord Gi* statistic, the potential HEC hotspots were mainly distributed around Mangao subreserve, Jingne Town, Mengman Town and near Mengwang Town. Physical barriers, including large rivers and highways, separated elephant position clusters and potential HEC hotspot areas. Generally, the potential HECs were near human settlements when the loss of human and elephant lives were emphasized more than the loss of economic plants. In addition, the potential HEC hotspots were distributed in regions with both lower slopes and lower river cover but higher food-rich covers. There have been few reports on HEC mapping based on UAV monitoring data, and our study may help widen and deepen the application of UAVs in mitigating HECs in China and elsewhere in the future. © 2023 The Authors.

Yeshey, R.J. Keenan, R.M. Ford & C.R. Nitschke

How does conservation land tenure affect economic impacts of wildlife: An analysis of subsistence farmers and herders in Bhutan

Trees, Forests and People 11 (2023) e100378

Abstract. Protected areas (PA) to conserve wildlife are the cornerstone of biodiversity conservation but they can also result in increased human-wildlife conflict (HWC), which poses a serious challenge to jointly achieving sustainable development goals of food security and biodiversity conservation, particular in regions with high conservation values and subsistence farmers. In the Himalayan Kingdom of Bhutan, expanding PAs and other conservation efforts have led to increased wildlife populations that are causing more damage to crop and livestock and impacting on the livelihoods of subsistence farmers and herders. In this study, we used a social-ecological systems framework to quantify the intensity this impact and associated economic losses with identified wildlife species and compared differences between livelihood types (crop farming versus livestock husbandry) and land tenure (inside versus outside protected areas). Results indicated that Meso-scale wildlife species that are not the focus of conservation caused higher economic losses. Approximately 43% of total economic loss through crop depredation was attributed to wild pig (Sus scrofa) and 56% of the total economic loss through livestock predation was caused by wild dogs (Cuon alpinus). Losses borne by respondents whose livelihoods depend mainly on livestock were significantly higher, with a mean loss equivalent to US$1328 per household per annum, than those depending on crop production (US$171 per household per annum). Economic losses incurred through crop and livestock depredation were significantly higher for the respondents residing inside PAs, which is attributed by those households to a perceived increase in wildlife populations because of conservation policies. Interventions for prevention and mitigation of these impacts should recognize these varying unintended effects of wildlife and be better targeted at groups living in different parts of the landscape. These include expanding compensation scheme to losses caused by wild dogs and pigs, supporting ecotourism ventures within PAs to diversify income options and introducing control measures for these animals. © 2023 The Authors.

C. Zhang, Z. Lian, B. Xu, Q. Shen, M. Bao, Z. Huang, H. Jiang & W. Li

Gut microbiome variation along a lifestyle gradient reveals threats faced by Asian elephants

Genomics, Proteomics & Bioinformatics 21 (2023) 150-163

Abstract. The gut microbiome is closely related to host nutrition and health. However, the

relationships between gut microorganisms and host lifestyle are not well characterized. In the absence of confounding geographic variation, we defined clear patterns of variation in the gut microbiomes of Asian elephants in the Wild Elephant Valley, Xishuangbanna, China, along a lifestyle gradient (fully captive, semicaptive, semiwild, and purely wild). A phylogenetic analysis using the 16S rRNA gene sequences highlighted that the microbial diversity decreased as the degree of captivity increased. Furthermore, the results showed that the bacterial taxon WCHB1-41_c was significantly affected by lifestyle gradient variations. Quantitative real-time PCR revealed a paucity of genes related to butyrate production in the microbiome of Asian elephants with a pure wild lifestyle, which may be due to the increased environmental unfavorable factors. Overall, these results demonstrate the distinct gut microbiome characteristics among AEs with a gradient of lifestyles and provide a basis for designing strategies to improve the well-being or conservation of this important animal species. © 2023 The Authors.

F. Zhao, Y. Zhang, Z. Zhao, X. Wang, S. Zhang, G. Luan, Q. Zhang, L. Zhu & H. Liu

Monitoring of human activities around the Asian elephant Reserve based on NPP-VIIRS night light remote sensing images: A case study in Xishuangbanna, China

Frontiers in Ecology and Evolution 11 (2023) e1088722

Abstract. Asian elephants (*Elephas maximus*) have a wide range of foraging needs and heterogeneous habitat preferences that bring them close to the forest edge. Currently, most of the range of wild elephants is located outside protected areas (PA). Night-time light data (NTL) has been used as a component of human footprint due to its characteristics of characterizing the intensity of human activities and spatio-temporal continuity. We chose Xishuangbanna National Nature Reserve, the main distribution area of Asian elephants, as the study area and used NTL to monitor human activities, supplemented by land cover (LC) type data, to study the Asian elephant sanctuary and its surrounding areas, and found that: 1) NTL features inside and outside the PA are approaching, and the boundary effect of the sanctuary is weakening; 2) The NTL gathering area in the study area is mainly distributed in the south of the PA, 86.21% of the area's night-time lights have a significant increase trend, and the human activity range is evolving toward the southeast in the past decade; 3) the percentage of areas with a significant increasing trend of NTL under different LC types is greater than decreasing, nearly 50% of the forest showed an increasing trend of NTL. LC types with reduced forest have been converted to cropland and building in the last decade. © 2023 The Authors.

B. Zheng, X. Lin, D. Yin & X. Qi

Does Tobler's first law of geography apply to internet attention? A case study of the Asian elephant northern migration event

PLoS One 18 (2023) e0282474

Abstract. One of the basic assumptions of spatial theory is formulated in Waldo Tobler's first law of geography: "Everything is related to everything else, but near things are more related than distant things." However, as internet space is a complex virtual space independent of the real world, whether this law is applicable to things in the internet space remains to be explored in depth. Therefore, this study takes the event of Asian elephant northern migration as an example, attempts to investigate the issue of the applicability of Tobler's first law of geography to internet attention by integrating geographic methods such as spatial visualization, spatial correlation analysis, and Geo-detector. The results show that Tobler's first law of geography does not fully apply to internet attention, which does not decay with increasing distance. Geographical distance, within certain boundaries, is influenced by "identity" and "relevance", and still plays a large role in internet attention. However, once the boundaries are exceeded, the impact of geographic distance on internet attention is weakened by the intervention of influencing factors such as the degree of information technology, population, and the strength of news media publicity. Overall, the strength of news media publicity has the greatest impact on internet attention. And when it interacts with geographic proximity, it has the most significant effect on internet attention. © 2023 The Authors.

Instructions for Contributors

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Research papers: Manuscripts reporting original research with a maximum of 5000 words are accepted for the "Research Article" section. Shorter manuscripts (2000 words max.) will be published as a "Short Communication". All research papers should include an abstract (100 words max.).

Tables and figures should be kept to a minimum. Legends should be typed separately (not incorporated into the figure). Figures and tables should be numbered consecutively and referred to in the text as (Fig. 2) and (Table 4). The lettering on figures must be large enough to be legible after reduction to final print size. Include tables and line drawings in the MS Word document you submit. In addition, all figures must be provided as separate files in JPEG or TIFF format.

References should be indicated in the text by the surnames(s) of the author(s) with the year of publication as in this example: (Olivier 1978 ; Baskaran & Desai 1996; Rajapaksha *et al*. 2004) Avoid if possible, citing references which are hard to access (e.g. reports, unpublished theses). Format citations in the 'References' section as in the following examples, writing out journal titles in full.

Baskaran N & Desai AA (1996) Ranging behavior of the Asian elephant (*Elephas maximus*) in the Nilgiri biosphere reserve, South India. *Gajah* **15:** 41-57.

Olivier RCD (1978) *On the Ecology of the Asian Elephant*. Ph.D. thesis, University of Cambridge, Cambridge, UK.

Rajapaksha RC, Mendis GUSP & Wijesinghe CG (2004) Management of Pinnawela elephants in musth period. In: *Endangered Elephants, Past Present and Future*. Jayewardene J (ed) Biodiversity & Elephant Conservation Trust, Colombo, Sri Lanka. pp 182-183.

Sukumar R (1989) *The Asian Elephant: Ecology and Management*. Cambridge Univ. Press, Cambridge, UK.

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