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GAJAH

Journal of the Asian Elephant Specialist Group
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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

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Cover

Emmentree, her new calf, and the allomother, Glenha, in southern India
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Editorial

Jennifer Pastorini (Editor)

E-mail: j.pastorini@icloud.com

This issue of *Gajah* includes four research articles, one short communication and a technical report. Four articles originate from India and two from Sri Lanka. *Gajah* 58 reports on five meetings regarding Asian elephants. There is also an obituary, a book review and the usual compilation of abstracts.

For the first **Research Article** Fernanda Diaz Osorio and co-authors screened news media and found 173 articles on casualties due to human-elephant conflict in India. They created a distribution map with the mentioned locations and compared it with the official range map from IUCN. Radhika N. Makecha *et al*. evaluated whether the inclusion of elephant cognition in an education program changes attitudes towards elephants and elephant conservation. They found it did not change the overall opinion of villagers at Bannerghatta National Park. The study of Ilayaraja Selvaraj and co-authors investigated the effects of saddle use on elephants. Their radiographic pictures nicely illustrate varying degrees of dorsal spinous process degeneration, impacting gait and body structure. Rengarasu Madeswaran *et al*. studied 22 serum biochemical parameters at four sites holding captive elephants. They compared values between sexes, age groups, locations and seasons.

In **Short Communications** Danushka S. Weerasekera and co-authors evaluated the use of non-invasive faecal testosterone analysis to differentiate between musth and non-musth condition in captive Asian elephant males. The **Technical Report** from Fernando *et al*. describes the procedure to build a community-based seasonal electric fence to prevent crop raiding by elephants. They describe the fence design, material specifications and how to prepare the bill of quantities.

In **News and Briefs** Prajna P. Panda and Vivek Menon provide a summary of the 11th Meeting of the IUCN Asian Elephant Specialist Group held in India in 2023. The technical sessions were conducted in New Delhi, followed by a field trip to Corbett National Reserve. Shiladitya Acharjee gives us a brief report on how the Saranda Forest Division celebrated World Elephant Day. Events were held at Kiriburu and GUA Range. Tran Thi Hoa informs us about the newly launched "Vietnam Elephant Conservation Action Plan to 2035, Vision 2050". With the carefully prepared VECAP 2022 Vietnam aiming to conserve its dwindling elephant population. Prajna P. Panda tells us about the CITES MIKE South-East Asia Sub-Regional Meeting and the CITES Trade in Asian Elephants Workshop held in Thailand last year. Prajna P. Panda also reports on the "14th Meeting of the Conference of Parties to the Convention on the Conservation of Migratory Species of Wild Animals" (CMS COP14). The side event "Room to Roam for Elephants: Conservation and Connectivity in Africa and Asia" involved three elephant range countries. Janine L. Brown wrote a beautiful obituary for Richard Lair who sadly passed away in Thailand last year. Deepak Bhat Dundi wrote a book review for "Composing Worlds with Elephants. Interdisciplinary Dialogues". The book was edited by Nicolas Lainé, Paul G. Keil and Khatijah Rahmat. *Gajah* concludes with a compilation of abstracts of research articles published in 2024.

I would like to thank the editorial board members for their work on each individual article. I am grateful to the authors for sharing their interesting findings with the readers of *Gajah*. The printing and mailing of this issue were funded by "SAFE: Saving Animals from Extinction". The AsESG is most grateful for SAFE's support enabling the distribution of hard copies.

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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

As we continue to witness both progress and challenges in the conservation of the Asian elephant, we are proud to have successfully organised the Fourth Asian Elephant Range States Meeting in Siem Reap, Cambodia in February 2025, marking a major step forward in strengthening regional cooperation. With the launch of the 2025 Siem Reap Declaration (https://asesg.org/images/2025%20Seam%20Reap%20Declaration.pdf), we solidified the collective commitment of the 13 elephant range countries to the protection of Asian elephants and their habitats across the continent. The declaration not only builds on the foundation set by the Kathmandu Declaration but also introduces new strategies and initiatives to enhance conservation outcomes.

I am also delighted to share that the IUCN SSC has awarded the AsESG its third Certificate of Appreciation for Excellence in recognition of our ongoing efforts and achievements in the field of Asian elephant conservation. This acknowledgment highlights the dedication, hard work, and collaboration of our entire team, and it reflects the significant impact of our initiatives at a global stage. I would like to extend my heartfelt congratulations to all members of the AsESG for their invaluable contributions. Each of you have played a crucial role in achieving this recognition, and it is your passion, expertise, and commitment that continue to drive the success of our collective mission.

I would like to express my heartfelt gratitude to the Government of Vietnam for the successful completion of the national Elephant Conservation Action Plan for Vietnam (VECAP), which was endorsed by the AsESG Working Group for assisting the conservation of elephants in Vietnam, led by Dr. Prithiviraj Fernando. Officially launched by the Government of Vietnam in November 2024, the VECAP, represents a significant milestone in elephant conservation in the region. The government is now organising meetings to support the implementation of this crucial plan, and we are optimistic that it will have a lasting, positive impact on the conservation of Asian elephants in Vietnam.

As part of the Working Group's initiative to map elephant distribution across Asia, the mapping exercise for Thailand was conducted in collaboration with the Department of National Parks, Wildlife, and Plant Conservation (DNP) of the Government of Thailand, AsESG members, and elephant experts from Thailand. This collaborative effort, funded by the Loro Parque Fundación, led to the official launch of the elephant distribution map of Thailand by the Department of National Parks, Ministry of Natural Resources and Environment, at the 8th IUCN Regional Conservation Forum in Bangkok. This milestone highlights the collective work of the AsESG and the elephant

Figure 1. HE Kim Nong, Undersecretary of State, Ministry of Environment, Government of Cambodia, at the Asian Elephant Range States Meeting.

Figure 2. Official group photo of the IUCN Leadership Meeting.

Figure 3. Receiving the Certificate of Appreciation for Excellence from IUCN SSC.

range state to refine population estimates, assess habitat connectivity, and address human-elephant conflict throughout Thailand.

In addition to this, the nine existing Working Groups continue to make remarkable progress in their respective areas. These groups are focused on (i) The Asian elephant as a flagship species needing climate change action, (ii) Human-elephant conflict guidelines, (iii) Mapping elephant distribution, (iv) Translocation of Asian elephants, (v) Green status of Asian elephants, (vi) Social science and policy, and (vii) Invasive species. I am pleased to report that the Working Groups on elephant translocation, led by Dr. Nurzfarina Othman and Dr. Sreedhar Vijayakrishnan, as well as the Working Group on the green status of Asian elephants led by Dr. Shermin de Silva, are gaining significant momentum. I encourage all nine Working Groups to continue their important work and present their findings at the 12th Asian Elephant Specialist Group Meeting. This meeting will provide an important platform to review our progress, share insights, and refine our strategies for the future.

Furthermore, I would like to take a moment to thank the Leadership Team and the Membership Advisory Committee for their invaluable contributions. Their dedication in meeting each quarter and their efforts in expanding our membership have been pivotal. With the addition of new members, we now have a strong and dynamic base of 126 committed members. Your collective expertise and active engagement are integral to the success of our group, and I deeply appreciate your continued involvement.

I am deeply moved by the unwavering support and dedication of the AsESG members in their efforts to protect and conserve Asian elephants. I would like to extend my sincere gratitude to our partners and donors for their generous financial contributions to the AsESG. As we move forward, I eagerly anticipate collaborating closely with each of you to reach even greater milestones in the conservation of Asian elephants.

Vivek Menon
Chair IUCN SSC AsESG

Figure 4. Presenting the new elephant distribution map to the DG Thailand.

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Research Article
Gajah 58 (2025) 4-10

Where the Wild Elephants Are: Assessing the Distribution of Asian Elephants Using Media Reports

Fernanda Diaz Osorio[1], Sanchaya Sharma[2]*, Nitin Sekar[2] and Sumeet Gulati[1]

[1]*Faculty of Land and Food Systems, The University of British Columbia, Vancouver, Canada*
[2]*Wildlife and Habitats Division, WWF-India, New Delhi, India*
**Corresponding author's e-mail: sanchaya.sharma@gmail.com*

Abstract. We present the first systematic use of news articles to map districts with wild Asian elephants in India. We analysed news articles mentioning human-elephant conflict between 2004 and 2018 and found that conflict was reported from 40 districts outside the elephant range published by IUCN, the only open data source for Asian elephant range in India. Sixteen of those districts reported multiple conflict incidents between 2004 and 2016, suggesting that the IUCN maps were outdated. Our analysis shows that news articles can be a useful tool for updating range information for charismatic species.

Introduction

The Asian elephant (*Elephas maximus*) is listed as a Schedule I species under the Wildlife (Protection) Act of India 1972, and since 1986 it also appears in Appendix 1 of CITES (Convention on International Trade of Endangered Species of Wild Fauna and Flora), granting it the highest legal protection against poaching and trafficking. Despite the physical size of Asian elephants and substantial conservation attention, information on the geographical range of Asian elephants in India is limited and may be outdated (Calabrese *et al*. 2017; Padalia *et al*. 2019). The International Union for Conservation of Nature (IUCN) is the only open data source on the range of Asian elephants in India. Developed based on 'expert opinion', the IUCN range maps are updated infrequently. The official government elephant census that is conducted every five years does not provide range maps that are accessible to the public. This makes conservation planning and effective conservation of elephants in India difficult.

Asian elephant distribution in India is predicted to change due to climatic and human pressures (Kanagaraj *et al*. 2019). Given the costs and logistical difficulties of systematically collecting data on the ranges of wildlife, methods that utilise readily available data from the public or the internet can help provide information on the whereabouts of wildlife (Doyle *et al*. 2010; Chauhan *et al*. 2021). The most popular way to get such low-cost data is through citizen science – for example, smartphone applications such as eBird and iNaturalist, as used to document wildlife sightings (Baker 2016). News articles are another source of such data; the location and date included in news articles can be used to create range data for species (Doyle *et al*. 2010; Chauhan *et al*. 2021). This can contribute to conservation (McKinley *et al*. 2017) and support researchers.

Asian Elephants, as a flagship species, attracts media attention (Barua *et al*. 2010). Human-elephant conflict (HEC) resulting in human or elephant fatalities or injuries are often reported in the news (Barua 2010; Doyle *et al*. 2010). Barua (2010) looked at different HEC news articles in India and analysed how HEC events are framed in regional, national and international media. Doyle *et al*. (2010) used news articles published in the English media between 2006 and 2008 in 13 different countries to explore the level of HEC reported in the news and assess the utility of using news articles to monitor HEC in Asia. Madhusudan *et al*. (2015) created an elephant presence map for the state of Karnataka in India, using a combination of media reports, dung counts, interviews and government data.

Manuscript Editor: Prithiviraj Fernando

In this study, we assess whether media reports can provide a relatively low-cost way to improve on the range maps of a charismatic species. Specifically, we explore whether articles in a media database on HEC could be used to update Asian elephant ranges in India.

Methods

To assess whether media reports can be used to improve our understanding of the range of Asian elephants in India, we analysed locations contained within HEC articles in the database of news articles compiled by the NGO Save the Elephants and compared these locations with the IUCN range map for Asian elephants.

HEC media database

Save the Elephant has consistently conducted web searches for Asian elephants since January 2004, creating an archive of media articles on Asian elephants. WWF-India was given access to all the articles compiled from January 2004 to December 2018. WWF-India employees created a HEC media database by analysing 10,296 English media articles in the Save the Elephant archives and coding the ones involving human death due to HEC or elephant death due to HEC. While crop damage affects a far greater number of families (about 500,000 a year as of 2010, Rangarajan *et al*. 2010) than deaths, it is comparatively rarely documented in media articles. We therefore focussed on human and elephant death reports in preference to crop damage reports. Elephant deaths and injuries included intentional and unintentional shooting, poisoning, electrocution, and accidents caused by trains. Human deaths and injuries included those arising from direct confrontation with elephants and incidents resulting from elephants destroying huts or other live-in structures. For each incident, all available location data were recorded, including the name of the village, sub-district, district, state, and country in which the event happened. In some cases, a single HEC news article mentioned two or more events with varying locations, dates, and casualties (human/elephant deaths and injuries); in these cases, multiple entries were made into the database from a single article. Media reports focusing on captive elephants were disregarded.

When more than one article reported the same event (same date, location and details about an incident) only one event was included in the database. Only HEC reports in India were used for this study. All the districts mentioned in the media articles were adapted to match the 640 district boundaries as per the 2011 Indian Census. The Indian Census is the main source of information on the characteristics of people in India and provided standardised district names and district boundaries.

IUCN data

The IUCN publishes worldwide ranges of threatened species. The IUCN ranges are created based on the available scientific data and rely on experts to validate them (Red List Technical Working Group, 2018). The IUCN published the current elephant range shapefile in 2020; however, it covers exactly the same geographical area as the one published in 2016. The IUCN Range shapefile was obtained directly from the IUCN website (IUCN 2020).

Mapping of data

The IUCN range covered multiple districts across different states. To identify the districts included in the IUCN ranges, the IUCN range was overlaid on the India 2011 Census map, using QGIS version 3.16.14. and the districts covered entirely or partially by the IUCN range were identified and labelled as “IUCN range districts”.

We mapped the HEC media events to districts identified in the 2011 Census of India but were unable to use the HEC media database to identify the locations of HEC to the sub-district, taluk, or village level. This was largely because the village and location names used in media articles did not allow for a one-to-one match with the villages in the census. Either they differed in spelling, matched the spelling of multiple villages in a district, or were absent from the census altogether (they were local but not official names).

We defined an ‘article’ as a unique written media piece collected by Save the Elephant mentioning wild elephants, an ‘event’ as a single in-

cident of HEC happening at a location on the given date, and a 'casualty' as a human or elephant death or injury. One article could contain more than one event, and each event could involve more than one casualty. For example, if one article describes two incidents of HEC happening at different locations and on different dates, with each resulting in 2 human deaths and 1 elephant injury, we would refer to it as 1 article with 2 events and 6 casualties. We summed the number of HEC media events reported from each district throughout the study period.

Results

According to the IUCN ranges, elephants were found in four regions: northern, northeastern, southern and east central (Fig. 1). The IUCN range depicts Asian elephant presence in 182 (28%) of the 640 districts in India (Fig. 1a). In some cases, the IUCN Asian elephant range covered the entire district; in others, only a small portion of it.

Of 10,296 articles mentioning elephants in Asia (Bangladesh, Bhutan, Burma, Cambodia, China, India, Indonesia, Malaysia, Nepal, Sri Lanka, Thailand, and Vietnam), 1730 (16%) mentioned HEC casualties in India, of which 1461 articles (1635 events) were matched with the district names according to the 2011 India census (Table 1). These 1635 events referred to a total of 2488 casualties (898 elephant and 1590 human casualties). The conflict incidents occurred across 160 (25%) districts of the total 640 districts in India. The number of events associated with each district varied greatly (Fig. 1b). The most heavily affected districts were widely dispersed. In the southern region, Coimbatore district in Tamil Nadu state reported 82 HEC events; Sundargarh district in Odisha in the east central region reported 77 events; and Jalpaiguri district in West Bengal in northeast India reported 69 events. While some districts appeared frequently in the news, some districts (37) were reported only once.

A total of 1269 (86.9%) articles used reported either an elephant or human death. Injuries of either elephants or humans were reported alongside fatalities in 107 articles and 211 articles reported injuries without reporting any human or elephant fatality.

A total of 222 (35%) of the 640 districts in India were included in either the IUCN range or mentioned in HEC media database (Fig. 2). Of the 222 districts, 120 were included in both, 62 only by IUCN, and 40 were only mentioned in HEC articles (Fig. 2).

In the northeastern region, the IUCN range included a greater number of districts (68) than

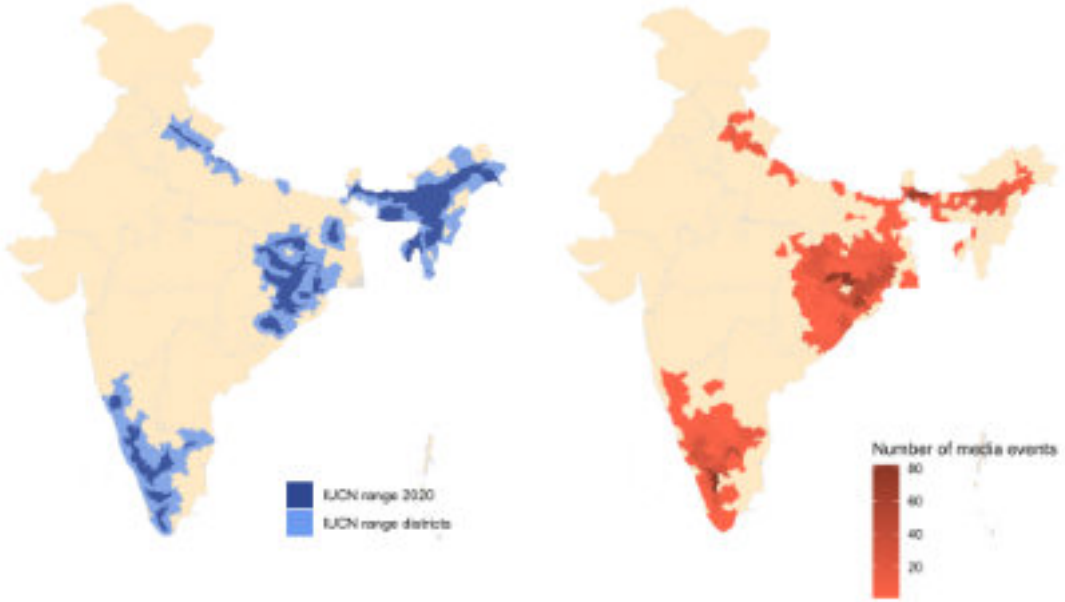

Figure 1. Asian elephant ranges. (a) Asian elephant range in India (IUCN shape file) and the districts with which it overlaps (i.e., IUCN range districts). (b) the number of media events reported for each district between 2004 and 2018.

Table 1. Summary of casualties by states ordered by the number of events (2004–2018).

Region	State	Elephant casualties		Human casualties		Total	
		Death	Injury	Death	Injury	Casualties	Events
East central	Odisha	199	11	256	117	583	398
Southern	Tamil Nadu	103	10	107	78	298	230
Northeastern	Assam	142	18	185	61	406	219
Southern	Karnataka	85	4	88	66	243	178
East central	West Bengal	117	21	101	60	299	175
East central	Jharkhand	47	2	107	46	202	113
Southern	Kerala	58	3	41	27	129	94
East central	Chhattisgarh	13	0	89	11	113	84
Northern	Uttarakhand	34	2	34	8	78	64
Southern	Andhra Pradesh	7	0	24	7	38	27
East central	Bihar	1	0	30	14	45	20
Northern	Uttar Pradesh	4	0	9	8	21	12
Northeastern	Meghalaya	7	0	3	0	10	6
East central	Madhya Pradesh	4	0	0	0	4	4
Northeastern	Tripura	1	0	2	1	4	4
Northeastern	Arunachal Pradesh	0	0	1	1	2	3
Southern	Maharashtra	3	0	0	6	9	2
Northeastern	Nagaland	2	0	1	1	4	2
Total		827	71	1078	512	2488	1635

the HEC media database (26), with 43 districts being only included in the IUCN range. In the northern region, the IUCN range included 13 districts, and the HEC media database reported 10 districts as having HEC, with the IUCN identifying 4 districts with elephants beyond those identified through the media. One district in each of the northern and northeastern regions found in the HEC media database was not included in the IUCN range. In the southern region, the IUCN range and HEC media database identified 46 districts and 49 districts, respectively, as having elephants, with the HEC media database showing elephant presence outside the IUCN range in 11 districts. The IUCN range data included eight districts in the southern region that were not identified as having HEC in the HEC media database. In the east central region, the IUCN range included 55 districts and the HEC media database identified 75 districts

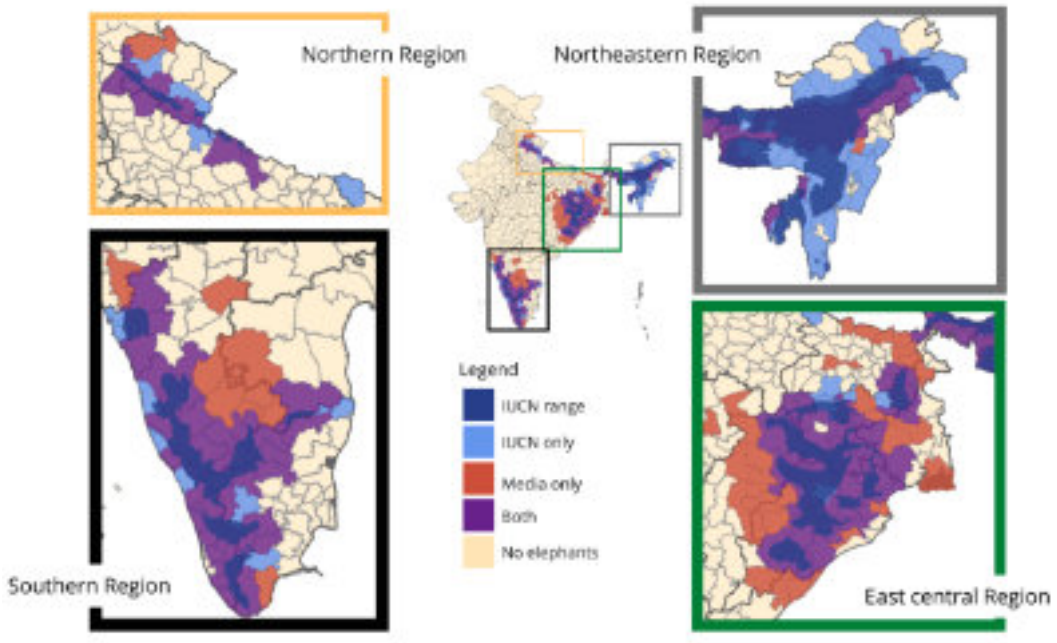

Figure 2. The range of Asian elephants as per the IUCN and HEC districts according to the HEC media database in the four regions of India. "IUCN only" refers to districts identified as having elephants by IUCN but not the HEC media database. "Media only" refers to districts where the IUCN data did not indicate elephant presence, but the HEC media database did. "Both" refers to districts where both the IUCN data and HEC media database indicate elephants are present.

Table 2. Count of districts with elephants by state and region as indicated by the IUCN and our HEC media database.

Region	State	IUCN & Media	IUCN only	Media only
East central	Bihar	4	1	7
	Chhattisgarh	3	0	6
	Jharkhand	17	4	2
	Madhya Pradesh	0	0	2
	Odisha	18	1	6
	Sikkim	0	1	0
	West Bengal	6	0	4
	Total East Central Region	48	7	27
Northeastern	Arunachal Pradesh	2	10	0
	Assam	19	8	0
	Manipur	0	6	0
	Meghalaya	2	5	0
	Mizoram	0	7	0
	Nagaland	1	4	1
	Tripura	1	3	0
	Total Northeastern Region	25	43	1
Northern	Uttar Pradesh	4	1	0
	Uttarakhand	5	3	1
	Total Northern Region	9	4	1
Southern	Andhra Pradesh	1	0	3
	Karnataka	14	1	6
	Kerala	11	2	0
	Maharashtra	0	0	1
	Tamil Nadu	12	3	1
	Goa	0	2	0
	Total Southern Region	38	8	11
Total		120	62	40

with elephants, with the HEC media database showing elephant presence outside the IUCN range in 27 districts. The IUCN range data included 7 districts in the east central region that were not identified as having HEC in the HEC media database.

A total of 31 districts with HEC that were not included in the IUCN range data had human-elephant conflict before 2016, with 14 districts having had multiple HEC incidents reported in the media before 2016 (Fig. 3). Two districts had conflict as far back as 2005.

Discussion

The geographical distribution of Asian elephants in India based on our HEC media database differs significantly from that derived from the official IUCN elephant range. Overall, the HEC media database showed elephants to be present in 40 districts that were not in the IUCN range, which amounts to a 22% increase in the number of districts with elephants. The difference cannot be wholly attributed to recent range expansion by elephants. The IUCN range data was last updated in 2016, and reports on HEC from fourteen districts predate this, with two districts having had elephants at least as far back as 2005 (Fig. 3), suggesting that the IUCN range map excluded areas where Asian elephants had been present for over a decade prior to its updating. Thus, the IUCN range map underestimates the distribution of elephants in India, and media data could be a useful tool to help identify and update elephant distribution.

While both spatial distributions show Asian elephants in the same four main regions (northern, northeastern, southern and east central), the districts identified as having elephants by each data set were different. In the southern and east cent-

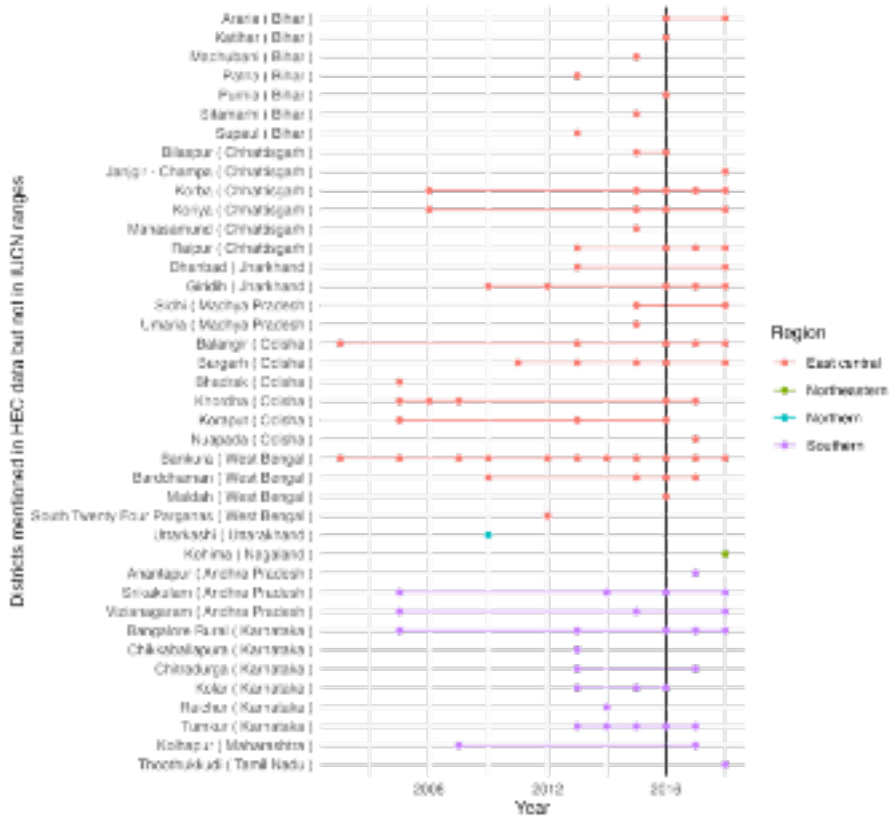

Figure 3. Timeline of fatal HEC events in the districts shown to have conflict in the HEC media database but not included in the IUCN range maps. The black vertical line indicates the year the IUCN range map was last updated (2016).

ral regions, elephants occurred in many districts outside the IUCN ranges, and there were only a few districts in the IUCN range that were not captured by the HEC media database. On the other hand, in the northern and northeastern regions, the IUCN range covered more districts than the HEC media database, and only one district in each region not in the IUCN range was shown to have elephants by the HEC media database. These discrepancies are likely driven by different phenomena. In South India, English media reporting may be more common than in the rest of the country, improving detection of elephant presence in this region by our study. In east central India, the recent range expansion of elephants (and resulting HEC) into Central India is probably deemed as more news-worthy, resulting in more English-language coverage. In contrast, in North and Northeast India, there has probably neither been a significant range expansion nor is there as strong a presence of English-language media. In theory, some areas may also have elephants but little HEC, and hence may also not be represented in media reports. Incorporating local-language media reports in the analysis could greatly increase the detection of elephant presence and make it more robust.

Our study also demonstrates that media articles can be used to identify areas with relatively high levels of conflict. Longitudinal analysis of data from particular districts could also indicate changes in conflict levels, suggesting changes in the effectiveness of mitigation or elephant presence or behaviour. Although again subject to the media biases discussed, information from a particular region over time is likely to be more comparable, hence identification of high conflict areas within regions may be more accurate. Although not specifically addressed in our study, media articles could also detect range expansion of elephants. Information on relative level of conflict, changes in conflict levels, and range expansion or contraction could be used for prioritising and guiding conflict mitigation and elephant conservation.

Given the limitations of media-sourced data, it is not a perfect tool for range mapping by itself. Nor are media data a good replacement for offi-

cial HEC data as only about 25% as many incidents recorded in the government data from 2014–2015 (Ministry of Micro, Small & Medium Enterprises, Government of India, 2021) were detected through the HEC media database. However, the availability of media data online means it could be used to improve our understanding of Asian elephants' range. For a relatively small expense, analysts (or an algorithm) could periodically repeat our approach, using media to identify districts that have elephants outside of the known range. Further refinement of the range can be conducted in districts outside of the established elephant range through field visits or by contacting experts there.

Our study shows that media articles can provide data that can effectively update Asian elephant range maps and contribute to HEC mitigation and elephant conservation. Media analysis may be made even more useful by the use of automated tools like 'web-scrapers' to extract date and location information from HEC articles, or even identify the HEC articles themselves.

While not every species will generate as much media attention as Asian elephants, our paper demonstrates large-scale utilisation of news articles to obtain data relevant to the conservation and management of an endangered species. Our method can be easily used with other charismatic species, especially those involved in fatal human-wildlife conflict, and spur research and conservation outcomes for them as well.

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Research Article
Gajah 58 (2025) 11-18

Conservation Education Using Elephant Cognition

Radhika N. Makecha[1]*, Sagarika Phalke[2,3] and Yoshie Nakai[1]

[1]*Eastern Kentucky University, Richmond, Kentucky, USA*
[2]*A Rocha India, Anekal (Taluk), Bangalore, India*
[3]*School of Biological Sciences, University of Hong Kong, Hong Kong SAR*
**Corresponding author's email: radhika.makecha@eku.edu*

Abstract. We evaluated whether the inclusion of elephant cognition in an education program resulted in changes in attitudes towards elephants and elephant conservation and the effect of rurality, gender, and age on attitudinal change. The study group was comprised of villagers living in and around Bannerghatta National Park. We found that adolescents had more favourable attitudes towards Asian elephants than adults, and participants in urban areas had more favourable attitudes than those in rural areas. No gender differences were observed. Overall, using elephant cognition as an educational tool did not result in more favourable attitudes towards elephants and elephant conservation.

Introduction

Human-elephant conflict (HEC) is on the rise due to habitat loss and a multitude of factors (Pandey *et al*. 2024). Community education plays a vital role in mitigating HEC, with numerous studies reporting positive changes in attitudes towards conservation after implementation of education programs (Hungerford & Volk 1990; Kwamboka 2013; Burnett *et al*. 2015). However, it is important to investigate the types of educational content that result in effective attitude change. The public is fascinated with animal minds (cognition), which can be a useful educational tool (e.g. Bielick & Karns 1998; Helton & Helton 2005; Harley *et al*. 2010; Bowler *et al*. 2012; Maust-Mohl *et al*. 2012; Carey 2018; Barrett *et al*. 2019; Callahan *et al*. 2021; Davis *et al*. 2023). However, Makecha *et al*. (2021), on assessing adult male villagers' attitudes in a high HEC landscape, Bannerghatta National Park (BNP) in Karnataka, India, found that including elephant cognition in an education program did not produce significant differences in attitudes towards elephants and their conservation.

Different types of cognitive information may vary in effectiveness regarding attitude change. For example, Davis *et al*. (2023) found that college students rated different species as more interesting, intelligent, and emotionally complex when given different types of cognitive information about them. This effect was strongest after receiving information about the species' emotional abilities, especially when these abilities were highlighted positively (e.g mourning dead conspecifics) versus negatively (engaging in emotionally hurtful behaviour towards conspecifics). Menor-Campos *et al*. (2018) reported similar results in Spanish primary school children, where positive attitudes towards animals were related to animals' ability to feel emotions.

Factors such as gender, age, and rurality may influence the outcome of educational programs. Makecha *et al*. (2021) only focused on adult male villagers due to their role as the primary decision maker in the family. However, Bandara & Tisdell (2003) reported that rural women in Sri Lanka expressed more negative attitudes towards elephants than men, due to elephants' "destructive" nature (e.g. loss of family members to elephant attacks, loss of income), resulting in the disruption of family life and mental well-being. Mabeluanga *et al*. (2016) also found that women in BNP have more negative opinions towards elephants than men, potentially due to their role as the primary caretaker of the family, and thus being more sensitive to income loss due to HEC. However, such effects are likely to be area/community

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specific, as other studies have reported no gender differences (Kideghesho *et al*. 2007; van de Water & Matteson 2018) or, in one case, women reported more favourable attitudes towards elephants (Nath *et al*. 2015).

Also, people who depend on agriculture are the most affected by HEC (Bandara & Tisdell 2003; van de Water & Matteson 2018; Sampson *et al*. 2021) and the study from Makecha *et al*. (2021) was limited to individuals from rural areas whose primary source of income was agriculture. Bandara & Tisdell (2003) reported that in Sri Lanka, urban populations had more positive attitudes toward elephant conservation and rural populations had more mixed attitudes. Additionally, van de Water & Matteson (2018) reported that individuals who rely primarily on agriculture are less likely to support elephant conservation.

Finally, younger individuals may have more malleable attitudes towards wildlife and may also have experienced less human and wildlife conflict than older individuals. However, current findings on age are mixed. For example, no differences in attitude towards tigers and elephants were found between different age groups in Western Ghats, India (Kanagavel *et al*. 2014). Heinen & Shrivastava (2009) found similar results in communities surrounding Kaziranga National Park, India for large mammals (e.g. tigers, rhinoceroses, elephants). In contrast, Arjunan *et al*. (2006) found that younger individuals living near Kalakkad Mundanthurai Tiger Reserve, India were more likely to show strong support for conservation in general.

Given the above, the current study assessed whether an elephant education program centred on elephant cognition, including elephant emotions, resulted in more positive attitudes towards elephants/elephant conservation, and whether gender, rurality, and age of participants influenced attitudinal change.

Materials and methods

Study area and participants

BNP is a fragmented but important elephant habitat with a dense human population (~107,000 individuals) in the area surrounding the national park (~260 km^2), along with three elephant corridors for wild Asian elephants (*Elephas maximus*) (Ramkumar *et al*. 2017). Participants in the study consisted of 122 adults (above 18 years) and 118 adolescents aged 12–14 years, of which 138 (57.7%) were males and 101 (42.3%) females. One participant was not used for the gender analysis because the gender was not recorded. Participants were also sampled from rural, semi-rural, and urban areas (Table 1). The participants were assigned to one of three elephant education programs or a control group receiving a non-related education program (see below).

Education programs

Two of the education programs included elephant cognition, with one focusing on elephant problem-solving and cooperation and the other focusing on elephant emotions (hereafter referred to as the 'cognition - problem solving/cooperation' program and the 'cognition - emotion' program, respectively). The third elephant education program did not incorporate any information on elephant cognition (hereafter referred to as the 'non-cognition program').

All three programs included information on the physical features of elephants, what elephants eat, where elephants can be found in India,

Table 1. Area definitions and participant information by area.

Area	Definition	N	Adults	Adolescents
Rural	Villages in the southern and eastern parts of BNP (furthest away from urban areas)	79	40	39
Semi-rural	Villages in the northern and western part of BNP (close to urban areas)	80	41	39
Urban	Villages located less than 5 km from BNP's boundary	81	41	40

Karnataka, and BNP, their approximate population size, their social structure, and why elephants are important for the ecosystem. The non-cognition program placed extra emphasis on elephant social structure and included a video of an elephant family (adult females, subadults, juveniles, and calves) and another video of a solitary adult male. Participants in this program also took part in an activity where they labelled a photograph of an elephant herd with different age classes.

The cognition problem-solving/cooperation program contained additional information on how elephants are like us, such as how they protect their young, play, etc. Participants engaged in a brief activity where they had to solve a cooperation task (modified from Plotnik *et al.* 2011). After solving this task, they were asked if they thought elephants could solve this task and then shown a brief video of elephants solving the task (BBC Earth 2017) from the Plotnik *et al.* (2011) study. The information on how elephants are like us, as well as the activity and video on cooperation/problem-solving, comprised the cognitive component of this program.

The cognition-emotion program talked about how elephants are like us as well as the emotional complexity of elephants. This was achieved by displaying two different photos and asking participants to describe what they thought was happening in the photos (the activity portion of the program). In the first photo, a calf that was struggling was supported by its mother. In the second photo, a mother elephant was shown carrying the body of her dead calf. The participants were informed that she carried the body for two days, only setting it down to eat. After discussing the photos with the participants, they were told that elephants have been reported to approach dying companions and touch them, both before and after death, including helping their dying companions and guarding the dead bodies (Douglas-Hamilton *et al.* 2006; Goldenberg & Wittemyer 2020). Two videos were also shown in the cognition-emotion program, one where a mother elephant was trying to wake up her dead calf, and the other where elephants were helping a calf cross a river.

The fourth program was for the control group and focused on BNP and its characteristics (landscape, wildlife, zoological park, etc.) and included an activity as well as a video. The programs and the included videos in all four programs were equal in length (~5–10 minutes, depending on the number of participant comments throughout the presentation).

Procedure

Data collection took place from May to June 2023 to avoid the high HEC season in BNP. Data was collected with the aid of two local translators who spoke Kannada, the local language. Participants in each area (rural, semi-rural, urban) were approached opportunistically and asked if they were willing to participate in a brief educational presentation and survey (both in Kannada). Educational presentations were displayed using Microsoft PowerPoint. All participants were told that their participation was voluntary and that they could withdraw at any point.

After the educational presentations, participants were surveyed on their attitudes towards both elephants and elephant conservation using two 9-item scales: Attitudes Toward Elephants Scale (AE) and Attitudes Towards Elephant Conservation Scale (AEC) (see Makecha *et al.* 2021). Internal consistency was $\alpha = 0.67$ ($\alpha = 0.70$ for adults, $\alpha = 0.63$ for adolescents) for the AE scale while internal consistency of the AEC Scale was $\alpha = 0.49$ ($\alpha = 0.61$ for adults, $\alpha = 0.32$ for adolescents). The internal consistency of the AEC Scale was limited, especially for the adolescent sample, and the results of this scale were interpreted with caution.

Both the AE and AEC scales were orally administered by the translators. Answers were recorded on a 4-point Likert scale (Yes, Maybe Yes, Maybe No, No). Demographic information (date, time, weather, gender, village/town/city, GPS location, perceived level of conflict, age, primary source of income, and level of income) was also recorded. Although there were two translators who interacted with participants in the study, the multivariate test indicated that the translators did not affect participants' attitudes toward elephant conservation and attitudes to-

ward elephants, Wilks' lambda = 0.989, $F_{(2,234)}$ = 1.34, p = 0.264.

Analyses

The data analyses were conducted using jamovi (Version 2.5). A series of four multivariate analyses of variance (MANOVAs) were conducted with the two attitude scales as dependent variables. To test the first research question, we tested program type (cognition emotion, cognition problem-solving/cooperation, non-cognition, control) as an independent variable. To test the second set of research questions, we tested gender (males and females), rurality of the area of residence (rural, semi-rural, and urban areas), and age group (adolescents and adults) as independent variables in separate MANOVAs.

Results

Program types

The multivariate test did not support the effect of intervention types on the attitudes toward elephant conservation and toward elephants (Wilks' lambda = 0.989, $F_{(6, 464)}$ = 0.447, p = 0.847). Thus, participants in the cognition problem-solving/cooperation program, cognition emotion program, non-cognition program, and control group did not differ significantly in their attitudes after program completion (Table 2).

Gender

The multivariate test indicated that participant gender did not affect their attitudes toward elephant conservation and elephants (Wilks' lambda = 0.978, $F_{(2,233)}$ = 2.61, p = 0.076).

Rurality of area of residence

A multivariate test indicated that participants' areas of residence influenced their attitudes toward elephant conservation and elephants (Wilks' lambda = 0.849, $F_{(4,466)}$ = 9.91 p < 0.001). Univariate tests (Welch's test for unequal variances) showed that participants in rural, semi-rural, and urban areas varied in their attitudes toward elephant conservation ($F_{(2,154)}$ = 4.32, p = 0.015) as well as their attitudes toward elephants ($F_{(2, 156)}$ = 20.60, p < 0.001). The Games-Howel post-hoc test (for unequal variances) indicated that the participants in urban areas reported significantly more favourable attitudes toward elephant conservation than those in rural areas ($t_{(142)}$ = -2.86, p = .013). Participants in urban areas were more favourable toward elephants than those in semi-rural ($t_{(158)}$ = -4.88, p < 0.001) and rural areas ($t_{(154)}$ = -6.02, p < 0.001).

Age

A multivariate test indicated that adults and adolescents differed in their attitudes toward elephant conservation and elephants (Wilks' lambda = 0.974, $F_{(2,234)}$ = 3.09, p = 0.048). Univariate tests (Welch's test for unequal variances) showed that adults and adolescents varied in their attitudes toward elephants ($F_{(1,235)}$ = 5.96, p = 0.015) but not in their attitudes toward elephant conservation ($F_{(1, 224)}$ = 3.15, p = 0.077). Specifically, adolescents reported more favour-

Table 2. Means and standard deviations (SD) of the four different educational groups' attitudes on the AE and AEC scales.

Attitudes	Program type	N	Mean	SD
Toward elephant conservation	Control	60	3.06	0.553
	Cognition emotion	60	3.09	0.532
	Cognition problem-solving/cooperation	58	3.17	0.368
	Non-cognition	61	3.03	0.566
Toward elephants	Control	59	2.72	0.580
	Cognition emotion	60	2.74	0.595
	Cognition problem-solving/cooperation	59	2.75	0.621
	Non-cognition	60	2.74	0.664

able attitudes toward elephants (M = 2.83) than adults (M = 2.64).

Discussion

Although information on animal cognition can have positive results when used in conservation education programs), we did not find a difference in attitudes towards elephants and elephant conservation between the different education programs. Our results are similar to Makecha *et al*.'s (2021) study in the same area, which used only adult males as respondents. The absence of attitudinal change in both studies may be because participants already had knowledge of elephant cognition, especially those in high HEC areas. For example, elephants often find new ways around barriers, such as electric fences, where they use their tusks or trees to bring down fences without shocking themselves (Sukumar 2003; Choudhury 2004; Barrett *et al*. 2019). Additionally, elephants can become desensitised to the scaring and chasing methods farmers use to deter elephants, resulting in continued crop-raiding (Bandara & Tisdell 2003). Individual elephants may be considered "more bold" by people and labelled as "troublemakers" (Mumby & Plotnik 2018; Barrett *et al*. 2019). Therefore, people in high HEC areas may consider elephants as cognitively complex and flexible and, as a result, more dangerous, which may result in a negative view of elephants and elephant conservation. For example, older adults living around Way Kambas National Park in Sumatra viewed elephants as smart, acknowledging that they can think and feel like humans, but also associated this intelligence with their ability to cross barriers set up to prevent raiding. Therefore, knowledge of the elephant 'mind' does not necessarily promote willingness to coexist with elephants, especially in older, more experienced populations. In contrast, studies that have reported positive outcomes when using animal cognition for outreach were conducted with Western audiences and species (e.g. primates, dolphins) that did not pose any conflict risk to these particular audiences (Bielick & Karns 1998; Helton & Helton 2005; Harley *et al*. 2010; Bowler *et al*. 2012; Maust-Mohl *et al*. 2012; Barrett *et al*. 2019; Davis *et al*. 2023).

One possible limitation of our study and Makecha *et al*. (2021), could be the comparatively brief duration of the education programs, which may have led to the lack of attitudinal change. Education programs may be more successful in changing attitudes the lengthier and more interactive they are (Sponarksi *et al*. 2016, 2019). For example, in a nine-week recreational program measuring children's belief in the animal mind, eight socio-economically challenged children participated in activities involving horses and other farm animals. All except one child reported greater awareness of animal minds and emotions, with one child reporting, "Now I think all animals have feelings and thoughts of their own (Tardiff-Williams & Roma 2022). Most studies reporting positive outcomes from the use of animal cognition content were either focused on visitors at an exhibit or had educational programs incorporating cognition over longer periods of time. Visitors were also found to spend more time at exhibits when they had the opportunity to observe the animals at the exhibit engage directly in cognitive research and learn about it (brown capuchin and squirrel monkeys (Bowler *et al*. 2012); bottlenose dolphins (Harley *et al*. 2010)).

In our study, adults did not view elephants as favourably as adolescents, possibly due to adolescents having less experience with conflict at their younger age. Adults in Ardiantiono *et al*.'s (2021) study also were less likely to view elephants as important and pleasant, a finding also reported by van de Water & Matteson (2018) in villages near the Salakpra Wildlife Sanctuary in western Thailand. Therefore, it may be better to focus on the younger generation when developing educational programs, who also tend to be more enthusiastic.

When looking at rurality in our study, participants in urban areas reported significantly more favourable attitudes toward elephant conservation than those from rural areas and significantly more favourable attitudes toward elephants than those in semi-rural and rural areas. Those living in rural areas, especially farmers, experience wildlife conflict, while urban residents typically do not and are therefore more likely to support conservation efforts (Bandara

& Tisdell 2003). Bandara & Tisdell (2003) reported that in Sri Lanka, 94% of rural participants in their study supported the statement: "The current wild elephant population in Sri Lanka is between 3,000 and 5,000 animals. It does not matter if this number is reduced by 50% to provide more land for agriculture and human settlement" but in contrast, 94% of urban participants did not support the statement. Similarly, they found 81% of urban participants did not support the statement "Local farmers in the vicinity of nature reserves should be allowed a greater freedom to control 'problem elephants' which cause crop and property damage", while 79% of rural participants supported it. Sampson *et al*. (2022) reported that in Myanmar, both urban and rural residents held positive views of elephants, but that rural communities were less likely to think that coexistence between humans and elephants was possible and they were more likely to view elephants as pests. We found that semi-rural and rural participants did not significantly differ in their attitudes towards elephants although the level of conflict experienced by semi-rural participants may have been less. This points to the role that other factors, such as intensity of conflict and/or proximity to rural areas, and word of mouth, may also play in influencing attitudes towards elephants. Overall, our findings are consistent with that of previous studies assessing the effects of rurality on people's attitudes to conservation and elephants.

When examining gender differences, we did not find any significant differences in attitudes towards elephants and elephant conservation, demonstrating that men and women in and around BNP did not differ in their views towards elephants. However, Mabeluanga (2016) reported that women held more negative views towards elephants in BNP than men, while Venkataramana *et al*. (2015) found that men in BNP expressed more fear of elephants than women, most likely due to the potential of experiencing direct conflict with them. They also found that the majority of women did not support conserving elephants, possibly due to the severity of potential indirect effects from conflict (Venkataramana *et al*. 2015). Differences in the findings between our study and the others could be due to changes in attitudes over time, as our study was conducted eight years later and over the past decade, both genders may have come to share similar levels of negativity towards elephants. However, the causation of negativity is likely to differ between the sexes, as men experience more direct conflict, and women experience more indirect effects such as the loss of the breadwinner of the family. These views are also reflected by Venkataramana *et al*. (2015).

Conclusions and future directions

Although the education programs in ours and Makecha *et al*.'s (2021) study did not result in significant differences in attitudes towards elephants and elephant conservation, information on the elephant mind may be a useful educational tool in different contexts. Thekaekara *et al*. (2021) reported that certain indigenous communities in South India view the elephant as "other-than-human persons". This view characterises elephants as having personhood, personality, agency, and moral values akin to human values, a view that can be especially useful for promoting and accepting coexistence. However, given the complexity involved in promoting coexistence, the efficacy of varying educational programs will differ, depending on the community and species being targeted. Therefore, affecting attitudinal change requires a tailored approach to designing studies, taking into consideration the specific attributes of the target community and its relationship with the species concerned.

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Research Article
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Incidence of Abnormality in Spinous Processes of the Thoracic Vertebrae in Abused Asian Elephants with Radiographic Evidence

Ilayaraja Selvaraj[1]*, E. Gochalan[1], Arun A. Sha[2], Rahul Prasad[1], Lalith K. Jangad[1] and Pramod Rajput[1]

[1]*Wildlife SOS, Mathura, Uttar Pradesh, India*
[2]*Wildlife SOS, Bangalore, Karnataka, India*
**Corresponding author's e-mail: ilasuvet@gmail.com*

Abstract. This study investigates the effects of saddle use on Asian elephants in captivity, focusing on issues like saddle gall and spinal damage caused by factors such as inadequate cushioning and overloading. Radiographic evidence from cases involving Asian elephants illustrates varying degrees of dorsal spinous process degeneration, impacting gait and body structure. The findings underscore the need for clinicians to use radiography in evaluating elephant skeletal health and advocate for improved health monitoring practices among elephant caretakers.

Introduction

At least in range countries, Asian elephants (*Elephas maximus*) in human care are used for carrying out many activities such as patrolling, koonkie, timber hauling, fodder collection, safari rides, joyrides for tourists, and participating in religious and civil ceremonies. Maintaining elephants purely for work may compromise the welfare conditions of the animals and hinder the species-specific activity of their choosing (Varmal *et al*. 2010).

It is paramount to ensure proper fixation of the saddle (howdah) on elephants that are carrying persons on their back. An improperly fixed saddle or overloading may result in saddle gall formation and induce inflammatory changes at the edges of the dorsal spinous processes due to chronic friction between the saddle and the dorsal spine (Bansiddhi *et al*. 2019). In Thailand, potential interventions suggest risk factors associated with skin of elephants that are used in the tourism industry due to saddle (Magda *et al*. 2015).

Elephants that are suffering from saddle gall, which later become a huge, infected wound on the dorsal spine and takes several months to heal completely. While healing, fibrotic scar tissue and callus are formed on the dorsal spinous processes which adheres together leading to complete or partial fusion of the dorsal spinous processes in the meaning of an ankylosis. In addition, the process may lead to various degrees of degenerative changes due to damage in growth plates. This results in abnormal body conformation and gait alteration of the elephant. Changes in gait patterns, effects on musculoskeletal function, and joint kinematics may be attributed to the impact of weight carriage on Asian elephants used for riding (Kongsawasdi *et al*. 2021). In equines, the "kissing" spinous processes of the lumbar vertebrae is considered one of the reasons for back pain (Turner 2003; Jeffcott & Haussler 2004).

In elephants, radiography is particularly helpful for the detection of chronic changes in bones or joints (George 1989; Gage 1999). Growth plate closure was defined as the time at which a radiolucent physis was no longer visible radiographically (Siffert 1981). Information about the growth plates of the spinous processes (latin: *Processus spinosus*) of the thoracic vertebrae of Asian elephants is largely unknown. Consequently, the objectives of this study were to determine the nature of lesions on the spinous processes in Asian elephants possibly caused by carrying heavy objects on its back, compromised welfare and management through radiographic evidence. The authors also demonstrate

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Figure 1. Photographs showing severely abused and exploited elephants.

differences in the growth plate closure of these dorsal spines in comparison to thoracic radiographs of apparently healthy individuals.

Methodology

Wildlife SOS, an NGO, established an Elephant Conservation and Care Center in India to provide proper veterinary care and nutrition to elephants rescued from abusive and challenging conditions (Fig. 1) in human care. The facility features an on-site hospital equipped with a wide range of therapeutic as well as diagnostic capabilities.

The elephants underwent positive reinforcement training to facilitate their comfort with sitting in an elephant restraint device (ERD) and familiarity with the radiographic examination procedure. Radiographs were taken using a portable direct digital radiography unit (EPCORSA 2.4, Epsilon Healthcare Solutions Pvt. Ltd.) with a Focus 35C detector (14×17 inch, Carestream, India). The X-ray generator and imaging plate were positioned bilaterally alongside the spine, with the imaging plate oriented perpendicular to the primary X-ray beam. (Fig. 2). Serial lateral radiographic projections were obtained using standardised exposure settings of 70 kV, 38 mA and 30 mAs to evaluate the elephants' skeletal health systematically.

Figure 2. Illustration of X-ray imaging.

The body condition scoring of elephants was assessed using visual observations based on criteria described by Wijeyamohan *et al*. (2014).

Results

Case 1

Inspection: Female, 29 years, BCS 1/10, alteration in conformation, altered gait, severe scars and depression in the dorsal aspect of the body.

Radiographic findings: Degenerative changes were observed in the thoracic vertebrae (T) 13-15 (Fig. 3b & 3c; marked with red arrow), while abnormal fusion of the spinous processes T16–T18 (Fig. 3a; marked with yellow arrows) and adhesion of the spinous process to the skin were noted at T19.

Case 2

Inspection: Male, 20 years, BCS 2/10, no visible scar on the skin but an abnormal projection on the dorsal spine was encountered.

Radiographic findings: Severe degenerative changes were observed in the dorsal spinous processes, along with avulsion of the growth plate avulsion from the spinous processes. Fusion of two thoracic spinous processes was noticed accompanied by severe degenerative lesions at T14–T15 (Fig. 4a; marked with yellow circle). Fragmentation of growth plate was also observed in several spinous processes, specifically T15–T19 (Fig. 4b; marked with white arrows). The epiphyseal growth plates are still visible (Fig. 4a; marked with red arrows).

Case 3

Inspection: Male, 57 years, BCS 1/10, presented with a history of chronic septic wounds due to saddle gall.

Radiographic findings: Severe degenerative changes were observed on spinous processes from T14–T19 (Fig. 5b & 5c; marked with red arrows) along with a kissing spine phenomenon between T18 and lumbar vertebrae 1 (L1) (Fig. 5a; marked with yellow arrow).

Figure 3. Abnormal fusion of spinous processes.

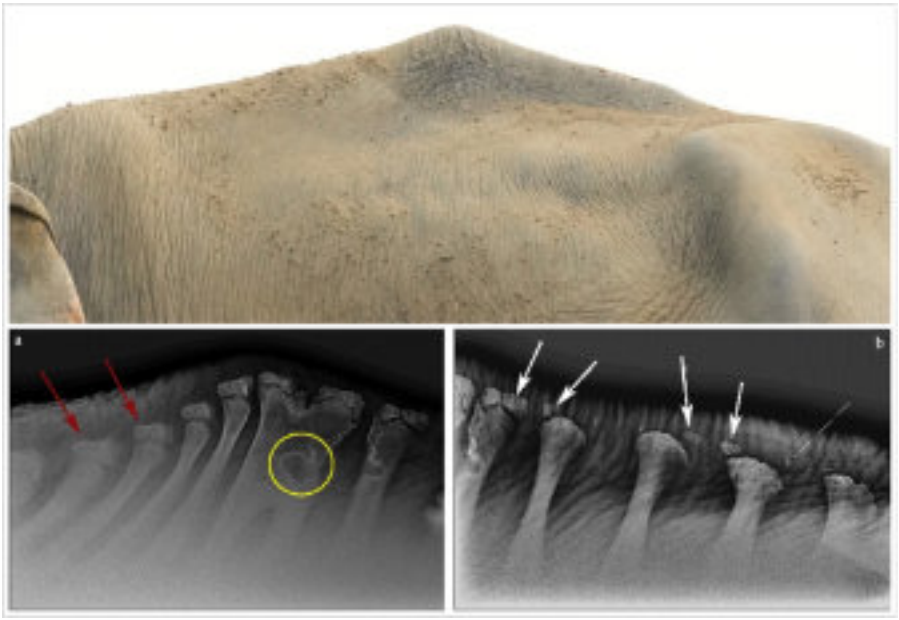

Figure 4. Growth plate fragmentation and avulsion from the spinous processes.

Figure 5. Spinous processes of thoracic vertebrae showing severe degenerative changes.

Case 4

Inspection: Female, 25 years, BCS 3/10, Abnormal swelling with ulceration of skin on the dorsal aspect of the body (marked with red arrow) was noticed.

Radiographic findings: Mild degenerative changes were noticed in the spinous processes, along with excessive thickening of the skin and no signs of abscess lesion/skin adhesion were noticed. The epiphyseal growth plates were not clearly visible indicating the initiation of epiphyseal mineralisation in the T16–T19 (Fig. 6a & 6b; marked with yellow arrows).

Case 5

Inspection: Female, 21 years, BCS 1/10, presented with degenerative joint disorder affecting forelimbs. Locomotion of the elephant is being affected due to abnormal gait.

Radiographic findings: Mild degenerative changes noticed in the spinous processes and fibrotic adhesion (Fig. 7a; marked with yellow arrows) was noticed at T12 and T13, possibly attributed to consistent saddle compression and overloading.

Case 6

Inspection: Female, 51 years, BCS 3/10, abnormal projection of dorsal spine encountered.

Radiographic findings: Various degrees of degenerative changes and remodelling of the dorsal spinous processes were observed from T14–T18. Abnormal callus formation was noticed at T16–T17, potentially indicative of fu-

Figure 6. Radiograph of thoracic spine showing mild degenerative changes in the spinous processes.

ture fusion (Fig. 8a; marked with yellow arrow). Furthermore, T9–T13 exhibited an unusual curvature at the tip with degenerative changes, likely due to partial avulsion of the growth plate caused by constant saddle pressure cranially with over loading (Fig. 8b; red arrows).

Case 7

Inspection: Female, 29 years, BCS 2/10, severe arthritis with abnormal gait. Elephant is exhibiting symptoms of lameness and degenerative joint disorder with both hindlimbs.

Radiographic findings: Degenerative and osteolytic changes were noticed on the dorsal spinous processes from T5–T7 and T12–T15 (Fig. 9a & 9c; marked with yellow arrows).

Case 8

Inspection: Male, 50 years, BCS 2/10.

Radiographic findings: Fragmented radiopaque lesions were observed between T4 and T5 of the spinous processes (Fig. 10a; marked with yellow arrow) suggesting potential growth plate avulsions and degenerative lesions. Kissing spine was noticed at L3 and L4 (Fig. 10d; marked with yellow circle) indicating contact between adjacent vertebral spinous processes.

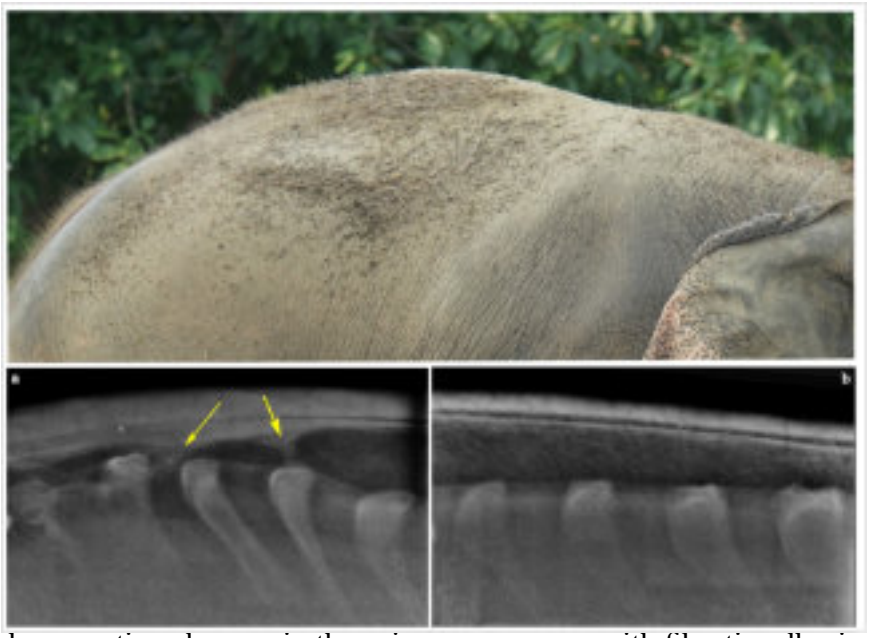

Figure 7. Mild degenerative changes in the spinous processes with fibrotic adhesions.

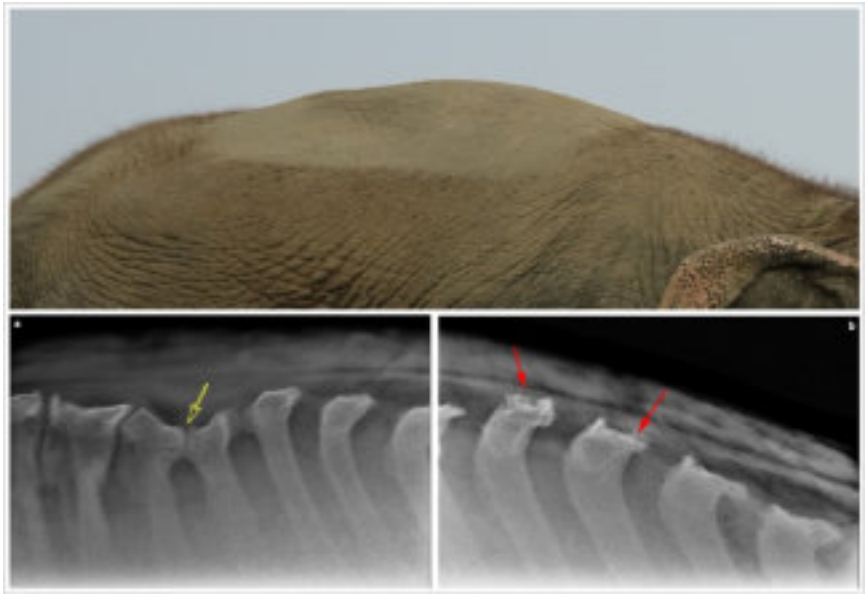

Figure 8. Remodelling of the dorsal spinous processes and abnormal callus formation.

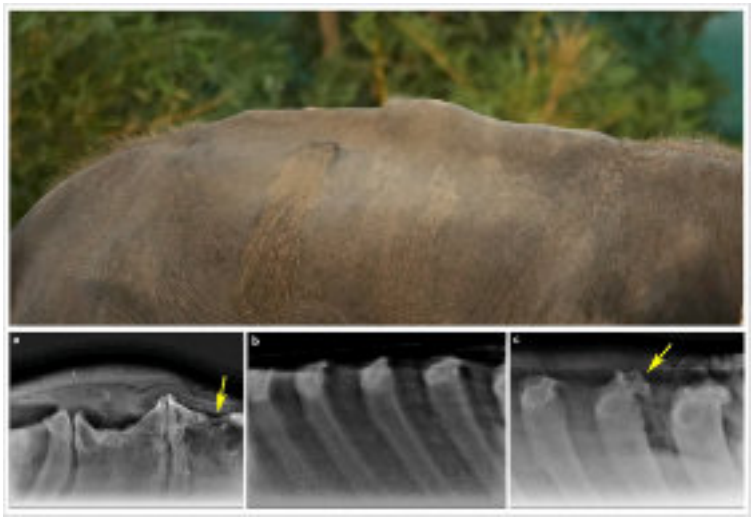

Figure 9. Abnormal degenerative and osteolytic changes in dorsal spinous processes.

Figure 10. Degenerative lesions with kissing spine.

Discussion

As in African elephants (*Loxodonta africana*), the spinous processes incline caudally in Asian elephants (Bezuidenhout & Seegers 1996). Skeletal anatomy suggests that Asian elephants have 19 pairs of ribs and 33 caudal vertebrae (Mikota *et al*. 1994), whereas African elephants have 21 pairs of ribs and 26 caudal vertebrae (Smuts & Bezuidenhout 1993, 1994).

Kolk *et al*. (2008) assessed bone mineralization in captive Asian elephants through radiography of the tail vertebrae and concluded that there was a gradual increase in the level of mineralisation and closure of the epiphyseal growth plates as the elephants aged. At the age of 36 years, the growth plates were still not closed. Male and female feet mature at different rates and for different lengths of time in humans. The metatarsals and proximal phalanges, of females reach full maturity approximately 54 months earlier than do males (Whitaker *et al*. 2002). In elephants, the timing of P3 ossification for each digit is variable (Siegal-Willott *et al*. 2008). The relative times of growth plate closure were consistent between right and left feet, but they varied between the sexes. For example, one male elephant did not exhibit radiographic closure of the P1 growth plate until 8.7 years of age, in contrast to closure detected at 7.6 years of age in a female animal (Siegal-Willott *et al*. 2008). Thus, it suggests the elephant's skeletal system continues growing and the growth plate closing times differ for each bone.

Authors observation and available data from the present study revealed that growth plate mineralisation of dorsal spinous processes was encountered earlier in females (Fig. 11) as com-

pared to males (Fig. 12; marked with yellow arrows). Turner (2011) reported the occurrence of spinous impingement most commonly between T13 and T18 in riding horses. In the present study, the authors observed that the dorsal spinous processes of vertebra T1–T9 are more affected than T10–T19. This may be due to the pressure of saddle being more cranially than caudally because Asian elephants carry most of their body weight on their forelimbs (Panagiotopoulou *et al*. 2012).

With available data, even in elephants aged >50 years not showing complete closure of the growth plate (Fig. 13b, 14a & 14b, yellow arrows). However, elephants appear to be capable of carrying a significant amount of weight on the back without showing signs of physical distress and no significant evidence shows carrying a 15% body mass load brings changes in elephant gait patterns (Kongsawasdi *et al*. 2021). Any injuries that happen to the bones of the dorsal spinous processes before the closing of the growth plate may lead to various degrees of degeneration and fracture. The fragmented and partial avulsion of growth plates may lead to the fusion of the spinous processes due to further mineralization process.

Conclusion

Improper saddling, overloading, inappropriate use of cushion materials, and ignored health care of the wound along with malnourishment may result in damaging the spinous processes of the thoracic vertebrae which involves unusual

Figure 11. Female, 24 years, BCS 5/10, showing clear mineralisation; open physis at T8–T10 and T18–T19 (yellow arrows).

Figure 12. Male, 22 years, BCS 2/10, showing even epiphyseal growth plates at T11–T15.

fusion, various degrees of osteolytic changes, and remodelling. Hence any injury or saddle gall on the dorsal spine needs intensive treatment, otherwise the recurrent infection and consecutive damage will interrupt the wound healing. Later this becomes a chronic wound and increases the fibrotic adhesion with the dorsal spinous processes. Since all the elephants in this study are rescued from severely distressed conditions, it needs further investigations on healthy individuals who are not saddled to understand the exact time of growth plate closure of the spinous processes.

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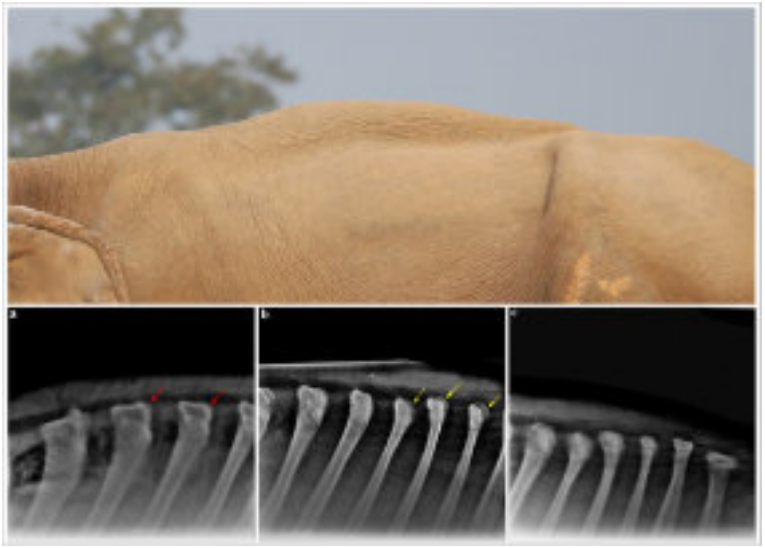

Figure 13. Male, 58 years, BCS 2/10, exhibiting partial mineralisation at T11–T13 (yellow arrows) and closure of growth plates at T5–T7 (red arrows).

Figure 14. Female, 67 years, BCS 2/10, complete closure (red arrows) of T13 and T14 vertebral growth plates, T16 and T17 yet to be closed (yellow arrows).

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Research Article
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Establishing Biochemical Reference Intervals for Semi-Captive Elephants in Tamil Nadu, India

Rengarasu Madeswaran[1], Parvathinathan Sandhya[1], M. Gabriel Paulraj[1]*. Arumugam Udhayan[1], Manikka G. Ganesan[1], Rangasamy Kanchana[2], Arulmani Manimozhi[1] and Dhayanithi Vasanthakumari[1]

[1]*Advanced Institute for Wildlife Conservation (Research, Training & Education), Vandalur, Chennai, Tamil Nadu, India*
[2]*Tamil Nadu Wildlife Crime Control Bureau, Chennai, Tamil Nadu, India*
**Corresponding author's email: gabriel_paulraj@yahoo.com*

Abstract. Serum biochemical parameters were studied in 65 Asian elephants maintained at Anamalai Tiger Reserve, Mudumalai Tiger Reserve, Srivilliputhur Megamalai Tiger Reserve and Elephant Rescue and Rehabilitation Centre in Tamil Nadu, India, from November 2022 to July 2023. Serum was separated from blood and 22 parameters were analysed. In male individuals at Anamalai, the blood urea nitrogen and calcium levels were significantly higher in the age group 1–15 years than >50 years. In Mudumalai, glucose concentration in females of 1–15 years of age was significantly higher than in 26–50 year-old females and >50 year-old females. Glucose, total protein and creatinine levels showed significant variations between the four seasons of the year.

Introduction

The Asian elephant (*Elephas maximus*) is distributed in 13 range countries. From ancient times, elephant capture, training and use for various purposes have been common in Indian states. Elephant camps in India like Theppakadu in Mudumalai Tiger Reserve (MTR) and Kozhikamuthi in Anamalai Tiger Reserve (ATR) were established in Tamil Nadu by the Forest Department. Theppakadu camp was set up in 1910 and Varagaliar camp in Topslip in 1956. The Varagaliar camp was shifted to Kozhikamuthy in 2007 (Baruah 2023).

Camp elephants are taken daily for a morning bath in a nearby river and then given a nutritious meal, at around 9:00 am. Afterwards they are set free to graze in nearby forest areas. They are taken for a bath in the evening, and evening feed is given at around 6:00 pm. During British rule, camp elephants were utilised for logging. Currently, they are used to patrol national parks, kumki operations, drive wild elephants, wild animal capturing operations and tourism. The elephants are semi-free ranging. MTR camps house 27 elephants and ATR camps house 28 elephants. Health monitoring of captive elephants under controlled living conditions is important because they may be prone to microbial and parasitic infections (Punya *et al*. 2021; Gautum & Koju 2022).

Diagnosis using blood and serum plays an important role in the early detection of health problems in elephants (Mikota 2006). Liver enzymes such as aspartate aminotransferase (AST), alkaline phosphatase (ALP), alanine aminotransferase (ALT), bilirubin, as well as blood glucose and creatinine are basic analytes to diagnose various diseases and abnormalities such as hyperglycaemia, stress, kidney ailments, hepatic diseases etc. (Kerr 2002; Mikota 2006; Thapa 2010). Serum biochemical tests are also important for the regular health monitoring of camp elephants, as they assess the functioning of organs such as the liver, kidneys and pancreas.

Serum biochemical values of African and Asian elephants have been studied by many investigators (Sreekumar & Nirmalan 1989; Sarmah *et al*. 1999; Wijesekera *et al*. 2008; Allwin *et al*. 2015; Edwards *et al*. 2020). A few serum bio-

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chemical studies have also been conducted in camp elephants in Tamil Nadu (Allwin *et al*. 2015; Veeraselvam *et al*. 2021).

Serum biochemical concentrations maybe affected by many factors such as type of food, exercise, seasonal variations, physiological condition of vital organs, stress, tissue damage and parasitic infection. Therefore, regular serum analysis of camp elephants is necessary for monitoring an individual's health. Perrin *et al*. (2020) have reported on the applicability of population-derived reference intervals of haematological and biochemical parameters for Asian elephants and stated that individual normal values should be used for the interpretation of blood results.

Repeated sampling is essential to establish reliable individual reference intervals for serum biochemical parameters of elephants in specific camps, which is lacking. The present study was undertaken to establish reference intervals for serum biochemical parameters of camp elephants in MTR, ATR and Elephant Rescue and Rehabilitation Centre (ERRC) in Tiruchirappalli and Srivilliputhur Megamalai Tiger Reserve (SMTR).

Materials and methods

Study area and study period

Blood samples were collected from camp elephants at Theppakadu (11°57'91.2"N; 76°58' 40.3"E) and Abhayaranyam (11°55'71.1"N; 76°56'19.5"E) elephant camps in MTR, Kozhikamuthi (10°44'53.8"N; 76°84'88.5"E) and Varakalayar (10°41'92.9"N; 76°86'66.1"E) camps in ATR, ERRC and SMTR.

The study was conducted between November 2022 and July 2023 with permission obtained from the Principal Chief Conservator of Forests and Chief Wildlife Warden, Tamil Nadu (Letter Ref. No. WL5(A)/28609/2022; dated 22-11-2022 and Permission No. 85/2022).

In Tamil Nadu, summer starts in March and ends at the end of May. The southwest monsoon season is between June and September and the Northeast monsoon season is from October to December. The winter season occurs from January to February. Blood samples were collected four times in the months of November 2022 (northeast monsoon), February 2023 (winter), May 2023 (summer) and July 2023 (southwest monsoon).

Elephants were categorised into size classes according to Fernando *et al*. (2022).

Blood sample collection and serum separation

Samples were collected from a total of 65 elephants. In ATR, blood samples were collected from 25 elephants (16 males and 9 females) of which four were sub-adults and 21 were adults. In MTR, blood was collected from 24 elephants (18 males and 6 females) which included one juvenile-II, one juvenile-III, two sub-adults and 20 adult individuals. At ERRC 10 adult elephants were accessed for blood samples. At SMTR, 6 elephants (one sub-adult and five adults) were accessed for blood sample collection. The rescued elephants in ERRC and SMTR were all females and were between the ages of 17–70 years.

From each elephant, 10 ml of blood was collected by the Forest Veterinary Assistant Surgeon (FVAS) from the auricular vein in the posterior part of the ear. The area surrounding the vein was cleansed with 70% alcohol and blood was drawn using a butterfly needle. The collected blood was divided into two aliquots of 5 ml each. One aliquot was collected in a clot activator tube and allowed to clot to separate serum. The serum was separated by centrifugation at 3000 rpm for 10 minutes and immediately stored in an icebox.

Serum parameters

The cold-stored serum samples were transported to the Centre for Animal Care Sciences, Advanced Institute for Wildlife Conservation (AIWC), Vandalur. Serum biochemical parameters measured using the IDEXX Catalyst One (IDEXX Laboratories, Inc., USA) were glucose, creatinine, blood urea nitrogen (BUN), BUN/creatinine ratio, phosphate, calcium, total protein, albumin, globulin, albumin/globulin, alanine aminotransferase (ALT), alkaline phos-

phatase (ALP), gamma-glutamyl transferase (GGT), total bilirubin, cholesterol, amylase, lipase, sodium, potassium, sodium/potassium, chloride and osmolality. IDEXX Chem 17 clips and Lyte 4 clips were used to quantify the serum biochemicals. All serum biochemical data were recorded and tabulated.

Reference intervals for serum biochemicals were established from the data. Very different biochemical values observed in any individual (outliers) were identified by GraphPad Prism software and removed.

Statistical Analysis

The mean biochemical values of four samplings taken from each individual and their standard deviations were calculated. Statistical comparisons of serum biochemical analyses between males and females, between four different age groups (1–15, 16–25, 26–50, >50 years) and between four different seasons (summer, southwest monsoon, northeast monsoon and winter) were performed using one-way analysis of variance (ANOVA) and post hoc 'Tukey's test' with the help of GraphPad Prism software. Simple linear regression analysis was done to determine the association between age and some important serum parameters in male and female elephants.

Results

Variations between male and female elephants

The average serum biochemical values of all individuals at ATR, MTR, ERRC and SMTR camps are presented in Table 1. Glucose concentration was significantly higher ($p < 0.05$) in rescued females kept in ERRC and SMTR camps. In ATR, average serum glucose concentration was higher in males than females, but the difference was not significant ($p > 0.05$). A gender-based variation in ALP concentration was observed in ATR and MTR camp elephants, but it was not statistically significant ($p > 0.05$) (Table 1 and Fig. 1).

Serum glucose concentration ranged from a low of 36 mg/dl in a 27-year-old male elephant to a high of 105 mg/dl in a 74-year-old female elephant. Rescued private elephants at ERRC and SMTR camps showed great variations in the serum glucose concentration among individuals. In rescued elephants, glucose concentrations ranged from 40 to 210 mg/dl. Eleven rescued elephants showed >130 mg/dl glucose concentrations. Cholesterol concentration was significantly higher ($p < 0.05$) in MTR males than in MTR females or elephants at other camps (Table 1).

Figure 1 shows the glucose, ALT and ALP concentrations in ATR and MTR camp elephants (rescued elephants were omitted). The glucose concentration was significantly ($p < 0.05$) lower in females of ATR compared to females of MTR. There were no significant differences in the concentrations of creatinine, blood urea nitrogen, albumin and globulin between male and female elephants at ATR and MTR (Fig. 1).

Significant differences in some serum parameters were correlated with age of ATR camp elephants. In male elephants, blood urea nitrogen concentrations were significantly different ($P < 0.01$) between the age groups "1–15 years and >50 years (Table 2). When analysing calcium concentration in females, the age groups 16–25 and >50 years showed a significant difference ($P < 0.05$). In male elephants, the calcium concentration was significantly different when comparing >50 years old elephants with 1–15 ($P < 0.01$), 16–25 ($P < 0.01$) and 26–50 ($P < 0.05$) years age groups.

The serum biochemical parameters of MTR elephants are presented in Table 1 and Figure 1.

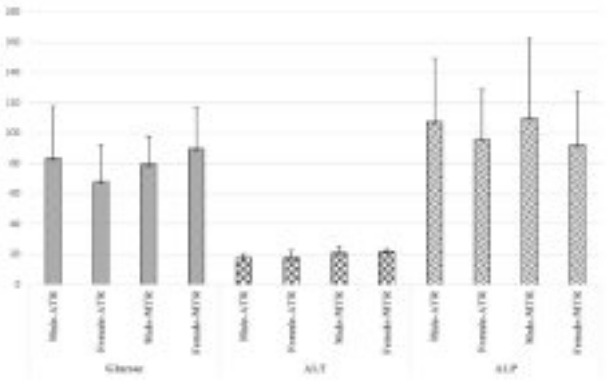

Figure 1. Average glucose (mg/dl), ALT (U/l) and ALP (U/l) concentrations in males and females at ATR and MTR camps. Each bar represents mean ± SD of three sample collections.

Table 1. Average serum biochemical values of male and female elephants at ATR and MTR camps and rescued private elephants at ERRC and SMTR (mean ± SD). If the mean values in a row are significantly different ($p < 0.05$, Tukey HSD Post hoc test), they are marked with different letters (a or b).

Parameter	Unit	ATR		MTR		ERRC & SMTR
		Male (N = 29)	Female (N = 24)	Male (N = 53)	Female (N = 22)	Female (N = 24)
Glucose	mg/dl	83.56 ± 34.38^{b}	67.87 ± 24.49^{b}	79.34 ± 18.57^{b}	89.70 ± 29.81^{b}	145.18 ± 60.06^{a}
Creatinine	mg/dl	1.56 ± 0.58	1.42 ± 0.26	1.31 ± 0.34	1.36 ± 0.09	1.55 ± 0.37
BUN	mg/dl	9.35 ± 2.98	9.86 ± 2.65	8.38 ± 3.03	9.11 ± 1.47	8.68 ± 2.08
BUN/Creatinine		6.79 ± 3.12	7.65 ± 3.09	8.08 ± 6.01	6.98 ± 1.24	5.81 ± 1.79
Phosphate	mg/dl	6.37 ± 1.80^{a}	6.72 ± 0.67^{a}	4.64 ± 0.62^{b}	5.02 ± 0.68^{b}	4.68 ± 0.61^{b}
Calcium	mg/dl	9.92 ± 0.45	10.16 ± 0.34	9.86 ± 0.48	10.50 ± 0.59	10.1 ± 0.61
Total Protein	g/dl	8.62 ± 1.05	8.80 ± 0.93	8.62 ± 0.55	9.10 ± 1.26	8.82 ± 0.55
Albumin	g/dl	2.70 ± 0.36	2.76 ± 0.29	2.49 ± 0.22	2.93 ± 0.43	3.07 ± 0.41
Globulin	g/dl	5.89 ± 0.92	6.05 ± 0.85	6.12 ± 0.58	6.16 ± 0.86	5.74 ± 0.35
Albumin/Globulin		0.46 ± 0.08	0.46 ± 0.08	0.40 ± 0.06	0.47 ± 0.04	0.53 ± 0.09
ALT	U/l	17.60 ± 3.00	17.80 ± 5.06	21.05 ± 4.10	21.85 ± 1.88	19.00 ± 7.44
ALP	U/l	107.58 ± 42.03	96.03 ± 32.59	109.98 ± 52.82	92.44 ± 38.76	139.12 ± 49.17
GGT	U/l	1.41 ± 4.05	0.81 ± 2.44	3.75 ± 8.05	0.00 ± 0.00	0.31 ± 0.70
Total Bilirubin	mg/dl	0.29 ± 0.11	0.26 ± 0.13	0.51 ± 1.12	0.33 ± 0.14	0.21 ± 0.10
Cholesterol	mg/dl	44.91 ± 11.10^{b}	45.70 ± 13.47^{b}	59.28 ± 12.14^{a}	43.34 ± 9.80^{b}	43.62 ± 9.64^{b}
Amylase	U/l	1597.07 ± 210.71^{b}	1421.31 ± 534.15^{b}	1762.00 ± 214.70^{a}	1740.04 ± 261.95^{a}	1711.87 ± 93.81^{a}
Lipase	U/l	23.86 ± 15.93^{b}	36.31 ± 12.81^{a}	43.05 ± 15.62^{a}	40.77 ± 7.28^{a}	34.54 ± 17.55^{ab}
Sodium (Na)	mmol/l	128.45 ± 1.71	131.01 ± 1.21	130.08 ± 2.21	130.83 ± 1.62	130.12 ± 2.63
Potassium (K)	mmol/l	5.93 ± 0.95	5.87 ± 0.46	4.94 ± 0.23	4.75 ± 0.26	5.87 ± 0.77
Na/K		22.61 ± 3.18	23.38 ± 1.53	26.43 ± 1.48	27.69 ± 1.96	22.56 ± 2.87
Chloride	mmol/l	93.85 ± 1.36	94.74 ± 1.53	94.38 ± 1.80	94.01 ± 2.00	95.06 ± 2.34
Osmolality	mmol/kg	257.75 ± 3.80^{a}	261.16 ± 2.13^{a}	258.20 ± 4.70^{a}	260.44 ± 2.54^{a}	179.75 ± 5.54^{b}

Serum glucose concentration was lower in male elephants than in females. But the difference was not significant. The highest blood glucose concentration was recorded in a 3-year-old female calf, and the lowest in a 37-year-old male. The average creatinine concentration was the same in both male and female elephants. The average cholesterol concentration was significantly higher ($p < 0.05$) in male elephants than in females at MTR (Table 1).

The individual's age was found to affect some serum biochemical parameters in both sexes. Glucose concentration in females at MTR showed significant differences between the age groups 1–15 years and 26–50 years ($P < 0.01$) and 1–15 years vs. >50 years ($P < 0.01$) (Table 2). The creatinine concentration in males at MTR also differed by age. The creatinine concentration of the age group 16–25 years was significantly different from the 1–15 ($P < 0.01$),

Table 2. Serum glucose, creatinine and BUN in different age groups at ATR and MTR camps. Values in a row carrying different letters (a, b or c) are significantly different ($p < 0.05$, Tukey HSD Post hoc test).

Parameter	Sex	Camp	1–15 years		16–25 years		26–50 years		>50 years	
			Mean ± SD	N	Mean ± SD	N	Mean ± SD	N	Mean ± SD	N
Glucose	Male	ATR	70.22 ± 27.65	7	76.94 ± 22.79	7	86.76 ± 33.08	10	102.33 ± 77.31	5
		MTR	98.83 ± 6.62^{a}	10	70.41 ± 14.02^{b}	5	76.81 ± 24.21^{b}	14	75.85 ± 16.05^{b}	25
	Female	ATR	34.0	1	68.27 ± 21.07	8	83.0 ± 1.4	3	72.24 ± 28.62	12
		MTR	133.75 ± 0.00^{a}	4	114.0 ± 0.00^{a}	3	70.0 ± 6.0^{b}	7	75.25 ± 25.45^{b}	8
Creatinine	Male	ATR	1.17 ± 0.19	7	1.85 ± 0.65	7	1.58 ± 0.48	10	1.6 ± 1.27	5
		MTR	1.13 ± 0.08^{b}	10	1.81 ± 0.12^{a}	5	1.34 ± 0.28^{b}	14	1.22 ± 0.38^{b}	25
	Female	ATR	1.9	1	1.19 ± 0.11	8	1.53 ± 0.00	3	1.43 ± 0.20	12
		MTR	1.27 ± 0.00^{b}	4	1.46 ± 0.00^{a}	3	1.31 ± 0.07^{ab}	7	1.42 ± 0.07^{a}	8
BUN	Male	ATR	11.61 ± 0.97^{a}	7	8.83 ± 3.32^{a}	7	10.04 ± 2.24^{a}	10	4.33 ± 0.94^{b}	5
		MTR	11.0 ± 2.00^{a}	10	8.91 ± 0.82^{ab}	5	9.06 ± 3.03^{ab}	14	6.85 ± 3.14^{b}	25
	Female	ATR	7.0	1	11.38 ± 1.91	8	10.0 ± 0.00	3	9.41 ± 3.32	12
		MTR	7.5 ± 0.00^{c}	4	8.33 ± 0.00^{bc}	3	10.91 ± 0.58^{a}	7	8.5 ± 0.35^{b}	8

Table 3. Serum glucose, creatinine and BUN concentrations at different seasons in male and female elephants at ATR and MTR camps. Values in a row carrying different letters (a, b or c) are significantly different ($p < 0.05$, Tukey HSD Post hoc test). NA = not available.

Parameter	Sex	Camp	November 2022		February 2023		May 2023		July 2023	
			Mean ± SD	N	Mean ± SD	N	Mean ± SD	N	Mean ± SD	N
Glucose	Male	ATR	97.85 ± 16.80^{a}	14	70.42 ± 37.06^{b}	7	24.0 ± 8.83^{c}	8	NA	
		MTR	79.66 ± 34.45	12	79.69 ± 12.76	13	75.07 ± 24.65	14	85.46 ± 35.08	15
	Female	ATR	115.75 ±55.42^{a}	8	61.12 ± 27.04^{b}	8	19.83 ± 8.23^{b}	8	NA	
		MTR	95.16 ±52.97	6	82.00 ± 25.52	5	94.50 ± 31.95	6	85.40 ± 28.07	5
Creatinine	Male	ATR	1.48 ± 0.56	14	1.27 ± 0.41	7	1.81 ± 0.69	8	NA	
		MTR	1.27 ± 0.48	12	1.30 ± 0.45	13	1.35 ± 0.30	14	1.32 ± 0.31	15
	Female	ATR	1.30 ± 0.36	8	1.3 ± 0.19	8	1.53 ± 0.26	8	NA	
		MTR	1.25 ± 0.13^{a}	6	1.24 ± 0.15^{a}	5	1.63 ± 0.25^{b}	6	1.32 ± 0.17^{ab}	5
BUN	Male	ATR	9.28 ± 3.40	14	7.28 ± 3.81	7	9.12 ± 3.94	8	NA	
		MTR	8.58 ± 3.77	12	7.72 ± 4.40	13	8.28 ± 3.33	14	8.13 ± 2.77	15
	Female	ATR	10.62 ± 4.20	8	8.87 ± 1.64	8	10.87 ± 3.09	8	NA	
		MTR	10.50 ± 2.07^{a}	6	8.80 ± 1.78^{a}	5	7.33 ± 2.16^{b}	6	9.60 ± 1.14^{a}	5

26–50 ($P < 0.05$) and >50 ($P < 0.01$) year groups. Blood urea nitrogen analysis in females showed a significant difference between the age groups 1–15 and 26–50 years ($P < 0.01$).

While examining total protein, there was a significant difference between the 26–50 and >50 years ($P < 0.01$) male age groups at MTR. In females, there existed a significant difference in total protein concentration between the 1–15 and 26–50 years groups ($P < 0.01$), the 1–15 and >50 years groups ($P < 0.01$) and the 26-50 and >50 years groups ($P < 0.01$).

Seasonal impact

Males at ATR showed a significant difference in glucose concentration between November 2022 (northeast monsoon) and May 2023 (summer) ($P < 0.01$) and between February 2023 (winter) and May 2023 (summer) ($P < 0.05$) (Table 3). In females, a significant difference was observed between November and February ($P < 0.05$) and November and May ($P < 0.01$). Total protein concentrations in males exhibited a significant difference between November and May ($P < 0.05$).

In MTR it was seen that creatinine concentrations significantly differed between November and May) ($P < 0.05$) as well as between February and May ($P < 0.05$) in females (Table 3). The total protein concentration in males showed a significant difference between May and July (southwest monsoon) ($P < 0.01$).

Figures 2 and 3 show the linear models for understanding the association between age and serum biochemical parameters in male and females at ATR and MTR camps. In ATR, a positive correlation was observed between age and serum glucose, creatinine and cholesterol in both sexes. But the correlations were not significant ($p > 0.05$). A strong negative association between age and BUN ($p < 0.01$) was observed in MTR males. Table 4 provides a reference interval for all serum biochemicals.

Discussion

The study indicated that some serum parameters, such as creatinine, glucose and calcium differed by age in both sexes. Ratnasooriya *et al*. (1999) reported that the glucose level in the serum of Sri Lankan elephants was not significantly affected by age. However, they found that glucose concentration was significantly higher in males (88–186.2 mg/dl) than females

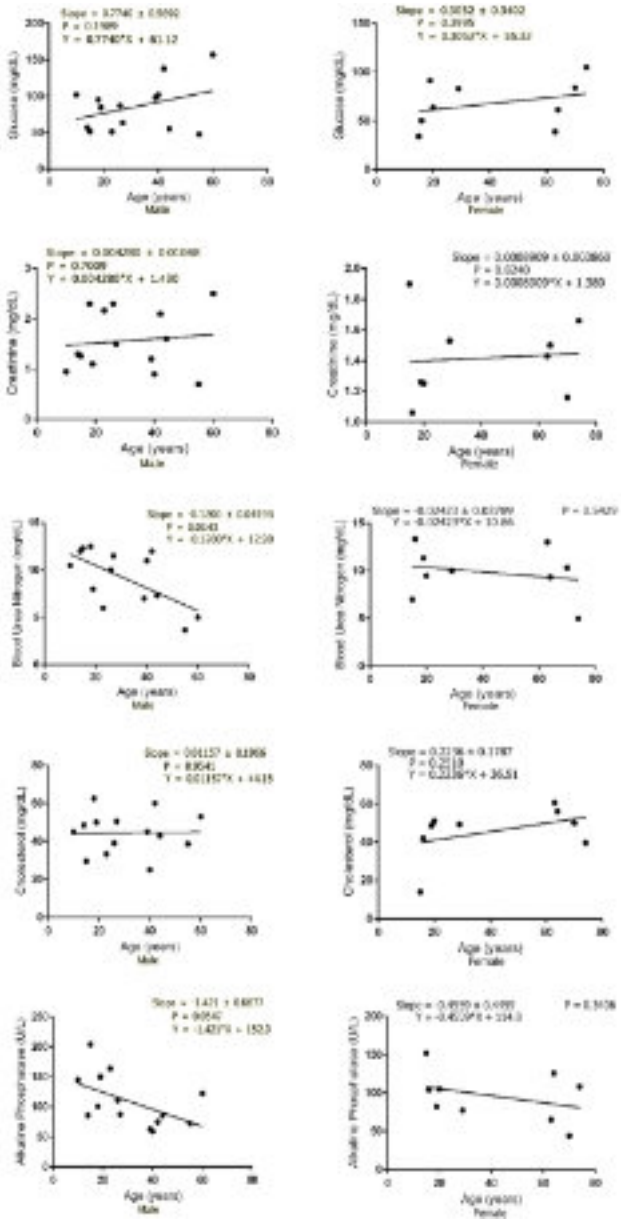

Figure 2. Simple linear regression model to show the association between age and serum biochemicals at ATR camps.

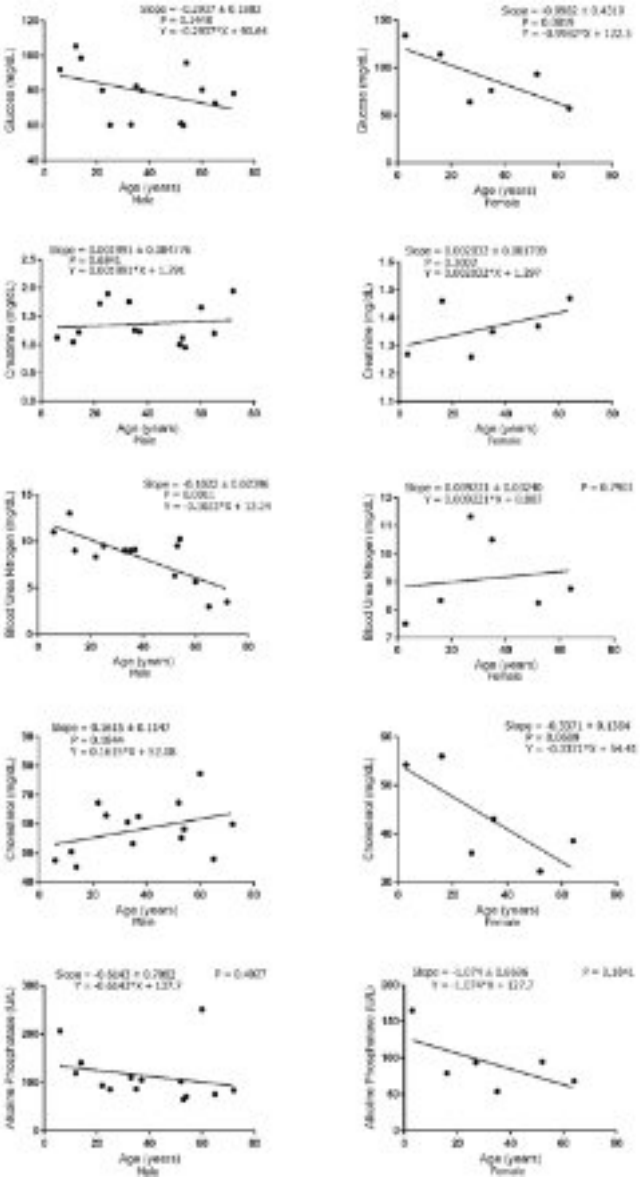

Figure 3. Simple linear regression model to show the association between age and serum biochemicals at MTR camps.

Table 4. Reference intervals for serum parameters of camp elephants based on the values obtained from ATR and MTR camp elephants (N=129).

Parameters	Units	Range
Glucose	mg/dl	67.87 – 89.71
Creatinine	mg/dl	1.31 – 1.56
BUN	mg/dl	8.38 – 9.87
BUN/Creatinine		6.78 – 8.08
Phosphate	mg/dl	4.65 – 6.72
Calcium	mg/dl	9.86 – 10.50
Total Protein	g/dl	8.62 – 9.10
Albumin	g/dl	2.49 – 2.93
Globulin	g/dl	5.89 – 6.17
Albumin/Globulin		0.40 – 0.47
ALT	U/l	17.60 – 21.86
ALP	U/l	92.44 – 109.98
GGT	U/l	0 – 3.75
Total Bilirubin	mg/dl	0.26 – 0.51
Cholesterol	mg/dl	43.34 – 59.28
Amylase	U/l	1421.31 – 1762
Lipase	U/l	23.86 – 43.40
Na	mmol/l	128.45 – 131.01
K	mmol/l	4.76 – 5.93
Na/K		22.61 – 27.69
Chloride	mmol/l	93.85 – 94.74
Osmolality	mmol/kg	257.75 – 261.16

(64.2–128.7 mg/dl). In our study, we observed significantly higher glucose concentrations only in males at ATR. However, in both ATR and MTR camp elephants, the serum glucose was within the reference range that was established by previous investigators (Ratnasooriya *et al*. 1999; Mikota 2006). Silva & Kuruwita (1993) reported that there were no significant differences in the serum biochemical values between males and females of captive elephants in Sri Lanka. In ERRC and SMTR, the rescued elephants showed glucose concentrations beyond 160 mg/dl and up to 210 mg/dl, which were very high compared to the average values reported by Ratnasooriya *et al*. (1999) (mean: 97.55 mg/dl in females) and Allwin *et al*. (2015) (mean: 72 mg/dl).

Biochemical parameters were prone to variation across age groups, but consistent between different samplings from the same individual. This finding corroborates the importance of establishing individual reference ranges for elephants under human care as previously recommended by Perrin *et al*. (2020). Glucose values, in spite of having a high level of variation, were similar across both camps. Creatinine and blood urea nitrogen also stayed within limits previously reported, indicating good renal health. The occurrence of biochemical values within normal limits suggested the absence of organ damage in the sampled camp elephants.

Veeraselvam *et al*. (2021) studied the serum biochemistry in 46 captive elephants in Tamil Nadu. They reported that the parameters were within the normal ranges and found that age-related differences in the parameters were not significant. Allwin *et al*. (2015) collected blood samples only once from 68 captive elephants at forest camps, in temples, circuses and in biological parks and analysed the serum biochemicals. Their findings clearly showed that there were no significant differences in the parameters between males and females. In the present study, blood samples were collected four times in the year corresponding to the four seasons, which helped to arrive at more reliable and precise results. Despite some variation in different seasons, age groups and genders, the results remained replicable and reliable. In MTR, a 60-year-old elephant showed very high ALP and GGT concentrations. Such outliers were excluded while establishing the reference interval for serum biochemical values.

Diet plays an important role in serum glucose levels. In forest camps, all elephants are given cut fodder and a prepared diet consisting of horse gram, ragi, salt and jaggery. We did not consider the effect of diet on serum biochemical parameters. But we recommend such a study. Camp elephants have the benefit of getting immediate diagnosis for any ailments they suffer. These findings can help the forest veterinarians to diagnose deviations from normal hence provide early treatment.

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Short Communication *Gajah 58 (2025) 37-39*

Faecal Testosterone Concentration in Sri Lankan Bull Elephants During Musth

Danushka S. Weerasekera[1]*, Mihiran Medawala[2], Samantha Herath[3], Damayanthi K. K. Nanayakkara[3], Ashoka Dangolla[4] and Kithsiri B. Ranawana[5]

[1]*Postgraduate Institute of Science, University of Peradeniya, Sri Lanka.*
[2]*Pinnawala Elephant Orphanage, Pinnawala, Sri Lanka*
[3]*Nuclear Medicine Unit, Faculty of Medicine, University of Peradeniya, Sri Lanka*
[4]*Faculty of Veterinary Medicine and Animal Science, University of Peradeniya, Sri Lanka.*
[5]*Faculty of Science, University of Peradeniya, Sri Lanka.*
**Corresponding author's e-mail: danushw2@gmail.com*

Abstract. We evaluated the use of non-invasive faecal testosterone analysis to differentiate between musth and non-musth in captive Asian elephants. Twenty male elephants were studied, including five in 'musth' from the Pinnawala Elephant Orphanage (PEO), five privately owned males in musth, and 10 males not in musth from the PEO. Musth was identified by temporal gland swelling and urine dribbling. Faecal samples were collected and analysed using a 125I testosterone radioimmunoassay (RIA) kit. Faecal testosterone levels in elephants in musth were significantly higher than those not in musth but were not different between PEO and privately owned elephants in musth.

Introduction

Musth, a regular, annual three-to-four-month period of elevated serum testosterone level in sexually mature male elephants, is associated with heightened sexual activity and is characterised by increased aggressive behaviour (Glaeser *et al*. 2022). Musth plays a crucial role in the reproductive dynamics and social behaviour of wild elephants (Lincoln & Ratnasooriya 1996).

Understanding the hormonal changes associated with musth is essential for managing captive elephant populations (LaDue *et al*. 2022). Privately owned captive male elephants coming into musth around the same time period, limits their availability for cultural processions in the country (Katupotha & Kodituwakku 2018). A number of guidelines have been developed for managing captive elephants in musth and early detection, determining the duration and predicting cessation of musth are considered important for management (Duer *et al*. 2016; Brown *et al*. 2020).

However, obtaining blood samples for monitoring, is difficult when males are approaching musth and during musth (Fontes 2017). However, non-invasive faecal testosterone analysis has been reported to be useful in predicting musth (Ghosal *et al*. 2013).

Materials and methods

The study involved a total of 20 adult elephants, consisting of five males in 'musth' from the Pinnawala Elephant Orphanage (PEO), five privately owned males in 'musth' and ten males not in musth from the PEO.

Both PEO and privately owned elephants in musth were mostly kept isolated, tethered day and night and managed individually. The males that were not in musth were allowed to remain within the herd at the PEO.

The behaviour of the elephants was monitored from January 1, 2022, to January 1, 2024. The observations focused on identifying signs of musth, such as temporal gland swelling and secretion (Fig. 1), and urine dribbling. An elephant was classified as being in musth if these signs were consistently observed. Elephants that did not exhibit these signs were considered to be not in musth.

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Figure 1. A tusker in musth, secreting a thick, tar-like substance from its temporal glands, a characteristic sign of elevated testosterone levels and heightened aggression.

Single faecal samples were collected from each of the study elephants upon observed defecation. Approximately 100 g of faecal matter was collected for each sample. Using sterile gloves, samples were taken from the centre of multiple boli in one dung pile and homogenised. The samples were placed in polythene bags, labelled with the elephant ID and the date of collection, transported on ice to the laboratory and stored at -20°C until analysis.

Samples were then dried in an oven and ground into a fine powder using a mortar and pestle. A 0.2 g subsample was combined with 5 ml of 90% ethanol in a test tube, briefly vortexed, and suspended in a 90°C water bath for 20 minutes. Ethanol was added periodically to prevent drying. Samples were then centrifuged for 20 minutes at 1500 rpm, the supernatant transferred to a vial, and the process repeated with an additional 5 ml of 90% ethanol. Combined extracts were dried down and reconstituted in 1 ml of methanol, vortexed for approximately 2 minutes, and stored at –20°C.

Testosterone concentrations were measured using a 125I testosterone RIA kit (Weerasekera *et al*. 2020), with a detection limit of 0.2 ng/g faecal powder. Inter- and intra-assay coefficients of variation were maintained below 12.4% (Weerasekera *et al*. 2020).

For validation of the technique, 10,000 cpm of 125I testosterone was added to a 0.2 g sample of dried elephant faeces from a non-study male elephant which was not in musth and incubated at room temperature for 1 hour, followed by methanol extraction. The recovery of radioactivity was measured using a gamma counter. Serial dilutions of faecal extracts from elephants in musth and non-musth were tested against a standard curve using a 125I testosterone RIA kit and assay accuracy was calculated.

Results

Mean faecal testosterone was significantly higher ($t = 7.37$, $p < 0.0001$), in elephants in musth compared to those that were not in musth (Table 1). No significant difference was observed between those in musth from PEO and privately owned elephants in musth ($P > 0.05$).

Discussion

Our study aimed to evaluate the efficacy of non-invasive faecal testosterone analysis in distinguishing between captive male elephants in-musth and not-in-musth. The results show that faecal testosterone concentrations were significantly higher in elephants in musth, corroborating findings from previous studies.

Table 1. Average faecal testosterone concentrations in musth and non-musth bull elephants.

Group	Institution	N	Mean ± SE (ng/g)	Range (ng/g)
Musth	PEO	5	9.88 ± 1.12	5.66 – 12.05
	Privately owned	5	10.48 ± 0.82	8.08 – 12.68
	Overall	10	10.18 ± 0.66	5.66 – 12.68
Non-musth	PEO	10	3.78 ± 0.56	1.77 – 7.67

No significant difference was observed between the faecal testosterone concentrations of elephants from PEO and privately owned elephants in musth, suggesting that the hormonal response measured by faecal testosterone is consistent across different captive environments. This finding underscores the reliability of non-invasive faecal testosterone analysis as a method for monitoring musth, regardless of the elephant's captive situation.

The method for measuring faecal testosterone used in this study demonstrated strong robustness. The validation process, which included radioactivity recovery and assay accuracy checks, ensured the reliability and accuracy of our results.

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Technical Report
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Community-Based Seasonal Electric Fences for Human-Elephant Coexistence

Prithiviraj Fernando[1]*, Sampath K. K. Ekanayaka[1], M. K. Channa R. De Silva[1] and Jennifer Pastorini[1,2]

[1]*Centre for Conservation and Research, Tissamaharama, Sri Lanka*
[2]*Department of Evolutionary Anthropology, University of Zürich, Zürich, Switzerland*
**Corresponding author's email; pruthu62@gmail.com*

Abstract. Community-based seasonal electric fences effectively prevent raiding of seasonal crops by elephants. However, their success is contingent on a number of inter-related factors such as community ownership and involvement, fence location and design, material quality, construction standards and maintenance. Farmers deploy the fences on the perimeter of cultivated fields when commencing cultivation, maintain them, dismantle them at harvest and store them till the next cultivation season. Farmers also bear part of the material cost and set up a maintenance fund for future exigencies. We describe the basic fence design, material specifications, how to prepare a bill of quantities and an effective implementation protocol, discussing relevant issues.

Introduction

Human-elephant conflict (HEC) is the principal challenge in conserving Asian elephants (*Elephas maximus*). Crop raiding by elephants is the most prevalent proximal cause of HEC and the main obstacle to human-elephant coexistence. Rice is the staple diet of most Asians and raiding of paddy (rice in cultivated form) is widespread. The issue is critical in Sri Lanka, where 70% of elephant range is shared with people (Fernando *et al*. 2021).

Methods of protecting crops from elephants can be divided into confrontational methods such as crop guarding and chasing elephants, and barrier methods such as fences and trenches (Fernando *et al*. 2008). Of the two, barrier methods are preferable, as – unlike confrontational methods – they do not cause reciprocal aggression by elephants, hence HEC escalation. Electric fences are arguably the most successful barrier (Fernando *et al*. 2008). However, to be effective they must fulfil three fundamental requirements; 1) proper location, 2) construction and 3) maintenance (Fernando 2020).

Using electric fencing to protect seasonal cultivations such as paddy is problematical. Paddy is a short-term crop of 3–4 months, usually cultivated once or twice a year. Permanent electric fences around paddy fields provide no benefit to people when the fields are not in cultivation. However, leftover-harvest is an important food source for elephants. They also use uncultivated fields as safe movement paths (Fernando 2020). Therefore, permanently fencing seasonal fields is detrimental to elephants and is likely to increase HEC, as elephants are compelled to seek alternate resources and routes (Fernando 2020).

'Exclosure' fences around agricultural fields and settlements are more effective than 'enclosure' fences around protected areas. This is mainly due to the consistent human presence next to exclosure fences and ease of maintenance by the beneficiaries (Fernando 2020). Farmer presence in paddy fields is high during cultivation and it is a simple task for them to maintain fences. However, farmers generally live away from paddy fields and engage in other activities in the non-cultivation period. The lack of human presence and fence maintenance in the non-cultivation period provides increased opportunities for elephants to learn how to break fences, resulting in high likelihood of fence failure.

Community-based seasonal paddy field fences protect cultivated fields from elephants, while

providing a solution to these issues. Farmers deploy the fences at commencement of cultivation, maintain them, dismantle them at harvest, and store them in villages till the next cultivation season. Therefore, such fences are not detrimental to elephants, do not increase HEC by preventing elephant use of uncultivated fields, do not tax farmers to maintain them during non-cultivation periods and do not provide elephants easy opportunities to learn how to break fences.

We have developed, tested and refined community-based seasonal paddy field fences over the past 20 years and implemented over 50 such fences in different parts of Sri Lanka. We are now in the second phase where our goal is to institutionalise fence implementation in relevant government agencies and upscale implementation. Community-based seasonal paddy field fences have been identified as one of the main HEC mitigation initiatives in the 'National Action Plan for the Mitigation of HEC' (Fernando *et al*. 2020).

Currently we are engaging with the development sector, including donor agencies such as the World Bank and Asian Development Bank, and government agencies such as the Department of Agrarian Development, by providing technical know-how, conducting awareness programs, workshops, training of trainers and assisting implementation. Through this initiative, the Department of Agrarian Development has implemented over 200 community-based seasonal paddy field fences in 2024 and a further 200 are to be implemented in 2025.

We have also conducted awareness programs and study tours for a wide range of participants from Asia and Africa including India, Nepal, Thailand, Vietnam, Malaysia, Myanmar, Botswana, Cameroon, Gabon, Ethiopia, Mali, Malawi, Mozambique, Republic of Congo, Zambia and Zimbabwe. Following our model, seasonal fences have been piloted by a number of organisations in other range states such as Myanmar, Nepal and India (Jayasinghe 2015; Sampson 2018; Stewart-Cox 2024).

Here we provide information on aspects relevant for implementing community-based seasonal paddy-field electric fences.

Fence design

The basic fence design consists of two live wires strung between energised posts. Since the fence borders a paddy field, the ground moisture is sufficient for good earthing, hence an earth wire is usually not needed. GI pipes are used for fence posts. The live wires are borne by split metal washers welded to the post, thus also energising the post. The post is prevented from earthing by a 'ground insulator', which is a non-conducting sleeve sealed at the bottom.

Simplistic designs such as single wire fences with bamboo/wooden posts are unlikely to be effective or last multiple seasons. More complicated designs such as seasonal 'hanging fences' have also been developed and trialled successfully by us. However, the more complicated and technical a fence, the greater the cost, the more likely it is that defects will occur and more challenging the deployment by farmers, hence less the possibility of scaling up deployment. Therefore, what is recommended and is described here is a basic, robust fence, which is easy to install, maintain, dismantle, transport and store. It is adequate to prevent elephant raiding under most circumstances and will last for many seasons.

Protocol for implementation

1. Selecting a site for implementation

Some basic conditions need to be met, which can be assessed by talking to a few farmers on site and viewing the location on Google Maps (with 'satellite layer') or Google Earth, to gain an overview of the location (Fig. 1).

Figure 1. Paddy field on Google Earth.

Conditions to be met:

- Cultivation is only seasonal (not permanent)
- Site experiences regular raiding by elephants
- Farmers consider elephant raiding to be a major issue
- Farmers are willing to work together to overcome the problem
- Fields can be encircled by a fence (while 'open' or 'linear' fences maybe appropriate in some situations, it is advisable to start with 'enclosure' fences and explore other options once experience is gained)

If any of these requirements are not met, the site is inappropriate. If it is suitable, introduce the basic concept to the farmers present and ask them to discuss it with their peers.

2. Community awareness

Upon expression of interest in moving forward, a meeting is arranged with all the farmers (Fig. 2). Reluctant communities should never be compelled or persuaded to get a fence, as it will result in non-maintenance and fence failure. Following are the aspects farmers need to be made aware of, to make an informed decision.

Discuss the problems caused by elephants, how often damages occur, what the farmers currently do to prevent raiding, and their successes and failures. Explain how an electric fence functions, using simple diagrams. Stress the difference between a fence connected to grid electricity – which will kill any person or animal touching it, hence is a 'death-trap' and is illegal – versus an 'electric fence', which is powered by an energiser. Electric fences only use smooth wire and never barbed or concertina wire.

Figure 2. Explaining the procedure to farmers.

An electric fence carries a DC (direct current) pulse at a very high voltage (around 6,000 – 9,000 V) but very low amperage (less than 100 mA), therefore causes a 'shock' but does not cause burns or harm life. The main fence components are the energiser, battery, power input, earth system, fence posts and wires. The current material costs of a seasonal electric fence using high-quality materials is about US$ 1,500 (for energiser, solar unit etc.) + US$ 1,000 per km of fence length (wire, posts etc.). For example, material for a 2 km fence will cost around 1,500 + (1,000 x 2) = US$ 3,500 and a 5 km fence 1,500 + (1,000 x 5) = US$ 6,500. The cost per acre varies widely with fence length and geometry.

The effectiveness of a community-based seasonal electric fence in preventing raiding by elephants is contingent on its proper deployment and maintenance by the community. Therefore, its success requires a strong sense of community ownership, which is promoted by the following conditions:

Fence committee: A pre-existing farmer society can be co-opted or a 'fence society' formed. All farmers should be members, and the committee selected from the membership. The committee will be responsible for coordinating fence construction and management. Imposition of penalties by the committee, on individuals for non-compliance and non-participation in activities, ensures effective fence management.

Fence construction: The fence is to provide relief from a pressing problem of the community. Therefore, they should be the main stakeholders in its implementation. The implementers will provide technical know-how and the farmers construct the fence accordingly. Thereby farmers gain knowledge of its function and will be able to correct any defects that arise, without delay.

Contribution to the cost: The few hours an individual farmer will contribute to fence construction is insufficient to create a lasting sense of ownership. Contributing to material costs in addition to labour, promotes greater ownership. The amount of community contribution should be determined by discussion with the farmers. A minimum of 25% of the material cost is sugges-

ted. The greater the community contribution, the greater the likelihood of success. The contribution by individual farmers can be based on a per acre amount and prorated according to extent owned. Collected funds should be used for purchasing fence material.

Fence maintenance: An electric fence will be effective only as long as it is properly maintained. The maintenance requirements are simple and mainly consist of regularly clearing vegetation that may come into contact with the live wires and seeing that the components remain functional. The community-based approach and fence location facilitates maintenance, as the fence is at the perimeter of fields being tended by the farmers.

Maintenance fund: A fund is formally set up with a bank account and procedures for withdrawal and accounting specified. A 'fee' is collected from each farmer at harvest and credited to the fund each season. The fund should be of a sufficient amount to replace components such as a battery or energiser after a few years. This ensures sustainability, without the community having to seek additional aid.

Fence removal: It is mandatory that the fence is removed at harvest (Fig. 3) and stored till the next season of cultivation, even if the next cultivation season is commenced one or two weeks later. Failure to do so will encourage keeping it for longer periods between cultivations and being viewed as a permanent fence, leading to its failure and/or obstruction of elephant movement and increased conflict. If cultivation occurs throughout the year, a seasonal fence is not appropriate.

Figure 3. Taking down the fence after harvest.

Crop-guarding: A fence will deter most elephants, but some may try to break it. Human presence in the field makes breakage much less likely. Continued crop guarding is therefore essential but can be at a reduced level from before. The fence committee should draw up a roster for guarding and ensure compliance. If crops are not guarded currently, it indicates that raiding by elephants is not a major issue, and that the location is unsuitable.

Fence monitoring: Community participation consists of a farmer accompanying the monitoring officer (see step 8 below). The farmer will report deficiencies to the fence committee, which needs to attend to it. Alternatively, a few farmers could accompany the monitoring officer and attend to any issues immediately. The fence committee should draw up a roster for accompanying and ensure compliance.

Termination of fence: If the fence fails – usually from lax maintenance – the fence should be discontinued. An option for encouraging compliance to agreed conditions is to have the energiser in the implementing agencies' custody between cultivation seasons. Termination would be a last resort. Regular monitoring and maintenance will prevent getting to this end point, as it will identify deficiencies before they become critical.

Once the conditions are presented, the farmers should be asked to discuss among themselves and given time to decide whether they want to proceed.

3. Sign agreement

Once the farmers have understood the procedure, agreed to the conditions and have set up the fence committee, an official agreement can be signed. It should include:

- Conditions for obtaining the fence (from above)
- A maintenance mechanism and schedule
- Penalties for non-compliance in maintenance, crop guarding or contribution to the maintenance fund
- Conditions of fence termination
- List of all farmers, with signatures, accepting the agreement

4. Mapping the fence line

The next step is to map the fence line, which is the perimeter of the paddy tract. Mapping is done by walking the perimeter of the fields with the farmers, noting the number of fence posts as follows: Note down a 'corner post' at the start of the fence. Then walk in a straight line along the perimeter, measuring 15 m lengths from the starting post, using a rope pre-marked at 15 m intervals. Note down a 'middle post' at each 15 m interval until a point where the perimeter changes direction is reached. Mark another corner post there. Continue in the new direction, again noting middle posts at 15 m intervals from the last corner post, till the next corner post. Repeat this till you come back to the starting point. If trees are present along the fence line approximately where a corner or a middle post should be, they can be used instead of posts and marked as 'corner trees' or 'middle trees'.

At the end of mapping, add up the tallies to determine the total number of corner posts, middle posts, corner trees and middle trees. Each section between corner posts/corner trees is counted as a span. A handheld GPS can also be used in mapping and creating a map on Google Earth. If only a portion of a tract is cultivated in a particular season, the fence should only enclose that part.

5. Clearing vegetation

The fence line is cleared of vegetation to a width of 3 m. It also needs to be reasonably levelled as otherwise the wire may touch the ground. Any small, uncultivated patches falling inside the fence line are cleared to ensure the fence is visible to crop guarding farmers. The farmer society does the clearing manually or – if major clearing is required – by machine. Clearing should be supervised or afterwards the site inspected to check that the clearing is adequate. Where elephants have learned to break fences by toppling trees on to the fence, trees should be removed.

6. Bill of quantities (BOQ)

The information from mapping is used to determine material quantities that vary by fence length (and geometry) and those that are a fixed number per fence (Table 1). In addition, implementers require electric fence pliers, voltmeter and a pair of gum boots which can be used for multiple fences. Gates are not needed as farmers can simply go under the fence. Gates also add expense and create weak points.

7. Fence installation

All farmers should participate in fence installation (Fig. 4). With experience, farmers can be divided into groups and their participation staggered by section of fence and time.

Fence installation procedure:

- Mark corners with stakes.
- Prepare post-holes for corner posts. In moist /soft ground post-holes are dug by driving the pointed end of a 7.5 cm diameter stake (of strong wood or metal) into the ground with a heavy mallet and making a hole 45 cm deep and of adequate diameter to install the corner post. On firmer ground, a 7.5 cm diameter heavy GI pipe cut at an angle at one end can be used. It is driven in partway, pulled out, the soil plug in the pipe removed and repeated till the correct depth is reached.
- Install corner posts.
- Stabilise corner posts with guy-wires anchored by anchor stakes. The guy-wire is a length of fence wire tied securely to the post at one end and to an anchoring stake through a bullnose insulator at the other, thereby being energised. Guy-wires and stakes have to be placed to oppose the pull exerted on a post by the fence wires and 1–3

Figure 4. Farmers installing their fence.

may be needed, depending on the fence angle and load at a particular post.
- Tie 4 bullnose insulators to each corner tree with tying wire, so that they are aligned with the fence wires.
- Nail the tree hooks to middle trees at appropriate height.
- Place a roll of wire on the wire dispenser and feed it out by spinning the dispenser and pulling out one end of the wire, taking care that it does not drag on the ground, as that will damage the galvanised coating.
- Pre-thread the fence wire through a reel insulator per each tree hook (for middle trees) used, when the fence wire is being installed for that span.
- Secure the fence wire of each span to the corner posts or corner trees at each end of a span. In the case of corner posts, insert the fence wire through the corner post wire holders on posts and tie it securely to the post. In the case of corner trees, thread it through the bullnose insulator and tie it securely. When securing the fence wires at the end of a span, pull it and tie it so that slack is minimised.
- Connect the fence wires on either side of corner trees with a short piece of fence wire that circumvents the tree without touching it.
- Mark the locations of middle posts along the fence line at approximately 15 m intervals between corner posts, dig 30 cm deep holes,

Table 1. Preparing the BOQ. Quantities are based on the mapping information.

Factor	Description	Quantity
Fence length	Fence length (m)	= (# corner posts + # middle posts + # middle trees + # corner trees) x 15
	Corner posts with ground insulator	= # corner posts
	Middle posts with ground insulator	= # middle posts
	Bullnose insulators	= (# corner posts x 2) + (# corner trees x 4)
	Reel insulators	= # middle trees x 2
	Tree hooks	= # middle trees x 2
	Iron nails 2”	= # tree hooks x2
	Fence wire 1.6 mm (kg)	= fence length x 2 / 55
	Tying wire 2.5 mm (kg)	= (# bullnose insulators x 3 / 25) + 5
	Wire tighteners	= # spans x 2
	Anchor stakes	= # corner posts x 2
	Fence indicator light	= fence length / 1000
Per fence	Energiser with alarm	1
	Lightning diverter	1
	Earth rod with wire clamp	7
	Lead-out cable (2.5 mm)	5 m
	L-joint wire clamp	3
	Solar panel with mounting kit	1
	Solar charge controller	1
	Solar battery with accessories	1
	Cutout switch	1
	Energiser cabin	1
	Energiser cabin stand	1
	Wire tightener handle	1
	Wire dispenser	1
	Electric fence voltmeter	1
	Utility pliers	1
	Warning signboard	5

install posts and insert the fence wire into the wire holders on posts.
- Install a wire tightener on both wires on each span and tighten to remove slack.

The power unit should be installed in tandem with installation of posts and wires:

- Install the energiser cabin and mount the solar panel, controller, battery and energiser.
- Install the energiser, according to the manual.
- Set up the earth system and connect it to the energiser.
- Install lightning diverters.
- Once the fence is installed and energised, check the fence voltage with the voltmeter. Correct any current leaks.

If the fence installation cannot be completed in a day, start with the section closest to the energiser and switch on the completed fence section at the end of the day. Installed fence posts and wire left overnight without power might be damaged by elephants.

8. Fence monitoring

Weekly for the first month, then once a fortnight, an officer from the implementing agency needs to walk around the fence. The voltage is checked every 10 posts and the fence is inspected for shortcomings such as current leaks, vegetation touching live wires, posts at an angle, loose wires etc. Any issues should be shown to the accompanying farmers and corrected. Completing a data sheet at each visit by marking the observed faults, provides a record of fence status and provides early warning of lax maintenance. Frequency of monitoring can be reduced in subsequent seasons based on farmer competency.

9. Fence removal and storage

The fence is dismantled in sections and stored in a village. The fence removal procedure is as follows:

- Switch off power to fence.
- Release the tension from the wire tighteners.
- Cut the fence wires where they are tied to the corner posts and tree-bullnoses.
- Rewind the fence wire using the wire dispenser, taking out the reel insulators.
- Number each roll of wire with the related span number, so that it can be reinstalled for the same span.
- Untie bullnose insulators from corner trees and anchor stakes, at the farther end from the bullnose. They can be reused as is.
- Remove posts and ground insulators.
- If the ground is dry, watering the base of posts enables removal without damaging the ground insulator.
- Damaged posts should be discarded.
- Remove the individual components of the power unit.

The material is transported to a suitable location and stored until the next cultivation season. When storing the battery, reconnect the solar panel to the solar charge controller and connect it to the battery so that it is kept charged.

Important factors to consider

For successful fences the implementers should be knowledgeable of all aspects of community-based seasonal electric fences, work closely with the farmers, supervise construction and conduct regular fence monitoring. Constructing a fence and handing it over to farmers or providing the farmers with material and expecting them to do it by themselves will result in failure.

The sustainability of a fence over multiple seasons is contingent on proper communal maintenance hence sense of ownership. In smaller communities, fence ownership and community cohesion tend to be greater, making long-term sustainability more likely. Similarly, the shorter the fence length, the easier is its management. Therefore, limiting the length of seasonal fences to less than 5 km is advisable. Where cultivation tract perimeters are longer, having a cluster of small fences instead of one long fence would be better. If only a single long fence is possible, breaking it up into independently powered serial sections allied with any pre-existing grouping of farmers would be better than a single long fence requiring the coordination of multiple groups.

In embarking upon a community-based seasonal electric fencing program, at first farmers may be reluctant to invest labour and particularly funds, as they may doubt its effectiveness. Therefore, concessions may need to be made in the conditions identified here. Although per acre costs will be higher, it is best to start with a small fence of about 2 km that will serve as an example and scale up in subsequent seasons, so that the implementers gain experience and issues are identified and addressed.

Material specifications

Corner post with ground insulator

Post: GI pipe; 1¼" (32 mm) diameter – 1.8 mm wall thickness; 2.3 m in length; bottom end deburred/filed smooth; two flat metal washers (0.5 mm thick, 2.5 cm outer diameter, 1.3 cm inner diameter) welded to post as wire holders, at 4 cm and 1 m from the top, vertically oriented to carry the fence wire; welds cleaned and painted over with zinc-phosphate anticorrosive paint; washers cut across at the top; –top end of post sealed by welding a zinc-coated gauge 18 plate (end plate), to prevent rainwater inflow into the GI pipe (Fig. 5).

Ground insulator: Composed of 2 concentric layers; inner layer 1½" PNT 11 uPVC pipe, 66 cm in length, sealed at the bottom end by a PVC end-cup glued on with PVC solvent cement; outer layer 2" black HDPE (alkathene) pipe, 76 cm in length (Fig. 6). It is important to use uPVC pipes and fittings and not PVC, as PVC may have added lead (Pb), which leads to current leakage. The ground insulator described is fabricated with commonly available supplies. We are currently working on developing an injection-moulded unit to replace it.

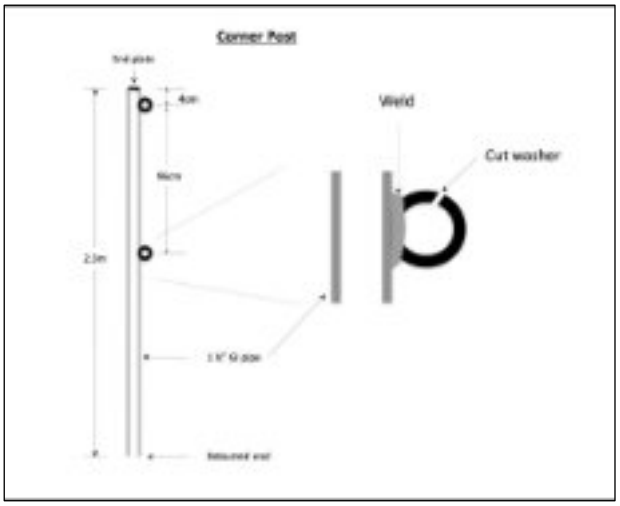

Figure 5. Detail of corner post.

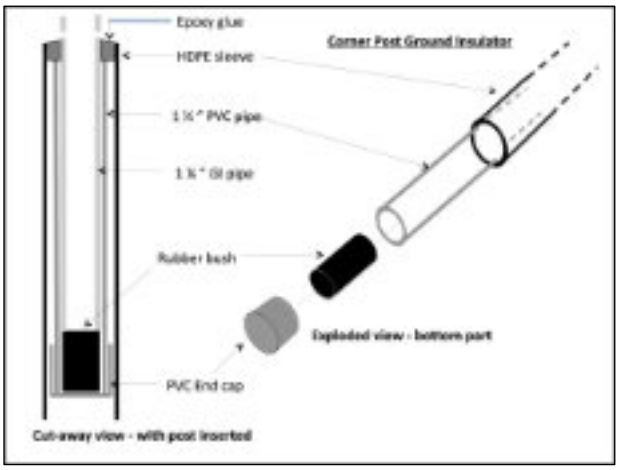

Figure 6. Detail of ground insulator for corner post.

Ground insulator assembly: A solid rubber bush, 2" long and 1.5" in diameter, tightly fitting the PVC pipe, is inserted into the 1.5" PVC pipe at its bottom end and sealed with the end cup; the assembled 1.5" uPVC pipe is inserted into the 2" HDPE sleeve, leaving 5 mm of the HDPE sleeve projecting at the top end (Fig. 6).

Post and ground insulator assembly: The 1¼" GI pipe (post) is inserted into the ground insulator and pushed to its bottom to contact the rubber bush; once post is inserted, the top end of the ground insulator is sealed by filling up the top of the HDPE sleeve lip with epoxy glue (Fig. 6).

Middle post with ground insulator

Post: GI pipe, – ¾" (20 mm) diameter – 1.8 mm wall thickness; 2.1 m long; bottom end deburred /filed smooth; wire holders and end plates same as for corner posts (Fig. 7).

Ground insulator for middle post: Composed of 3 concentric layers; an inner layer of 1" PNT 11 uPVC pipe, 66 cm in length, a middle layer of 1¼" PNT 11 uPVC pipe, 66 cm in length, sealed at the bottom end by a PVC end-cup glued with PVC solvent cement, and an outer layer of 1½" black HDPE (alkathene) pipe, 76 cm long (Fig. 8).

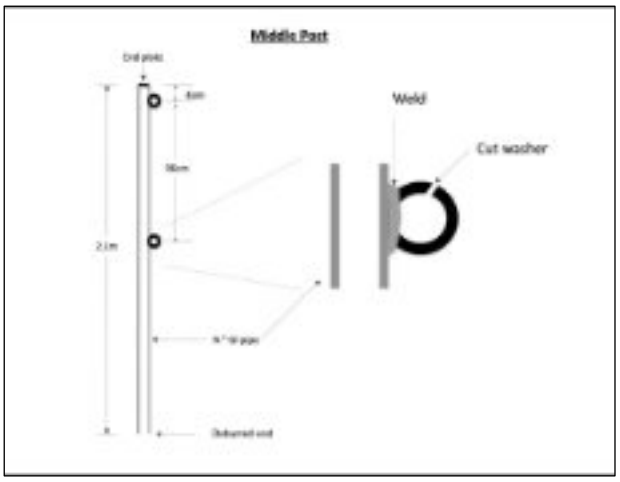

Figure 7. Detail of middle post.

Ground insulator assembly: A solid rubber bush, 5 cm long and 1" in diameter (tightly fitting the PVC pipe), is inserted into the 1" PVC pipe; then the 1" PVC pipe with rubber bush is inserted into the 1¼" PVC pipe and the bottom end of the 1¼" PVC pipe sealed with the end cup; next a 5 cm long piece of 1" PNT 400 pipe split vertically is inserted between the 1" and 1¼ " PVC pipes to fill the gap ('PVC socket' in Fig. 8); finally the assembled 1¼" PVC pipe is inserted into the 2" HDPE sleeve, leaving 5 mm of the HDPE sleeve projecting at the top end.

Post and ground insulator assembly: Same as for the corner posts.

Items to fix wire to the post

Bullnose insulator: Porcelain; able to be used with galvanised wire diameter up to 3 mm; can withstand a minimum 2 kN fence wire tension; high quality glaze finish and fire resistant with a life span of more than 10 years; minimum track distance of 25 mm; withstands up to 50°C temperature for a prolonged period of time.

Reel insulator: Porcelain; diameter 40 mm; height 40 mm; glaze frame finished; withstands up to 50°C temperature for a prolonged period of time.

Tree hook: Made of 8 mm round iron bar (30 cm in length) with the end bent into a half round shape to securely hold a porcelain reel insulator; the other end welded onto a 15 cm, ¼" x ½" flat iron bar with two 3 mm holes drilled 1/2" from either end; completely painted with zinc phosphate anticorrosive paint (Fig. 9).

Fence wire: 1.6 mm diameter; hot dip heavy-galvanised high tensile steel; minimum zinc coating not less than 200 g/m^2; minimum tensile strength 1200 MPa and minimum breaking load 280–300 kg; DC electrical resistance not exceeding 70–100 Ω / 1000 m at 20°C temperature; supplied as 25 kg rolls.

Soft wire: 2.5 mm diameter; hot dip galvanised; minimum zinc coating not less than 60 g/m^2; minimum breaking load 250 kg.

Wire tightener: Designed to adjust the wire tension by tightening or loosening a wire; can be installed in line with the wire; non-corrosive.

Anchor stakes: Wooden poles around 1 m in length and strong enough to bear the strain from the posts, sharpened at one end or 1 m lengths of GI pipes one end cut at an angle.

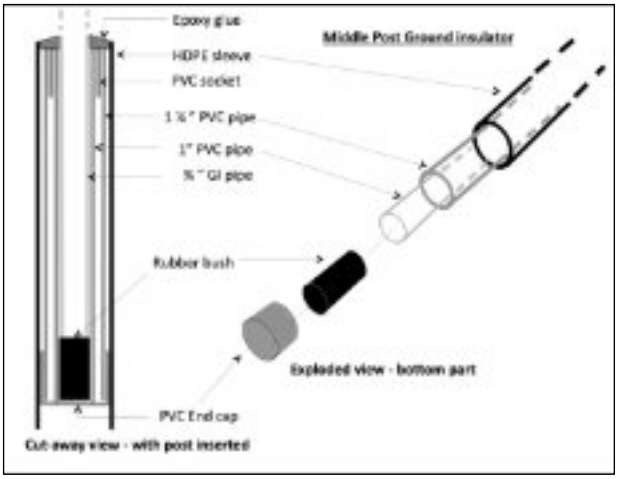

Figure 8. Ground insulator for middle post.

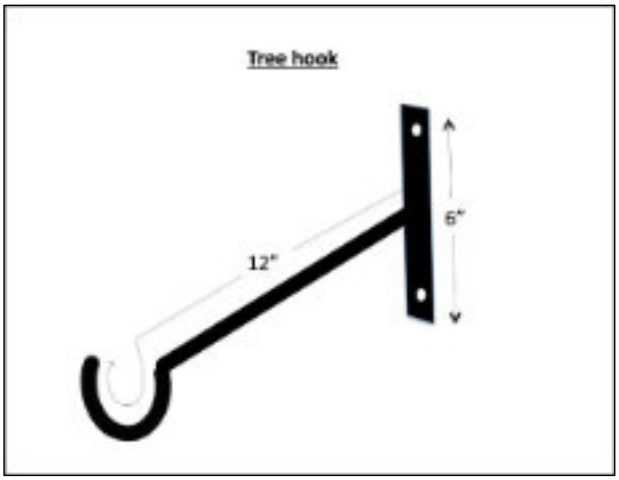

Figure 9. Detail of tree hook.

Fence indicator light: Attachable to the fence wires and lights up with each energy pulse.

Marker stakes: Small sticks about 1 m in length 2 cm diameter.

Items needed once per fence

Energiser with alarm: Complying with International Electromechanical Commission standards (IEC 60335-2-76 Ed.3.0) for current-limited electric fence energisers; powered by a 12 V DC battery; peak energiser output energy of 10 Joules; maximum energy delivered at a load of 500 Ω; resistance not less than 6.5 Joules; incorporate internal adaptive control, so that as the fence is more heavily loaded, the output energy is automatically increased to maintain pulses of a minimum of 6500 V at a load resistance of 250 Ω upwards; minimum interval between electric pulses not less than 1 second and pulse duration not exceeding 50 milliseconds; display indicating 'output pulse voltage' and 'working status'; activate an alarm when the fence is shorting (voltage drops under 6500 V) or the fence is disconnected and the battery under voltage; incorporate lightning protection as prescribed by IEC 60335-276 (2013V2.2)

Lightning diverter: Able to prevent lightning strikes on the fence from reaching the energiser and instead divert it to the earth rods; able to withstand multiple lightning strikes; manually adjustable at site to suit any fence voltage; UV resistant.

Earth rod with wire clamp: Earth rod made of 1.5 m long 50 mm diameter 2.3 mm thick hot-dip heavy galvanised G.I. pipe with one end cut at a 45° angle. Wire clamp made of a G.I. plate which is 2 mm or Gauge 14 thick and 25 mm wide; wire clamp secured to earth rod by two galvanised nuts and bolts on either side (13 mm long).

L-joint wire clamp: Heavy galvanised or stainless steel, non-rusting; suitable for securing various diameters of wire up to 4 mm diameter; able to hold multiple wires.

Solar panel with mounting kit: Solar array 100 Watt peak power; mono crystalline solar cell; short circuit current (Isc) above 5 Ampere; frame for mounting solar panel on a 1" GI pipe – when fixed, the panel should be at a 10° angle and able to be oriented to desired direction; solar wire 3 m.

Solar charge controller: MPPT type controller; capable of handling 16–20 Amperes at 12 V and compatible with other solar accessories and specified 12 V battery; battery-deep-discharge protection; protect load against short circuit conditions; include a visual charge indicator and a battery voltage indicator; manual boost charging facility; reverse polarity protection.

Solar battery with accessories: 12 V, 100 Ampere-hour (Ah); maintenance free; deep cycle gel battery; two terminal clips; heavy duty connecting wire 2 m.

Cutout switch: Able to isolate a fence voltage up to 15 kV; have clearly visible ON/OFF positions; protected contacts that eliminate electric shocks; sealed to be weather and insect proof.

Energiser cabin: Steel cabin ca. 45 cm wide x 75 cm high x 30 cm deep; weather proof; lockable door on front with durable hinges; ventilated for cooling; two 13-mm screws projecting out from the midpoint of the two sides of the floor, to fix the cabin to the stand; robust construction; able to carry the weight of a 12 V, 100 Ah solar battery, energiser and components.

Energiser cabin stand: Strong enough to support the energiser cabin with battery, energiser and components, and a 100 W solar panel; fabricated with 1" GI pipes; legs 120 cm high with pipes welded horizontally to brace the frame, 30 cm from the bottom; rectangular frame of 45 x 30 cm made of 1¼ "L-iron bars welded onto the top to receive the energiser cabin, with two holes drilled at the middle of the side bars, to receive the 13 mm screws of the cabin (see specs for cabin); a socket, closed at the bottom end, welded onto the outside of one leg to receive a 120 cm long, 1" GI pipe; a 120 cm long, 1" GI pipe for fixing solar panel to the stand (Fig. 10).

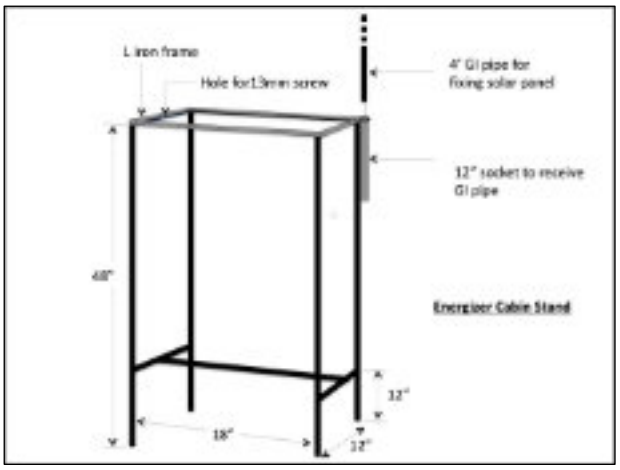

Figure 10. Detail of energiser cabin stand.

Wire tightener handle: Compatible with wire tightener.

Wire dispenser: Spinning-Jenny type; made of steel; able to hold up to 50 kg of fencing wire at a time; of robust design with six fixed (non-foldable) arms; tensioning system to control spinning speed; adjustable to handle wire rolls from 45–90 cm inner diameter; painted with anticorrosive paint (Fig. 11).

Electric fence voltmeter: Compatible with energiser used and able to measure up to 15 kV.

Utility pliers: Heavy duty utility pliers; able to cut and handle high tensile wire; rubberised grip.

Figure 11. Wire dispenser.

Warning signboard: Weatherproof signboard that can be hung on the wire with 'Warning – high voltage' message.

Acknowledgments

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Report on the 11th Meeting of the IUCN Asian Elephant Specialist Group

Prajna P. Panda* and Vivek Menon

Office of the Chair, Asian Elephant Specialist Group, Noida, India
**Corresponding author's e-mail: prajna@wti.org.in*

Introduction

The IUCN SSC AsESG meeting is a consultative meeting of the members of the IUCN Asian Elephant Specialist Group (AsESG), government officials of the elephant range countries and other conservation organisations to identify priorities and challenges at a country and range level and ways to address them and also to devise best practices for the conservation of elephants in wild and in captivity. The AsESG meeting is an opportunity to foster a closer relationship among range countries and members of the AsESG to deliberate and plan a way ahead as a Specialist Group to promote the long-term conservation of Asian elephants in 13 range countries.

The IUCN SSC AsESG hosts the meeting of its members and range country officials every 18 months to deliberate on various issues related to conservation of elephants in Asia. The previous two AsESG meetings i.e. the 9th AsESG meeting was held at Bangkok, Thailand in April 2018 and the 10th AsESG meeting at Kota Kinabalu, Sabah, Malaysia in December 2019.

Aiming to bring together the elephant conservationists in India that holds 60% of the global Asian elephant population, the 11th meeting of the IUCN SSC AsESG was held in India. The meeting was organised from 14th to 15th March 2023 at Hotel Royal Plaza, New Delhi and from 16th to 17th March 2023 at Infinity Resorts, Corbett National Park. The meeting was organised in partnership with the Ministry of Environment Forest & Climate Change and Uttarakhand Forest Department to take stock of the decisions of the last AsESG meeting as well as identify the priorities and challenges at a country and range level and ways to address them for the conservation of elephants in wild and in captivity. Overall, there was participation from 130 members who participated and helped in organising the meeting. The participation included 67 AsESG members, representatives from 11 Asian elephant range countries, 11 conservation partners, special invitees and organisers from MoEF&CC, Uttarakhand Forest Department and Wildlife Trust of India. In this meeting, there were 57 plenary presentations in total with wide participation from 51 AsESG members actively involved in presenting, chairing and co-chairing the sessions. Dr. Jon Paul Rodriguez, Chair IUCN SSC, and Ms. Kira Mileham, Director, IUCN SSC Strategic Partnerships, also participated in the meeting and helped in linking the conservation partners into the strategic priorities and activities of the AsESG.

The event was inaugurated by Mr. Praveen Pardeshi, Member Admin, Capacity Building Commission, Prime Minister Office, Dr. Jon Paul Rodriguez, Chair IUCN SSC, Mr. Ramesh Kumar Pandey IGF & Director PE, MoEF&CC and Mr. Vivek Menon, Chair, IUCN SSC AsESG. The first volume of the "Action Elephant" including the National Elephant Action Plans of six elephant range countries was released during the inaugural session.

Chair's summary on AsESG's achievements

Mr. Menon thanked the Government of India and all the Conservation Partners for facilitating the organisation of the meeting and presented the report of AsESG activities since the last meeting held at Sabah in 2019. The updates on the 14 Working Groups working to assess, plan and act in this Quadrennium (2021–2025) were discussed (Fig. 1).

Assess

In terms of assessment, the team has successfully submitted the red list assessment of the Asian elephant and categorised it as Endangered. The mapping of elephant distribution in Asia is in progress and preliminary information has been received from Thailand, Peninsular Malaysia.

Plan

The first edition of "Action Elephant" including six National Elephant Conservation Action Plans was released during the inaugural session of the 11th AsESG meeting. The "Elephant Conservation National Action Plan for Sabah Malaysia" has been finalised and printed in 2020. Similarly, the National Elephant Conservation Action Plan of Lao PDR has been completed in 2022. The drafts of the Sumatra Elephant Conservation Action Plan are ready and waiting approval of the government. The drafting of National Elephant Conservation Action Plans of Peninsular Malaysia and Vietnam are also in process.

The three Working Groups that have completed and submitted their outcome documents include guidelines for creating artificial water holes in elephant habitats; guideline for welfare and use of elephants in tourism; management and care of captive elephant in musth. The draft for guidelines for the reintroduction of captive elephants in the wild as possible restocking option and the guidelines on emerging diseases affecting Asian elephants is ready and being reviewed. The Working Groups that are still working to complete their outcome documents include guidelines for best practices in addressing and mitigation of human-elephant conflict, mapping of elephant distribution in Asia, taxonomy of elephants in Sabah and its Red Listing, research paper on the Asian elephant (*Elephas maximus*): A flagship species in imminent need of climate change action.

Act

The membership advisory committee and the communications advisory group are also working on their respective mandate and will continue till the end of the quadrennial. A total of five Membership Advisory Committee meetings are organised in the new quadrennium and five members were added to the group. AsESG activities are now being uploaded in the social media such as Twitter, LinkedIn and Instagram.

The editorial board of the journal Gajah has published five volumes since 2019. One of the major hurdles has been the lack of papers for publication and the editorial board urged members to submit their work for publication.

Activities of the AsESG representatives

Mr. Menon informed that of the 115 AsESG members, 56 members are part of the Working Groups constituted for drafting of the reports/guidelines and 47 members actively participating in the 11th AsESG meeting as chairs, co-chairs, moderators or as presenters.

The SSC Chair confirmed Mr. Vivek Menon as Chair of AsESG for the new quadrennium (2021–2025). The Chair attended the IUCN World Conservation Congress from 2nd to 11th September 2021 in Marseille, France and was also elected to the IUCN Governing Council as IUCN Councillor from South and East Asia Region. He also presented on conservation of Borneo elephants at the session "Assess-Plan-Act to reverse the Red within SSC" on 5th September 2021 organised by the IUCN SSC.

Third Asian Elephant Range States Meeting: The Chair, Vice Chair, Program Manager AsESG and Mr. Naresh Subedi took the lead in organising the third meeting of the Asian Ele-

Figure 1. Vivek Menon, Chair of the AsESG, presenting the report to the members.

phant Range States at Kathmandu, Nepal. The meeting was held from 27th to 29th April 2022 at Kathmandu with 48 persons participating in person and 27 virtually. The AsESG members that participated in the meeting were Mr. Salman Saaban, Dr. Prithiviraj Fernando, Dr. NVK Ashraf, Mr. Wahdi Azmi, Dr. Ashok Kumar Ram and Mr. Ganesh Pant. The meeting resulted in the signing of the Kathmandu Declaration signed by all 13 Asian elephant range countries. A final report of the third range states meeting in Kathmandu will be prepared and circulated.

Side event at CoP 19 of CITES: The AsESG organised a side event at CoP 19 of CITES at Panama on 16th November 2022, in partnership with IFAW, on the "Kathmandu Declaration and its implication towards conservation of Asian elephants" involving the Chair, IUCN SSC AsESG; Dr. Jon Paul Rodriguez, IUCN SSC Chair; Mr. Azeddine Downes, President IFAW; Country delegation from India, Malaysia and Nepal; Ms. Tanya McGregor, CITES and Mr. Benson Okita-Ouma and Ms. Rose Mayienda, African Elephant Specialist Group.

The Chair presented on the overall status of Asian elephants at the "VIII International Conference on Mammoths and their Relatives" held from 25th to 28th October 2021 at the Indian Institute of Science, Bangalore, India. Dr. Adrian Lister, Dr. Raman Sukumar and Dr. Nurzhfarina Othman also were actively involved in the conference.

The AsESG has submitted a report on "Asian elephant: status, threats and conservation action" for the 74th Standing Committee report in November 2021. It also has published document on "Protecting Asian elephants from linear transport infrastructure" with IUCN WCPA Connectivity Conservation Specialist Group.

Technical Working Groups

Day 1

The technical sessions focused on discussions on threats and challenges impacting the conservation of Asian elephants and the various guidelines and plans being drafted by the group and range countries for the conservation and welfare of elephants in wild and in captivity. The first day discussions focused on country presentation from all 13 range countries, both by ex-officio and AsESG members. The ex-officio member of the country presented a general outline on status of wild/captive elephant population of the country, main conservation issues and threats, if the country has an action plan and the interventions being made by the range country. This was followed by the country presentations by AsESG members of the respective countries specifically outlining the emerging challenges towards elephant conservation in the country and providing specific suggested solutions to counter the problem.

Day 2

The discussions on the second day were on the various guidelines and plans being produced by the AsESG Working Group members. The AsESG Chair reported that by the end of March 2023 six Working Group reports were completed which are enlisted as below:

- Bhutan Elephant Conservation Action Plan
- Sabah Elephant Conservation Action Plan
- Red List assessment of Asian Elephant
- Guidelines for creating artificial water holes in elephant habitats
- Guideline for welfare and use of captive elephants in tourism
- Management and care of captive elephant in musth

The status on the remaining eight Working Group reports were presented by the respected Working Group convenors. The ninth Working Group i.e. on the Sumatra Elephant Conservation Action Plan has been finalised by the Working Group members and submitted to the Indonesian Government for approval.

- Guidelines for best practices in addressing and mitigation human elephant conflict
- Guidelines for the reintroduction of captive elephants in the wild as possible restocking option
- Plan to arrest the decline of the elephant population of Vietnam. The Working Group has been revamped to now work on the preparation of the National Elephant Conservation Action Plan of Vietnam.
- Mapping the distribution of Asian elephants

- Emerging diseases affecting Asian elephants
- Taxonomy of elephants in Sabah and its Red Listing
- Drafting the Peninsular Malaysia NECAP
- The Asian elephant: A flagship species in imminent need of climate change action

The two ongoing Working Groups are as below:
- AsESG Communication Working Group
- Membership Advisory Committee

Six speed talk presentations were moderated by Dr. Ee Phin Wong (Deputy Chair, IUCN SSC AsESG) where presentations by members from Cambodia, Nepal, India and Malaysia.

Ms. Heidi Riddle chaired a parallel session on the stocktaking of the Kathmandu Declaration. This focused on the follow up to be done on the Kathmandu Declaration 2022.

A Partners roundtable meeting was held with all the conservation partners to discuss on the way forward to support the AsESG activities.

A workshop on addressing transboundary illegal wildlife trade was organised involving representatives of Wildlife Crime Control Bureau (WCCB), United Nations Office on Drugs and Crime (UNODC) and US Embassy-INL representatives.

The meeting also provided a forum for the emerging scientists to present their work in form of speed talks on various issues of elephant conservation and take feedback of AsESG experts to refine their studies.

Day 3

The meeting in Delhi was followed by a field visit to the site of elephant interventions done in Corbett Tiger Reserve. Under the guidance of Mr. Dheeraj Pandey (Field Director, Corbett Tiger Reserve) the AsESG members interacted with Eco Development Committee (EDC) members on the challenges they face living close to the forests and sharing the landscape with elephants (Fig. 2). The members were also shown the honeybee power fencing done by the Uttarakhand Forest Department to counter human-elephant conflict issues in the area.

Day 4

On the last day of the AsESG meeting a session was organised at Infinity Resorts, Corbett National Park in which AsESG members shared their work, experience and studies on various topics from across different Asian countries on elephant conservation.

The closing session of the AsESG meeting was presided by Mr. Subodh Uniyal, Hon'ble Minister Forest & Environment, Uttarakhand. The other guests of the closing ceremony were Dr. Samir Sinha, Principal Chief Conservator of Forests (WL) & Chief Wildlife Warden, Mr. Jon Paul Rodriguez, Chair, IUCN SSC, Mr. Vivek Menon, Chair IUCN SSC AsESG and Mr. Dheeraj Pandey, Field Director, Corbett National Park. A short film, showcasing the flora and fauna of the Jim Corbett National Park was also screened during the closing session. Dr. Prajna P. Panda proposed the vote of thanks.

Figure 2. Group photo taken during the field visit at the Corbett Tiger Reserve.

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Report on World Elephant Day Celebration in Saranda Forest Division, Jharkhand, India

Shiladitya Acharjee

Saranda Forest Division, Jharkhand, India
Author's e-mail: shiladitya.sa@gmail.com

Introduction

World Elephant Day, observed annually on August 12th, is a global event dedicated to the preservation and protection of elephants. In 2024, the Saranda Division of the Forest Department marked this day with enthusiastic participation from students and the community in two key locations: Kiriburu and GUA Range. The aim of the program was to raise awareness about the importance of elephant conservation and the significance of protecting their natural habitats.

Kiriburu event

Participants and activities

The event at Kiriburu was organised with the active participation of students from Project Central School. The day began with a vibrant morning rally, where students marched from the school premises to the Sasangada Forest Range Office. The participants carried placards and banners, with slogans emphasising the need to protect elephants and conserve their habitats.

Painting competition

A painting competition was conducted, where students expressed their creativity and concern for elephants through art. The themes revolved around the life of elephants, their struggles for survival, and the importance of maintaining ecological balance. The paintings were displayed at the Sasangada Range Office, drawing attention from the local community.

Documentary screening

The highlight of the program was the screening of the award-winning documentary film, The Elephant Whisperer. The film provided a deep

Kiriburu event.

insight into the lives of elephants, their intelligence, emotions, and the challenges they face due to habitat loss and human interference. The students were moved by the film, which sparked discussions on how they could contribute to elephant conservation.

GUA Range event

Participants and activities

In GUA Range, the World Elephant Day celebrations began with a morning rally organised by students from DAV Public School. The rally started from the school and ended at the GUA Range Office, where students held placards and chanted slogans to spread awareness about elephant conservation.

Sensitisation session

Following the rally, a sensitisation session was conducted by Forest Department officials. The session focused on the significance of World Elephant Day, the importance of protecting elephant corridors, and the role of each individual in ensuring the survival of these majestic animals. The students were encouraged to become ambassadors of wildlife conservation in their communities.

Documentary screening

A documentary on elephant space and corridors was shown to the students, highlighting the critical importance of these areas for elephant migration and survival. The film shed light on the human-elephant conflict and the need for coexistence strategies. The students were deeply engaged and asked several questions about how they could help protect elephant habitats.

Conclusion

The World Elephant Day programs in the Saranda Division, particularly in Kiriburu and GUA Range, were a resounding success. The events helped educate the students regarding elephant conservation and empowered them to take an active role in conservation efforts. The rallies, painting competition, and documentary screenings helped foster a deep understanding of the challenges facing elephants today. The Forest Department of Saranda Division expressed their gratitude to the schools and students for their enthusiastic participation and reiterated the importance of continued efforts to protect elephants and their habitats.

GUA Range event.

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Vietnam Sets Bold Milestones for Elephant Conservation with New National Action Plan

Tran Thi Hoa

Department of Forestry, Ministry of Agriculture and Rural Development, Hanoi, Vietnam
Author's email: vpyflowerhoa@gmail.com

The "Vietnam Elephant Conservation Action Plan to 2035, Vision 2050" (known as VECAP 2022), was launched on 20th November 2024, by the Ministry of Agriculture and Rural Development (MARD) (Fig. 1). This groundbreaking initiative aims at conserving Vietnam's dwindling elephant population. The strategic plan seeks to safeguard both wild and captive elephants while promoting coexistence with human communities. It will guide the recovery of the Vietnam elephant population from now until 2035, with the vision: "To conserve and develop sustainable populations of wild elephants, promote harmonious coexistence between elephants and humans, and ensure the welfare and foster the development of a sustainable captive elephant population in Vietnam by 2050". Hon. Nguyen Quoc Tri, Vice Minister of MARD, emphasised the plan's significance at the launch, stating: "This action plan reflects Vietnam's strong commitment to protecting Asian elephants, a vital part of our natural heritage, while fostering harmonious coexistence with human communities."

Vietnam's elephant population plummeted from an estimated 1,500–2,000 in the 1970s to just 100–130 individuals by the early 2000s, due to habitat loss, fragmentation and human-elephant conflict. To arrest the decline, a series of conservation policies and regulations have been regulated and implemented since 1996, including ministerial-level and national government level plans, underscoring the importance given to conserving elephants in the country. National government-level decisions are binding on all relevant ministries, while ministerial-level decisions apply only to the issuing ministry and are not obligatory for others. They include Ministerial Decision No. 1204/NN-LN-QĐ dated 16/07/1996, issued by MARD and implementation of the Action Program for Elephant Conservation in Vietnam for the 1996–1998 period, focussing on Dak Lak Province, which is considered to hold the largest elephant population in Vietnam. National Government Decision 733/QD-TTg, dated 16/05/2006 Emergency Action Plan for Elephant Conservation until 2010. National Government Decision 940/QĐ-

Figure 1. Official launch of the VECAP 2022.

TTg, dated 29/07/2012 regarding approval of the Emergency Action Plan for Elephant Conservation in Vietnam until 2020, the National Government Decision No. 763/2013/QĐ-TTg dated 21/05/2013, approving the Master Plan for Elephant Conservation in Vietnam for the 2013–2020 period and the National Government Decision No. 413/QĐ-TTg, dated 31/03/2022, granting an extension for the implementation of the Master Plan for Elephant Conservation until 2025. The latest policy initiative in this process is the VECAP 2022, which is a national-government level plan. It takes a scientific, data driven approach and is based on scientific findings and methodologies, international conservation standards such as the 'Guidelines for Species Conservation Planning' and 'Species Conservation Planning Principles and Steps: Process Design and Facilitation' of the IUCN, and it conforms to all national guidelines and regulations.

The background for the VECAP 2022 was prepared through a pilot program initiated in the Dong Nai province in 2019, for identifying methodologies to obtain reliable data on which to base management decisions and adapting them to the Vietnamese context (Fig. 2). Under the project, three main initiatives consisting of assessing elephant populations and monitoring by camera traps (Fig. 3), assessing and monitoring human-elephant conflict through community data collection and the mapping of elephant distribution through a grid-based questionnaire survey were developed and tested. Dong Nai Forest Protection Department (FPD) officers conducted all the field activities. Financial and technical support for the initiative was

Figure 2. The first workshop in Dong Nai in 2019 to identify feasible methods for obtaining reliable data.

Figure 3. Elephants captured via camera traps, used to identify different individuals.

provided by the Humane Society International (HSI). Project design, training of FPD officials and data analysis was conducted by Ms. Nguyen Thi Mai and international consultants Dr. Prithiviraj Fernando and Dr. Jennifer Pastorini, through HSI. The results of the pilot program were presented and discussed at an international workshop held in August 2023 in the Dong Nai Province. The identified methodologies were highly commended by national and international experts who attended the workshop and were deemed particularly relevant to Vietnam's small, fragmented, and high-risk elephant populations.

MARD/Department of Forestry has been assigned by the Vietnamese Government as the authority on elephant conservation. VECAP 2022 preparation was formally initiated in 2022 by the MARD/Department of Forestry and formulated through a multi-step process. The first steps involved assessing the conservation status of elephants via a literature review and a questionnaire survey of stakeholders. The literature review included scientific publications, as well as grey literature such as unpublished reports and news items. The questionnaire survey was conducted by the VECAP 2022 composing board of the Department of Forestry. The questionnaire targeted stakeholders in elephant conservation, including government agencies at national and provincial levels, enforcement units, national and international NGOs, research universities/institutions, international and national experts, captive elephant owners, and local communities. While most stakeholders provided input via official correspondence or

Figure 4. The first national technical workshop in Hanoi in July 2022.

online, in-depth group interviews were conducted with communities living in proximity to wild elephant habitats and captive elephant mahouts/owners. Through the literature review and questionnaire survey, the existing knowledge on elephant distribution, abundance, threats and management were assessed, and gaps identified. Overall, it was found that the available information was inconsistent and unreliable, due to outdated data, unscientific methodology and lack of long-term data collection based on consistent methodology. Based on the findings, an overall approach was defined, with identification of appropriate, effective scientific interventions and their possible timings, locations and costs.

Next, a four-day national workshop was held in July 2022 to define conservation goals and objectives, formulate strategies and actions, setting indicators of success and identifying constraints and resource requirements (Fig. 4). Based on the results of the workshops, log frame drafts of the action plan for both wild and captive elephants were prepared (Fig. 5).

Afterward, five provincial workshops were conducted in in Dak Lak, Dong Nai, Nghe An, Ha Tinh, and Quang Nam from August to December 2022, where the suggested approach for the VECAP 2022 was explained, the availability of resources and current capacity to implement the interventions reviewed and resource requirements and training needs identified (Fig. 6). Based on the results, a draft plan for each province was prepared. The provincial meetings were coupled with 10 community consultations in key elephant habitats of Dak Lak, Nghe An, and Ha Tinh (Fig. 7). The community consultations provided opportunities to local communities to voice their concerns and requirements,

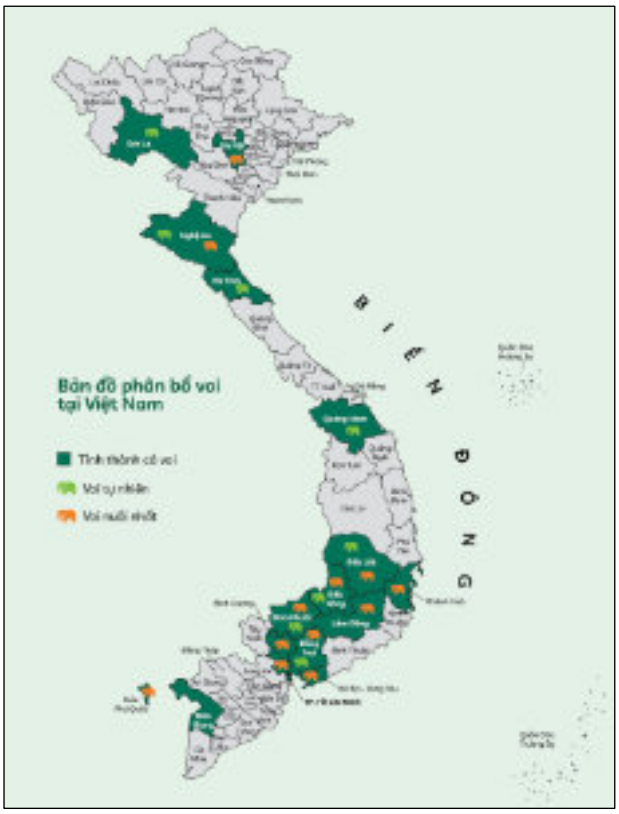

Figure 5. Map of Vietnam showing elephant range provinces (dark green areas). Green elephants stand for wild elephants and orange elephants for captive elephants.

which were assessed and integrated in the plan as appropriate. Subsequently, at the national level, technical meetings and thematic workshops were held and the log frames were reviewed and revised.

Another two national workshops were conducted in February 2023 and December 2023 and many technical meetings of key experts were held to further refine the action plan (Fig. 8). The outline of the proposed plan was also presented at five international meetings. Through this process, inputs from local, regional, national and international stakeholders

Figure 6. Provincial consultation workshop held in the Quang Nam province in 2022.

Figure 7. Village meeting in Thanh Son Commune, Dinh Quan District, Dong Nai Province.

were incorporated and the draft finalised. The final draft was endorsed by the Asian Elephant Specialist Group working committee on 'Assisting elephant conservation in Vietnam'.

The VECAP 2022 balances conservation science with community perspectives, addressing Vietnam's unique challenges of fragmented elephant populations and high-risk habitats. It also aligns with Vietnam's obligations under the 'Kathmandu Declaration on Asian Elephant Conservation'. This strategic, practical and scientific plan marks a pivotal step in Vietnam's efforts to protect its elephants and preserve the country's biodiversity for future generations.

Acknowledgements

I wish to thank the Dong Nai Forest Protection Department and officers for their efforts in making the Dong Nai a success, all the local, regional, national and international stakeholders who contributed to the development of VECAP 2022, the Humane Society International for providing technical and financial support, and particularly Ms. Nguyen Thi Mai (HSI), Dr. Prithiviraj Fernando, Dr. Jennifer Pastorini and Mr. Nguyen Tri Man, for their enthusiasm and guidance in developing the VECAP 2022 throughout the process.

Figure 8. The second national technical workshop in Hanoi in February 2023.

Citation

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The VECAP 2022 (Fig. 8) is available for download on the website of the Department of Forestry, MARD:
https://cuclamnghiep.gov.vn/wp-content/uploads/2024/11/VECAP-2022-Report-16.pdf

An English version is in preparation.

Figure 8. Cover of the VECAP 2022.

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Report on the CITES MIKE South-East Asia Sub-Regional Meeting and CITES Trade in Asian Elephants Workshop

Prajna P. Panda

Office of the Chair, Asian Elephant Specialist Group, Noida, India
Author's e-mail: prajna@wti.org.in

Introduction

The CITES MIKE South-East Asia Sub-Regional Meeting and the CITES Trade in Asian Elephants (*Elephas maximus*) Workshop were held in Hua Hin, Thailand, from 30th to 31st January 2024. This important event brought together key stakeholders from across Southeast Asia, including government representatives, conservation organisations, and experts, to address pressing issues related to the conservation of Asian elephants and the regulation of international trade under CITES (Convention on International Trade in Endangered Species of Wild Fauna and Flora). The meeting provided an essential platform to discuss the role of the MIKE (Monitoring the Illegal Killing of Elephants) programme in the region and the ongoing challenges related to the illegal trade in Asian elephants.

Key objectives

The main objectives of the meeting and workshop were to:

- Review MIKE programmes: To evaluate the progress of the MIKE programme in Southeast Asia, with a focus on monitoring and addressing the illegal killing of elephants.
- Enhance regional cooperation: To strengthen collaboration among Southeast Asian countries on elephant conservation, particularly in tackling issues of poaching and illegal wildlife trade.
- Discuss CITES trade regulations: To assess and refine strategies to curb illegal trade in Asian elephants and their parts and ensure CITES regulations are being properly implemented.

Summary of discussions and outcomes

Asian elephant regional overview

A presentation by the IUCN SSC Asian Elephant Specialist Group (AsESG) provided an overview of the current status of Asian elephants. The presentation highlighted the ongoing conservation challenges facing the species, including habitat loss, fragmentation, human-elephant conflict, and poaching. The presentation emphasised the critical need for coordinated conservation efforts across range states to ensure the species' survival. The AsESG stressed the importance of a multi-faceted approach to conservation, which includes the protection of elephant habitats, mitigating human-elephant conflict, and implementing effective anti-poaching strategies. The need for more robust data collection, including better tracking of elephant populations and movements, was also emphasised. The AsESG's commitment to fostering collaboration among governments, NGOs, and local communities was reiterated, with a focus on implementing practical, on-the-ground solutions to ensure the long-term protection of Asian elephants

Range states updates

Representatives from Indonesia, Laos, Malaysia, Thailand, and Vietnam presented their na-

tional perspectives on the main threats to elephant populations, regulatory frameworks, and the actions taken to address these challenges. The updates also included details on MIKE site-level strategies adopted in each country, as well as initiatives for transboundary cooperation.

MIKE programme review

The meeting began with a comprehensive review of the MIKE programme's operations in Southeast Asia. It was noted that the programme has been successful in improving the monitoring of elephant populations and illegal killings. However, challenges such as data gaps, inconsistent reporting, and the ongoing threat of poaching were highlighted. Representatives from countries participating in MIKE discussed the need for enhanced capacity-building, particularly in terms of law enforcement and on-the-ground monitoring systems.

Illegal killing and poaching

The workshop extensively discussed the growing threats of poaching and the illegal killing of elephants in the region. Specific case studies from countries such as Thailand, Cambodia, and Myanmar were presented, illustrating the complex relationship between poaching, habitat loss, and the illegal wildlife trade. It was emphasised that stronger, coordinated efforts between countries are necessary to combat these threats effectively.

Key discussion focused on improving stockpile management of elephant ivory and other elephant products. Several countries are facing challenges in managing seized stockpiles and ensuring that these items are not diverted into the illegal trade. Workshop participants discussed the importance of secure and transparent management practices, including the destruction of confiscated ivory to send a strong message against illegal trade.

Additionally, the forensic investigation of poisoning cases was highlighted as an emerging issue. Elephant poisoning is becoming a significant threat, with some countries reporting an increase in incidents. Forensic techniques are being developed to trace the chemicals used in poisoning and to support investigations into illegal elephant killings.

CITES trade in Asian elephants

A significant portion of the workshop was dedicated to addressing the illegal trade in Asian elephants and their parts. The workshop highlighted the need for stricter enforcement of CITES regulations and better coordination among law enforcement agencies in Southeast Asia. The importance of improving the traceability of elephant products, utilising advanced technology, and ensuring robust reporting mechanisms was underscored.

The CITES Standing Committee (SC77) was discussed in relation to key elephant conservation issues. The committee is actively monitoring the implementation of resolutions regarding the illegal trade in elephants, particularly addressing issues related to trade in elephant ivory and other products. There were discussions on ensuring that countries adhere to CITES regulations and take proactive measures to curb the illegal trade.

Sustainability of MIKE programme

There was considerable discussion about the sustainability of the MIKE programme, particularly with regard to securing long-term funding and ensuring the continued effectiveness of monitoring efforts. The importance of maintaining consistent data collection and expanding MIKE coverage to new sites was emphasised. Countries were encouraged to integrate MIKE data into national conservation strategies and decision-making processes to ensure its long-term impact.

Management priorities for the next 3 years

Group discussions were held and the groups agreed on the importance of continued regional cooperation to ensure the sustainability of elephant populations in Southeast Asia. Action plans were discussed, focusing on the need for more comprehensive data sharing, enhanced capacity building for enforcement agencies, and continued awareness-raising about the illegal wildlife trade. Countries were encouraged to implement stronger national policies and integrate elephant conservation into broader environmental and wildlife protection agendas.

Recommendations

The meeting concluded with several key recommendations:

- Strengthening MIKE implementation: Expand MIKE monitoring across the region and address data inconsistencies.
- Improved enforcement: Enhance law enforcement efforts and strengthen cross-border collaboration to curb illegal wildlife trade.
- CITES compliance: Strengthen the implementation of CITES regulations, focusing on the prevention of illegal trade in Asian elephants and elephant products.
- Capacity building: Provide targeted training for local authorities on elephant conservation and monitoring the illegal killing of elephants.

Conclusion

The CITES MIKE South-East Asia Sub-Regional Meeting and CITES Trade in Asian Elephants Workshop were a significant step forward in the region's efforts to protect the Asian elephant and combat the illegal trade in elephant products. The collaborative approach, strengthened by shared knowledge and resources, holds the potential to address the pressing conservation challenges faced by elephants in Southeast Asia. Continued regional cooperation, improved enforcement mechanisms, and a focus on capacity building will be crucial in ensuring the long-term survival of the species in the wild.

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Report on the Side Event of the IUCN SSC AsESG at the CMS CoP14

Prajna P. Panda

Office of the Chair, Asian Elephant Specialist Group, Noida, India
Author's e-mail: prajna@wti.org.in

Deforestation, linear infrastructure and poor connectivity across boundaries has resulted in elephants residing in small, fragmented pockets and elevating the risk of human-elephant conflict. To protect Asian and African elephants, the elephant range countries must protect and restore ecological connectivity between elephant habitats and accelerate transboundary conservation through international cooperation.

Addressing this concern, the IUCN SSC Asian Elephant Specialist Group (AsESG) in collaboration with IFAW organised a side event at the "Fourteenth Meeting of the Conference of the Parties to the Convention on the Conservation of Migratory Species of Wild Animals" (CMS COP14) held in Samarkand, Uzbekistan. The side event "Room to Roam for Elephants: Conservation and Connectivity in Africa and Asia" took place on 15th February 2024 involving three elephant range countries, i.e. India, South Africa and Malawi, to deliberate on promoting transboundary cooperation and protection for long – range movement of elephants. This was a step to address one of the nine targets outlined in the Kathmandu Declaration signed by all Asian elephant range countries in 2022 to "Develop bilateral transboundary agreements, protocols, or understandings in relevant countries to ease movement of Asian elephants through appropriate corridors and transboundary protected areas".

The African Elephant Action Plan also highlights the need to establish fora for exchanging information between and among range states for better monitoring of transboundary movements of elephants and outlines the critical need for transboundary movement.

Taking the way forward, the side event brought together the Asian and African range countries and discussed on ways to protect, restore and connect elephant habitats locally, regionally and continentally to facilitate unhindered elephant movement, increase genetic diversity and help in meeting the 30% conservation target of the "Kunming-Montreal Global Biodiversity Framework". IUCN SSC AsESG also discussed on the upcoming handbook on "Mitigation for Roads and Railways in Asian Elephant Landscapes" being developed in collaboration with the Connectivity SG.

The session achieved its objectives in highlighting the importance of connectivity for large mammals such as elephants. The discussions shall foster synergistic efforts, transboundary agreements and collaborative partnerships to work together to ensure unhindered movement of elephants across boundaries, both national and international. This also facilitated the elephant range countries in understanding the need to adopt site specific wildlife friendly linear infrastructures that could eventually lead to reduced human-elephant conflict and shall help in fostering coexistence between humans and elephants in the long run.

The side event was well-attended and received positive feedback from range countries and institutions and organisations working on connectivity of mammals across landscapes.

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Obituary

Memories of Richard Lair (25.9.1942 – 19.7.2024)

Janine L. Brown

Center for Species Survival, Smithsonian's National Zoo & Conservation Biology Institute, Front Royal, VA, USA
Author's e-mail: brownjan@si.edu

Richard Lair, artist, award-winning filmmaker, and distinguished figure in the world of Asian elephant conservation, passed away peacefully on July 19, 2024, at his home in Lampang, Thailand. He was 81 years old.

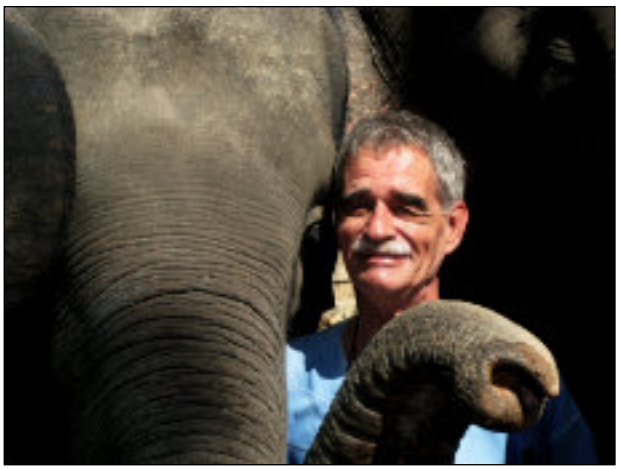
I don't have a clear memory of when I first met Richard. Perhaps that is because he had such a big presence in Thailand long before my first trip in 2000 to study elephant sperm that I felt I knew him already. But, when we did finally meet, there was an instant familiarity, as if I had known him for decades. Known affectionately as Professor Chang, he became fluent in Thai and was deeply integrated into Thai culture. His life was a testament to the profound impact one person can have on the world when they follow their passion with unwavering dedication. And he had an impact on me. I still remember how thrilled I was to receive my copy of Gone Astray from the Food and Agriculture Organization of the United Nations (FAO) office in Bangkok. People call it the elephant bible, and it taught me a lot about the challenges facing "captive" or "tamed" elephants - not "domesticated" as Richard would explain – throughout Asia. To me, he was always larger than life. Visiting him in Lampang during my frequent trips to Thailand to work with elephant veterinary colleagues was always insightful, and I so appreciated how a major focus of his life's work was on improving not just the lives of the elephants but their mahouts as well. He was a pragmatist and understood that the welfare of mahouts was directly related to the welfare of elephants. When he became ill earlier this year (an unresolved issue with an abdominal hernia that became inoperable), I was in Thailand. He knew his time was limited, but in true Richard style, he didn't dwell on that. He had a scientific brain and so wanted to know about the biology of dying – what would happen when he could no longer take in solid food, should he take supplements and which ones, and how long would his already frail body last? He wanted a scientist's point of view. Curious to the end. He was clear, however, that he would not give up his whiskey and cigarettes. I miss those calls and texts.

Born in Lompoc, California, in 1942, he was among the many children who contracted polio before its eradication in the early 1950s. During his recovery, he became an avid reader, devouring a book a day on various topics. His fascination with elephants was apparent from early childhood as he filled countless notebooks with sketches and read as much as he could about them. Richard would later dedicate his life to preserving and understanding Asian elephants, but not until after a successful career in filmmaking. Some might not know it, but Richard had multifaceted talents and diverse interests that extended far beyond his renowned work with elephants, embodying the essence of a modern-day polymath. His wide-ranging expertise and accomplishments across various fields exemplified the spirit of a true Renaissance man.

Richard started as an art major at San Francisco State College in the late 1960s but soon transferred to the film department, where he developed his filmmaking skills. Being a California girl, I found it interesting that he produced films for the psychedelic scene in San Francisco during the 1967 "Summer of Love." In the early 1970s, he produced the wildlife documentary "Where Will They Go?", addressing en-

dangered species in California with a foresighted message that is eerily relevant today (https://www.youtube.com/watch?v=Ry33Dg1NErI). His filmmaking talents earned him accolades, including work on award-winning projects such as "The Taiwan Experience" for the 1974 World's Fair and "Welcome to Washington" for the National Park Service in 1976. His documentary "Alice Elliott," focusing on one of the last Pomo Indian basket makers (https://www.youtube.com/watch?v=54PMM-FChxw), won the prestigious CINE Golden Eagle Award in 1975.

In 1973, he travelled to India to photograph and learn more about Asian elephants, and then in 1977, he spent a year working with elephants at Marine World in Redwood City, California. But then, seeking a change from the fast-paced American lifestyle and with an increasing fascination with elephants, Richard moved to Thailand, where he found his true calling. He initially spent years in the forest counting elephants before moving on to issues related to captive elephants. Logging had been the primary source of income for elephants and their keepers (i.e., mahouts) in Thailand, but after it was banned in 1989 due to environmental destruction caused by deforestation, the livelihood of elephants and mahouts was threatened. Many out-of-work elephants and their mahouts found their way into the tourist industry, where today, about 3,500 work by providing rides, participating in shows, or just being observed. Not surprisingly, the management of these animals was varied and inconsistent, and he recognised the need to improve their welfare. In 1991, he became a consultant to the



Richard Lair (photo credit Galen Garwood)

Thai Elephant Conservation Center (TECC) and quickly became a leading voice in elephant care and management. A skilled writer, Lair wrote the master plan for the TECC. He played a crucial role in establishing Thailand's first school for mahouts, bridging traditional wisdom and training skills from Burmese mahouts with modern veterinary and husbandry practices. Today, the TECC remains a beacon of hope for elephant conservation, veterinary medicine, and research.

Richard was an innovator and jumped at opportunities to highlight the uniqueness and intelligence of elephants. He consulted and trained elephants for "Operation Dumbo Drop" in 1995, a movie based on an attempt to transport an elephant through the jungle to a south Vietnamese village to help American forces monitor Viet Cong activity. It dealt broadly with the themes of war and politics, as well as animal welfare. During production of the 1984 film, "The Killing Fields," Richard crossed paths with storyteller Spalding Gray, which left an impression that was memorialised in the book and film, "Swimming to Cambodia.". Gray wrote "I was so bored that I began talking to the driver – an extra. He was an expatriate from San Francisco, an elephant expert, who was spending his time counting elephants in the Thai jungle because he thought, 'America is going crazy. Going nuts, going to the dogs. Going to the wow-wows.' He went to Thailand to get his sanity back, and in Thailand he only trusted elephants. So they were all he was interested in. He slept in the bush at night and in the morning he got up, grabbed his elephant counter and just counted elephants." That sums up Richard.

In 1997, he teamed with Russian-American artists Vitaly Komar and Alex Melamid to start an "Elephant Art Academy" at the TECC, providing opportunities for elephants to paint while increasing awareness of the plight of elephants in Asia. Partnering with the World Wildlife Fund and prestigious auction houses like Christie's, the effort raised funds for elephant conservation. However, perhaps Richard's most endearing contribution was co-creating the Thai Elephant Orchestra in 2000 at the TECC with American musician and Columbia University neuroscientist Dave Soldier. Together, they de-

veloped over twenty elephant-ergonomic instruments tailored to the musical styles of northern Thailand, resulting in three CDs of improvised music recorded at the TECC. The elephants often played spontaneously and used the activity as a social event. Importantly, the orchestra demonstrated that a non-human species could create beautiful instrumental music. Orchestral improvisations by the elephants have even been arranged for human musicians, including Steven Beck and the Composer's Concordance Orchestra. While the Thai Elephant Orchestra no longer performs, it was the subject of a documentary by the British Thai filmmaker Paul Spurrier and profiled by many press outlets, including the BBC, The Economist, the New York Times, and the Bangkok Post. The orchestra's performances touched the hearts of audiences globally, changing perceptions about elephant intelligence and creativity.

As an author, Richard's books have become essential reading for anyone working in elephant conservation. As I said, his seminal work, "Gone Astray: The Care and Management of the Asian Elephant in Domesticity," published in 1997, is regarded as the definitive book on elephant care and conservation, carrying the imprimatur of the United Nations FAO. Richard's dedication to elephant welfare also led to his conception and co-authorship of the "Elephant Care Manual for Mahouts and Camp Managers," published in 2005 in Thai and English. The book, written for mahouts and camp managers, provides information on elephant diseases, hygiene, and biology and has been widely distributed throughout Thailand. His writing style, both informative and engaging, made complex elephant biology and conservation issues accessible to a broader audience. As a translator, he also brought important cultural works to the English-speaking world, including Nikom Rayawa's, "High Banks, Heavy Logs," a poignant tale of cultural change involving elephants, and "Sihanouk Reminisces," along with many Thailand travel guides. Richard was a perfectionist, especially in his writing. As Dave Soldier recalled, 'he would take months fretting about commas, and it took him over a year to edit one page of the introduction to the orchestra piece.' I suspect he would find many flaws in this eulogy – sorry Richard.

Richard's contributions to research conducted at the TECC were notable. For example, the "running index" describes the mechanics of running, and while it was known that elephants could be extraordinarily fast, their manner of locomotion was unknown. In a 2003 paper in Nature, Lair and coauthor John Hutchinson reported that for short periods of time, their speed reached 15.5 miles per hour, and they exhibited a gait that qualified as running. Joshua Plotnik, a comparative psychologist, collaborated with Richard on the first experimental study of elephant cooperation, finding that elephants not only understand how cooperation works, but that partner behaviour contributes to its success. In 2016, Veterinarians International president Scarlett Magda bestowed upon Richard a Lifetime Achievement Award in acknowledgment of his commitment to enhancing our understanding of Asian elephants and their welfare. Richard's final and unfinished project is "EyeD," a deep learning software application that would allow individual elephants to be identified by photos of the distinctive wrinkle patterns around their eyes: if and when completed, using his voluminous photos of elephant eyes for training, it will provide a fitting completion to the circle of his life's passion. Richard's legacy lives on in the countless lives he touched – human and elephant. He mentored mahouts, researchers, and conservationists, sharing his vast knowledge and infectious passion for elephants. While to the uninitiated, he could appear gruff and even curmudgeonly at times, he is most remembered as a patient teacher to those who want to learn, always ready with a witty remark or a fascinating anecdote. He was known for bridging cultural gaps and earning the respect of local Thai communities and international conservationists alike. His work inspired a new generation of conservationists and changed how we understand and interact with elephants. As we bid farewell to Richard, we celebrate a life of purpose and passion. His impact on elephant conservation will be felt for generations to come, a fitting tribute to a man who dedicated his life to these magnificent creatures. Richard is survived by his brothers Jim and Mike, and his longtime partner Boonpeng Khantong (Noi). He will be deeply missed by the global elephant community and all who knew him, including me.

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News and Briefs
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Comprehensive Guidelines for Elephant Crossing Structures: Insights from the Handbook to Mitigate the Impacts of Roads and Railways on Asian Elephants

Norris Dodd, Melissa Butynski*, Rob Ament, Shu Chen, Nilanga Jayasinghe, Jia Cherng Lim, Salman Saaban, Sandeep Kumar Tiwari, Rodney van der Ree, Yun Wang and Ee Phin Wong

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

Introduction and context

The expansion of linear transportation infrastructure (LTI) across Asia continues to challenge the conservation of Asian elephants (*Elephas maximus*), an endangered keystone species. Roads, railways, and canals fragment habitats, impede movement, and increase human-elephant conflicts.

To address the impacts of LTI, the Asian Elephant Transport Working Group (AsETWG) was formed. The AsETWG is a collaboration between the IUCN World Commission on Protected Areas' Connectivity Conservation Specialist Group (CCSG) and the IUCN Species Survival Commission's Asian Elephant Specialist Group (AsESG). Its mission is to serve as the hub of expertise and technical support to deliver practical, science-based solutions that avoid and mitigate threats to Asian elephants posed by LTI across all 13 range states. In 2024, the AsETWG released the "Handbook to Mitigate the Impacts of Roads and Railways on Asian Elephants", a detailed guide focusing on specific mitigation strategies and best practices for elephant crossing structures (Fig. 1).

Building on the 2021 publication, "Protecting Asian Elephants from Linear Transport Infrastructure, the AsETWG's Introduction to the Challenges and Solutions" (Ament *et al*. 2021), the new handbook offers elephant-specific mitigation measures to address the negative impacts of LTI, including nuanced design and site selection criteria for wildlife crossing structures to ensure safe, effective passage for elephants.

With the projected expansion of LTI across Asia, even with concerted efforts to avoid high-biodiversity areas, effective mitigation measures will be critical to reduce project impacts and prevent further habitat degradation for Asian elephants. The handbook aims to foster the application of effective mitigation measures, specifically crossing structures.

Best practice guidelines for elephant crossing structures

The AsETWG aims to establish a consistent nomenclature for Asian elephant wildlife crossing structures, especially with the diversity of names used for structures (e.g., flyovers,

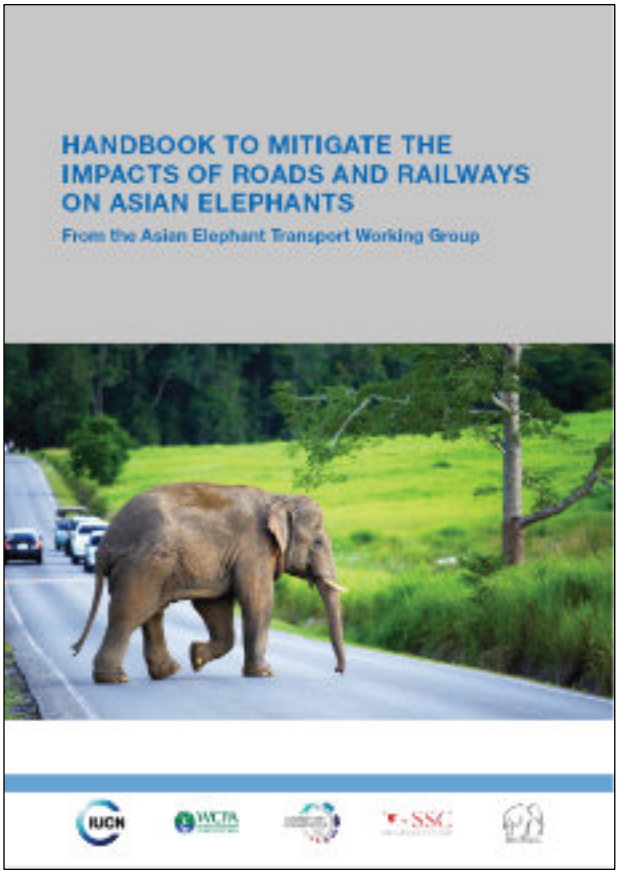

Figure 1. The cover of the second publication by the IUCN's AsETWG.

ecoducts, wildlife bridges, etc.) design types and applications. Wildlife crossing structures are classified as underpasses providing below-LTI-grade passage or overpasses that provide above-LTI-grade passage (Clevenger & Huijser 2011; Smith *et al*. 2015). Each passage type has a range of applications, design variations, and preferences in use by various wildlife taxa (Clevenger & Huijser 2011; van der Ree *et al*. 2015).

Underpasses

Minor bridge underpasses are girder bridges, typically less than 30 m wide, and include arch structures and large reinforced concrete box culverts (RCBC). Though they are often designed for wildlife passage, they may also function as dual-use drainage structures. They are most effective when constructed along established travel corridors within drainages (Pan *et al*., 2009).

Major bridge underpasses are wider, often multi-span bridges with spans exceeding 30 m but less than 120 m. They are often designed explicitly for elephant and other wildlife passage but may also span rivers, streams, and wetland areas. Their large size makes them especially effective as crossing structures for Asian elephants and other wildlife.

Long-span bridges are structures with spans exceeding 120 m that typically span rivers. Typically, they are not designed for wildlife passage. However, their size allows them to accommodate elephant use alongside river and stream areas, especially where dense vegetation exists and passage is not blocked by steep terrain or obstructions. In addition to creating 10–12 m wide flat, obstruction-free passage lanes adjacent to bridge abutments, minimum bridge heights should follow those in Table 2.

Viaducts typically are not designed specifically for wildlife passage (Clevenger & Huijser 2011), but the sensitive habitats they protect allow for the maintenance of wildlife movement and adjacent habitats. As such, they are highly effective wildlife passages due to their large size, high clearance, and the degree of openness they afford for approaching and crossing animals. The AsETWG recommends a 10 m clearance height to ensure effectiveness for passing elephants.

Table 1. AsETWG sliding-scale guidelines for minor bridge underpasses up to 30 m in width by underpass length across LTI.

Underpass	Minimum underpass dimensions		
Length (m)	Width (m)	Height (m)	Openness index
≤10	12.0	6.0	7.2
11 – 20	15.0	6.5	4.9 – 8.9
>20	20.0	7.0	4.7 – 6.7

Flyovers are extended (up to 10 km), elevated roadways passing over a variety of habitats. Increasingly used in India and now proposed in Nepal, these structures are specifically designed and constructed for elephant and tiger passage within protected areas. Both flyovers and viaducts provide animals with many crossing options and do not require costly wildlife funnel fencing to be effective. The AsETWG recommends a 10 m clearance height to ensure effectiveness for passing elephants.

Overpasses

Bridged (engineered) overpasses include girder, arch, and RCBC structures designed for wildlife passage and linking ridgeline travel corridors at cut slopes and embankment areas. Recognising that overpass widths should reflect the span length over which they cross LTI, the AsETWG guidelines provide a sliding scale of minimum overpass widths based on three classes of total overpass length, including landscaped approach slopes (Table 3). For narrow 2-lane highways or railways with total overpass lengths less than 60 m, a minimum 50 m width is acceptable; wider overpasses are recommended for longer lengths over LTI (Table 3).

Table 2. AsETWG sliding-scale guidelines for bridged underpasses up to 30 m in width by underpass length across LTI.

Underpass	Minimum underpass dimensions	
Length (m)	Width (m)	Height (m)
<20	30	6.5
>20	30	7.0

Table 3. Sliding-scale guidelines for engineered overpasses by total overpass length across LTI, including landscaped approach slopes.

Overpass length including approach slopes (m)	Minimum overpass width (m)	Width : length ratio
≤60	50	≥0.83
61 – 80	60	≥0.75
<80	70	≥0.88

The AsETWG feels that 1 m high side walls with durable fencing/barrier above are adequate to guide elephants across sufficiently wide overpasses. Other treatments, including earthen berms, trees or similar vegetation (e.g., bamboo) established along overpass edges, can provide more cost-effective and environmentally sensitive options to limit noise and light disturbance from LTI below. The full revegetation of overpasses with native vegetation is strongly recommended, and thus sufficient (1 m or deeper) soil depth is needed atop structures to establish vegetation effectively.

Natural overpasses are tunnels through mountainsides and ridges through which vehicles or trains pass. In China, natural overpasses (up to 765 m long) have been created by tunnelling, allowing elephants to pass over highways through undisturbed habitats. Though costly to excavate, natural overpasses can provide superior (Wang *et al*. 2015) passage for Asian elephants as they maintain natural ecological connectivity and vegetation without impact or disruption. Based on China's experience, natural overpasses should be constructed in areas not subject to human disturbances (homes and other buildings) that limit effective use.

Methodologies for Asian elephant crossing structure site selections

Identifying suitable sites for Asian elephant crossing structures is pivotal in ensuring their efficacy. The Handbook emphasises a multi-faceted approach integrating ecological data, field observations, and advanced technologies. One primary method involves aligning crossing structure placement with regional and national connectivity plans, which map key habitats and movement corridors based on ecological studies and stakeholder input. These plans provide a foundational framework to ensure that interventions support existing movement patterns and do not create new barriers.

Field-based sign surveys remain a crucial tool, particularly in remote or data-deficient areas. These surveys identify movement corridors through physical evidence, such as tracks, dung, and feeding marks, which indicate frequently used pathways. Camera traps further supplement these efforts by capturing real-time data on elephant activity, offering insights into the frequency and timing of crossings as well as herd composition. Advances in technology, particularly the use of GPS telemetry, have revolutionised site selection by enabling precise tracking of elephant movements across fragmented landscapes. These data help identify critical bottlenecks where infrastructure intersects established routes, providing a basis for evidence-driven mitigation.

Historical data on vehicle- and train-related elephant collisions offer another critical layer of information. Collision hotspots often align with high-use habitat corridors where barriers such as roads and railways present acute risks. Targeting these areas for crossing structures can significantly reduce mortality.

Role of fencing in promoting effective elephant crossing structures

The Handbook emphasises the importance of integrating fencing with wildlife crossings to ensure their functionality and reduce mortality rates. By physically preventing elephants from accessing dangerous roadways or railway tracks, fencing funnels animals toward safe crossing points, increasing the likelihood of their use. This approach not only safeguards elephants but also reduces the risk of vehicle collisions, protecting human lives and property.

The design and implementation of fencing require careful consideration of both ecological and engineering factors. Fencing must be robust enough to withstand elephant interactions, as their size and strength often make traditional

fencing ineffective. Reinforced materials, such as welded tube metal or concrete barriers, are recommended, with designs tailored to specific landscapes and infrastructure types. Additionally, fencing should extend far enough along the LTI to prevent elephants from circumventing it, which could compromise its utility. Post-construction monitoring of fencing systems is essential to identify weaknesses, ensure maintenance, and adapt designs based on observed elephant behaviour.

Non-structural mitigation approaches

Non-structural mitigation approaches are complementary measures to structural interventions for reducing the impacts of LTI on Asian elephants. These approaches are designed to modify human behaviours and improve the safety of both elephants and humans. They are particularly useful in areas where structural mitigation may be infeasible or insufficient. Motorist alert systems, including signage and flashing lights, warn drivers of potential elephant crossings and are intended to modify driver behaviour through reduced vehicular speed and increased alertness. Traffic calming measures, such as speed bumps or rumble strips, are another effective strategy to reduce vehicle speed and improve driver reaction time in high-risk zones, decreasing the likelihood of a collision with animals on or approaching the road. When traffic calming measures are integrated with effective signage within designated (place-specific) high-incidence elephant crossing zones, they have the potential to be quite effective, but more studies are needed.

Technological innovations, such as thermal imaging cameras and real-time warning systems, represent another promising avenue for non-structural mitigation. These systems can detect elephants near railways or highways and relay alerts to train operators or motorists, providing critical time to prevent collisions. Additionally, scheduling train and traffic operations to avoid peak elephant activity periods, such as nighttime or crop harvesting seasons, has proven effective in reducing train-elephant collisions in some regions.

Citation

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AsETWG (Asian Elephant Transport Working Group); IUCN WCPA Connectivity Conservation Specialist Group/IUCN SSC Asian Elephant Specialist Group.
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Book Review

Composing Worlds with Elephants

Deepak Bhat Dundi

Nature Conservation Foundation, Mysore, India
Author's e-mail: deepak.280bhat@gmail.com

While reading the book "*Composing Worlds with Elephants. Interdisciplinary Dialogues*" (edited by Nicolas Lainé, Paul G. Keil and Khatijah Rahmat) I remembered a story narrated by the Jenu Kuruba Adivasi people of Karnataka, who have lived with elephants for hundreds of years. According to the story, certain people control and tame elephants through special powers, but when they lose these powers, the elephants turn wild and may attack or kill them. This story echoes some of the main themes of the book, which challenges the dichotomy between wild and domestic and between nature and culture.

The book originated from an online conference on human-elephant interactions held in 2020. The chapters offer fresh insights into the entangled worlds of humans and elephants and look beyond the dominant frames of conservation biology and ecology. Although most contributors are trained in specific disciplines such as anthropology, biology, ethology, history, architecture, and geography, some integrate insights from other fields and use novel research methods.

The book is divided into four sections. An interesting aspect is that each section, except Section 4, contains an essay exploring elephant-related art. An essay by Shubhra Nayar and Paul G. Keil presents a comprehensive analysis of the Lantana Elephants Project. An article by Philippe Coste focuses on the author's experiences of photographing elephants and mahouts in Laos. Deborah Schrijvers provides a rich explanation of Carlos Casas' film Cemetery. As argued by the editors, the texts and images in the book enable readers to see human-elephant relationships beyond an academic lens, and I agree with this perspective. When I witnessed the lantana elephants in Bangalore city, the combination of elephants, invasive lantana, and the urban backdrop prompted me to reflect on human-elephant relationships in the light of planetary change.

The first section explores the relationship between wild elephants and humans who share space. The initial chapters by Sayan Banerjee and Anindya Sinha examine human-elephant interactions through the lenses of political ecology and gender. As "the terms 'human-elephant conflict' or 'habitat loss' do not adequately conjure the daily experiences of farmers and elephants in high-conflict regions" (p. 50), Chapter 2 by Elizabeth Oriel and Toni Frohoff examines farmers' experiences to explore affective ecologies of human-elephant relations. Chapter 3 by Nishant M. Srinivasaiah and Anindya Sinha, and Chapter 4 by Lauren A. Evans and Redempta Njeri Nduguta, provide fascinating accounts of the personalities of individual Asian (India) and African (Kenya) elephants. They were identified and observed using various techniques over a long period.

The following two sections shift focus to the relationship between mahouts and captive elephants in South and Southeast Asia. One of the significant features of these sections is that many of the chapters highlight how the relationship between mahouts and elephants is characterised more by mutual trust and collaboration than by control and dominance. The historian Thomas R. Trautmann (Chapter 5) examines the role of forest people in the capture and training of wild elephants in the Indian subcontinent by drawing from history and present-day ethnography. In Chapter 6, Srikumar M. Menon and

Anindya Sinha provide a detailed account of elephant depictions in the old Buddhist stupa of Kanaganahalli, Karnataka. The elephant sculptures of this ancient stupa provide important insights into human-elephant relationships during the second and third centuries CE. Teckwyn Lim (Chapter 7) investigates the origins of elephant culture in Asia through a phylogenetic analysis of elephant command lexicons. Jacob Shell (Chapter 8) reflects on the future of Asian elephants and mahouts in the context of rapid human population growth, utilising the concept of 'ecumenopolis'.

An insightful ethnographic study by Nicolas Lainé (Chapter 9) reveals that mahouts in Laos regard elephants as co-producers of knowledge. Mahouts incorporate the knowledge of elephants, particularly regarding medicinal plants and biodiversity, to benefit both species. In Chapter 10, Sreedhar Vijayakrishnan and Anindya Sinha provide a fascinating account of the relationship between captive elephants and mahouts from two South Indian communities, the Malasar and Malayali, comparing their elephant management practices. They also create a dialogue between the past and present of captive elephants and mahouts by utilising ethnographic observations and the ancient elephant treatise Mātangalīla.

An article by Jennifer Crawley (Chapter 11) examines factors influencing mahout-elephant relationships across Asia. She argues that the 'mahout profession is threatened by low socio-economic status and diminishing knowledge and experience in elephant handling' (p. 218). She recommends more systematic studies to document how these changes impact the welfare of both mahouts and captive elephants. Paul Keil (Chapter 12) examines the phenomenon of musth through a multispecies lens, analysing its physiological, behavioural, and cultural aspects to explain why it is a 'biosocial' event.

Since the final section of *Composing Worlds with Elephants* closely relates to my own concerns and experiences, I found it very interesting. As a conservation practitioner who works on human-elephant interactions, I have often encountered the limitations of methods and theories in both the social and natural sciences while exploring the complexities of interspecies interactions. The chapters in this section offer detailed discussions on the necessity of an interdisciplinary approach to understanding elephants and humans in shared landscapes. Additionally, they explore the inherent challenges involved in bringing together various disciplines in elephant research. In Chapter 14, Anandi Gandhi employs multiple methods to study coexistence between elephants and farmers in Thailand. Chapter 15, authored by Tarsh Thekaekara, addresses the tensions that emerge when integrating natural and social science in the study of elephant behaviour in hybrid landscapes. A very insightful article by Hannah S. Mumby (Chapter 16) examines the possibility of incorporating the human dimension into elephant behavioural ecology research. In Chapter 13, Khatijah Rahmat uses "multi-temporality" to explore how elephants are conceptualised in various knowledge traditions.

One significant limitation of the book is that only one chapter is dedicated to African elephants. Furthermore, I believe a more in-depth exploration of role technological interventions in human-elephant coexistence could add greater diversity to the book.

Although the book explores diverse aspects of human-elephant relationships, I think the main question it seeks to address is how to live well with elephants in a rapidly changing world. It is undoubtedly an important resource for envisioning innovative approaches to human-elephant coexistence. The book provides valuable insights for conservationists, wildlife scientists, and anyone interested in the complexities of human-animal and human-nature interactions.

Citation

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News and Briefs
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Recent Publications on Asian Elephants

Compiled by Susan Mikota[1]* and Jennifer Pastorini[2,3]

[1]*Elephant Care International, Hohenwald, TN, USA*
[2]*Department of Evolutionary Anthropology, University of Zürich, Zürich, Switzerland*
[3]*Centre for Conservation and Research, Tissamaharama, Sri Lanka*
**Corresponding author's e-mail: smikota@elephantcare.org*

If you need additional information on any of the articles, please feel free to contact us. You can also let us know about new (2025) publications on Asian elephants.

A. Abdelgawad, M. Nascimento, A. Prahl, M. Fluegger, C.A. Szentiks, S. Holtze, T.B. Hildebrandt & J. Trimpert

Fatal infection caused by a genetically distinct elephant endotheliotropic herpesvirus type 5 in a captive Asian elephant in Germany

Virology Journal 21(2024) e221

Abstract. Elephant endotheliotropic herpesvirus (EEHV) infection is the most common cause for lethal hemorrhagic disease in captive juvenile Asian elephants. Although EEHV1 is known as the most likely cause of fatal haemorrhagic disease in Asian elephants, EEHV5 was lately involved in lethal cases of haemorrhagic disease in captive elephants. Here we report the first death of a four-year old Asian elephant diagnosed with EEHV5 in Germany. Molecular diagnosis yielded detection of EEHV5 DNA in all tested tissues. Histopathological examination revealed typical features of hemorrhagic disease in all examined organs. EEHV5 was sequenced from total DNA isolated from heart tissue by Illumina and Nanopore sequencing. Sequencing data showed 3,881 variants, distributed across the entire genome, compared to the published EEHV5 sequence. We have detected EEHV5 in a fatal disease case of a male Asian elephant. Whole genome sequencing revealed substantial differences of our DNA isolate compared to available EEHV5 sequences. This report of fatal haemorrhagic disease associated with EEHV5 infection should raise awareness for EEHV5 as an important elephant pathogen. Genome sequencing and downstream SNPs analysis will further encourage future research to understand genetic diversity, pathogenesis and virulence of EEHVs with respect to developing new diagnostic methods, prophylactic strategies, and implementation of surveillance and control measures.

D. Abraham, P.M. Deepa, C. Purnima, K.C. Bipin, C.V. Rajani, K. Vijayakumar & T.V. Anilkumar

Histomorphological features of pulmonary tuberculosis in Asian elephants (*Elephas maximus*)

Journal of Veterinary and Animal Sciences 55 (2024) 661-663

Abstract. Tuberculosis in Asian elephants usually shows involvement of lungs and associated lymph nodes. Grossly, the affected lobes of lungs reveal circumscribed lesions of varying sizes with central areas of caseation and necrosis. This report documents histomorphological features of pulmonary tuberculosis in six Asian elephants. The important cell types present were lymphocytes, foamy macrophages, epithelioid macrophages and Langhan's type of giant cells. In addition, caseation necrosis, fibrotic capsule, and mineralisation (calcification) were also observed. Characteristic features of tuberculoid granulomas observed in the six cases showed similarities with other species. The six cases showed varying proportions of the seven defined features but all features were present together only in one case.

S. Ann Jose, K.B. Thiyagarajan, S. Ganesan, B.A. Chandrasekaran, C. Baskar, R. Singh, D.V. Kumari, M.G. Ganesan & A. Udhayan

Development of FTIR spectral library for the identification of Asian elephant ivory: An

innovative approach in wildlife forensics
Discover Applied Sciences 6 (2024) e 586
Abstract. The illegal ivory trade remains a prime threat to elephant populations. Identification of ivory is crucial for combating illicit ivory trading. Studies have demonstrated that FTIR spectroscopy is one of the most suitable techniques for identifying ivory and its products. However, this technique could not have been fully utilized due to the lack of a reference IR spectral library/database. In light of this, the present study aimed to develop the FTIR spectral library for Asian elephant ivory. We collected eight Asian elephant ivory (n = 8) samples from our institute repository and recorded the FTIR spectrum. Further, based on the biochemical composition of ivory, we identified various characteristics, functional groups, and their respective wavenumbers. Furthermore, we used the FTIR spectrum of Asian elephant ivory as a reference to identify the fifteen carvings (n = 15) suspected to be of Asian elephant ivory. The results revealed that samples 1-13 are visibly identical to the FTIR spectrum of Asian elephant ivory; in contrast, samples 14 and 15 do not match the FTIR spectrum of Asian elephant ivory. Hence, it is confirmed that out of fifteen samples, thirteen are likely to be of Asian elephant ivory origin. To confirm this finding, we employed the PLS-DA analysis. The result showed an R Square value of 0.9 for calibration and 0.75 for validation, and the model exhibited 100% accuracy in classifying the original and fake ivory samples. The results confirmed that FTIR combined with chemometrics analysis was useful for identifying ivory and fake materials. To validate the FTIR results, we extracted the DNA from suspected samples 1-15 and amplified elephant-specific D-loop and Sry (sex-determining region on the Y chromosome) genes. Subsequently, the PCR amplicons were examined on a 2.5% agarose gel and observed for samples 1-13, one band at 137 bp (for D-loop) and another at 97 bp (for Sry). These results indicated that samples 1-13 are of elephant origin, whereas samples 14 and 15 are not of elephant origin. To confirm this finding, the PCR amplicons (D-loop) from nine samples (1-9) were sequenced, and % similarity was analyzed. The results showed 96.6 to 100% similarity to the *Mammuthus primigenius*, *Elephas maximus indicus*, and *Loxodonta africana*. The primers (D-loop and Sry) used in this study are elephant-specific and do not distinguish the elephant species. Overall, DNA-based results supported the results from FTIR analysis and confirmed that the suspected samples 1-13 are of elephant origin and 14 and 15 are not of elephant origin. The current study has demonstrated the identification of ivory substitutes through FTIR spectral library for Asian elephant ivory, which is rapid, cost-effective, and has excellent potential for forensic analysis. The FTIR spectral library was developed for Asian elephant ivory. The suspected elephant carvings were identified using the FTIR spectral library of Asian elephant ivory. The FTIR results were confirmed through PCR amplification of elephant-specific D-loop and Sry genes.

S. Banerjee, D. Nayak & A. Sinha
Adivasi (Tea Tribe) worldviews of living close to wild Asian elephants in Assam, India
Conservation Biology 38 (2024) e14397
Abstract. In Assam state, northeastern India, human-elephant conflict mitigation has included technocentric measures, such as installation of barriers, alternative livelihoods, and afforestation. Such measures treat conflict as a technical problem with linear cause-effect relations and are usually ineffective over the long term because they do not consider how historical conditions have shaped present interactions between humans and elephants. Human-elephant encounters in South Asia, including in Assam, have arisen from colonial and postcolonial land-use policies, ethnic relations, and capital extraction. To disentangle these relations, we conducted ethnographic fieldwork in Udalguri district of Assam among the Adivasi (Tea Tribe) to examine their interactions with wild elephants. Through socioecological ruptures, caused by displacement and deforestation, Adivasi (Tea Tribe) and elephant lives have intersected through space and time. Adivasi (Tea Tribe) life narratives and observations of daily encounters with elephants revealed that their interactions are multifaceted and motivated by multiple factors. Myths and oral testimonies revealed that the community has created conceptualizations of the elephant by closely observing their behavior, especially their movements, diets, vocalizations, and interactions with hu-

mans. These conceptualizations are filled with vignettes of shared marginalized lives, caused by the loss of homeland, food poverty, and uncertain ways of living. The empathy, expressed by the Adivasi (Tea Tribe), highlights ways of living with elephants that are affective and reach beyond technocentric interventions. For Adivasi (Tea Tribe) members, cohabitation could thus be achieved by living close to elephants as uneasy neighbors. Concepts of cohabitation, we suggest, could be harnessed to inform conservation policy and bring into focus the critically important-and yet often underutilized-values, encompassed by bottom-up, place-centric understandings of what elephants are and how coexistence may be possible in increasingly anthropogenic landscapes.

K. Berliani, P. Patana, W. Azmi, N.S.M. Manullang & C. Gozali

Identification and chemical composition analysis of salt licks used by Sumatran elephants *Elephas maximus sumatranus* in Tangkahan, Indonesia

J. of Threatened Taxa 16 (2024) 25639-25790

Abstract. A crucial aspect of successful conservation strategies is the identification of critical aspects of local habitats required for species preservation in a given region, such as salt licks. Tangkahan is adjacent to the Gunung Leuser National Park in North Sumatra, Indonesia. The park collaborates with the Indonesia Conservation Response Unit using captive Sumatran elephants for forest patrols, mitigation of human-elephant negative interactions, public education, and ecotourism in the area. An initial study on the daily activities of captive Sumatran elephants revealed their search for salt licks, which are essential for maintaining their optimal daily sodium intake. Information on salt licks in Tangkahan is limited and deserves further investigation. Ethical clearance is deemed unnecessary, as the research employs a non-invasive approach, exclusively observing the natural behaviors, and daily activities of elephants. The well-being of the elephants takes precedence over invasive technologies, with continuous monitoring ensuring their care throughout the research process. The study utilizes a descriptive-analytic methodology, tracking the daily movements of Sumatran Elephants to identify the locations of salt licks in the area. Four salt licks-Encepan-1, Encepan-2, Namo Cencen, and Hot Spring-were identified by participating in the elephants' territorial exploration. Although the salt licks were located adjacently, Encepan-1 was most frequently visited by the elephants. The salt licks were characterized as waterholes containing Na+ (sodium ion) rich waters from springs. However, according to the atomic absorption spectrophotometry method, the sodium concentration in these salt licks ranged 34-55 ppm, which is estimated to be insufficient for the physiological requirements of the elephants. Therefore, further investigations are needed to explore other complementary salt licks and the incidence of geophagy to support the mineral needs of Sumatran elephants in the Tangkahan region.

L. Cao, J.-F. Tan, Z.-G. Zhang, J.-W. Yang, Y. Mu, Z.-L. Zhao, Y. Jiang, X.-S. Huang & L. Han

Discovery of structurally diverse sesquiterpenoids from Streptomyces fulvorobeus isolated from *Elephas maximus* feces and their antifungal activities

Natural Products and Bioprospecting 14 (2024) e61

Abstract. Thirty-six structurally diverse sesquiterpenoids, including caryolanes (1-12), germacranes (13-16), isodaucane (17), cadinanes (18-22), epicubenols (23, 24), oplopanane (25), pallenanes (26, 27), and eudesmanes (28-36), were isolated from the fermentation broth of *Streptomyces fulvorobeus* derived from *Elephas maximus* feces. Pallenane is a kind of rarely reported sesquiterpene with a distinctive C5/C3 bicyclic skeleton and was firstly found from microbial source. The structures of fifteen new compounds (1-4, 13-15, 17, 18, 22, 23, 25-28) were established through detailed spectroscopic data analysis, which included data from experimental and calculated ECD spectra as well as Mosher's reagent derivative method. Compound 34 exhibited moderate antifungal activity against *Cryptococcus neoformans* and *C. gattii* with MIC values of 50 μg/mL. It effectively inhibited biofilm formation and destroyed the preformed biofilm, as well as hindered the adhesion of *Cryptococcus* species. The current work would enrich the chemical diversity of sesquiterpenoid family.

A.N. Chan, P. Leimgruber, C. Williams, N.M. Shwe, S.S. Aung, N. Lwin, Z.M. Oo, A.M. Chit & G. Wittemyer

Individual variation in habitat selection behavior of Asian elephants in a human-wildland interface

Global Ecology and Conserv. 53 (2024) e03025

Abstract. Habitat loss and fragmentation due to accelerated agriculture expansion is a major threat to existing wildlife populations across Asia. The human-wildlife interface mosaic across Asia is varied in terms of juxtaposition and structure, which can strongly influence biodiversity value and impacts on wildlife species. Here we analyzed habitat selection behavior of Asian elephant (*Elephas maximus*) across three study sites with different agriculture use patterns in Myanmar, a country recognized as a global biodiversity hotspot, including but not limited to, commercial palm oil and sugarcane plantations, and subsistence agriculture. These different agriculture use landscape capture landscape mosaic structure found across Asia. Given elephants exhibit heterogeneous spatial behavior, we fitted individual step selection and resource selection models to gain insight into the diversity of strategies employed at the local (step) and home range (third-order) scale. We used variance partitioning analysis to quantify the explanatory contribution of individual and study sites across both scales. We found that the variation in the resource selection behavior was mainly due to individual differences, and the configuration of agriculture present in an individual 's range was the most influential to its selection behavior. Enhancing understanding of how the level of fragmentation on the landscape relates to agricultural use can serve to help focus conservation efforts. Continued accelerated agriculture expansion is increasing the rate of contact between elephants and humans and, thereby escalating negative human-elephant interactions, often resulting in human and elephant deaths. Gaining a deeper understanding of habitat selection behavior by elephants across the changing landscapes of Asia can help inform management decisions and conservation actions. © 2024 The Authors.

S.K. Chaudhary, A.C. Pandey & B.R. Parida

Geospatial analysis of elephant habitat suitability and movement for mapping the elephant corridor in Dalma Wildlife Sanctuary (India)

Environmental Monitoring and Assessment 196 (2024) e936

Abstract. No permission to print abstract.

S.E. Childs-Sanford, W.K. Kiso & D.L. Schmitt

Serum Vitamin D and selected biomarkers of calcium homeostasis in Asian elephants (*Elephas maximus*) managed at a low latitude

Journal of Zoo and Wildlife Medicine 55 (2024) 430-435

Abstract. An understanding of species-specific vitamin D metabolism and its role in calcium homeostasis is essential for correct diet formulation and development of husbandry protocols for managed nondomestic species. This study documented serum vitamin D metabolites and other analytes involved in calcium homeostasis in Asian elephants (Elephas maximus) managed at a latitude similar to their wild natural habitat. Serum values for 33 elephants managed at a low latitude were measured in the peak of summer, revealing low vitamin D-2 (25(OH)D-2 2.3 ± 6 0.6 ng/ ml and 24,25(OH)(2)D-2 2.17 ± 6 0.52 ng/ml) and nondetectable vitamin D-3. Serum minerals (calcium, phosphorus, magnesium), ionized calcium, and parathyroid hormone were within normal reported ranges. In comparison with previously reported values in elephants managed at a high latitude, 25(OH)D-2 ($P < 0.001$), 24,25(OH)(2)D-2 ($P = 0.001$), and magnesium ($P = 0.013$) were significantly lower, and parathyroid hormone was significantly higher ($P < 0.001$). The lack of D-3 production during ample sun exposure at a low latitude suggests that Asian elephants are incapable of cutaneous photobiosynthesis of vitamin D, and that low serum D-2 is normal for this species. © 2024 American Assoc. of Zoo Veterinarians.

J.L.S. Clinton, T.E. Hoornweg, J. Tan, R. Peng, W. Schaftenaar, V.P.M.G. Rutten, C.A.M. de Haan & P.D. Ling

The EEHV1A gH/gL complex elicits humoral and cell-mediated immune responses in mice

Vaccine 42 (2024) e126227

Abstract. No permission to print abstract.

J.A.H. Crawley, H. Nandar, H.T. Zaw, M. Lahdenpera, D.J.F. dos Santos, M.W. Seltmann,

J.L. Brown, R.M. Goodsell, Z.M. Oo, W. Htut, U.K. Nyein, H.H. Aung & V. Lummaa

Asian elephant calf physiology and mahout perspectives during taming in Myanmar

Royal Society Open Science 11 (2024) e 231172

Abstract. A quarter of Asian elephants are captive, with greater than 90% of these tamed and cared for by handlers (mahouts) in Asia. Although taming is a much-discussed welfare issue, no studies to our knowledge have empirically assessed its impact on calves, and dialogue surrounding taming often lacks perspectives of those involved. Here, we interviewed mahouts involved in taming and monitored five physiological measures (faecal glucocorticoid metabolites (FGMs), serum cortisol, glucose, creatine kinase (CK) and heterophil:lymphocyte (H:L)) over the first 10 days of taming and following six months in 41 calves undergoing taming and 16 control individuals. These measures assess the duration and intensity of stress during taming. Interviews suggested mahouts had major concerns for their safety when discussing changing taming practices, an important consideration for future management. Calf physiological measures were elevated by 50-70% (FGMs/cortisol/glucose), 135% (H:L) and greater than 500% (CK) over the first few days of taming, indicative of elevated stress, not seen to the same extent in control adults. Some measures stabilized sooner (glucose/cortisol/CK/FGM: 7-10 days) than others (H:L: one-two months), indicating mostly acute stress. Our findings inform the welfare of approximately 15 000 captive elephants around the world. Future studies should compare taming in different populations and consider calf and mahout welfare. © 2024 The Authors.

S.J.C. de Mel, S. Seneweera, A. Dangolla, D.K. Weerakoon, R. King, T. Maraseni & B.L. Allen (2024)

Attitudes towards causes of and solutions to conflict between humans and Asian elephants

Conserv. Science and Practice 6 (2024) e13238

Abstract. Many Asian elephant populations inhabit fragmented human-dominated landscapes. Human-elephant conflict (HEC) has intensified in such regions, resulting in the deaths of hundreds of people and elephants each year. Controversy between stakeholders then arises as people debate the merits of HEC mitigation approaches, stifling progress. We conducted a survey to evaluate the opinions of experts, farmers and others who have and have not experienced HEC (n = 611), on the causes of HEC, the importance of, conservation of and co-existence with elephants, and on the acceptability and effectiveness of potential HEC mitigation methods. Analysis of variance and the Potential for Conflict Index showed that all groups agreed with nine of the 10 causes of HEC assessed, on average. All respondent groups had mostly positive attitudes towards the importance and conservation of elephants. However, farmers exposed to HEC disagreed that people should coexist with elephants and supported the view that elephants should be removed from human habitats. All groups agreed on the acceptability and effectiveness of electric fencing, early warning systems with infrasonic call detectors, Global Positioning System collars and geophones. However, there was disparity in views between the experts and other stakeholder groups on the acceptability and effectiveness of restricting elephants to protected areas, and translocation of problem elephants to protected areas away from their capture site or to wild elephant holding grounds. While similar views between stakeholders on many subjects are encouraging for elephant conservation, the disparities identified should be given greater attention when planning HEC management programs to minimize conflict between stakeholders. © 2024 The Authors.

R. De, R. Sharma, S.K. Singh, R. Rasteiro, R. Bhaskar, I. Khan, R. Kanagaraj, K. Kakati, P. Nigam, A.C. Williams, P. Davidar, B. Habib & S.P. Goyal

Conservation implications of high gene flow and lack of pronounced spatial genetic structure in elephants supported by contiguous suitable habitat in north-western India

Conserv. Science and Practice 6 (2024) e13075

Abstract. The western Terai Arc Landscape (wTAL) in Uttarakhand, India, marks the range limit for the Asian elephant in north-western India. This region has been impacted by land-use changes and infrastructure expansion for the last seven decades. To evaluate the impact of habitat deterioration on the population structure of elephants in the region, we characterized

their genetic diversity and local genetic structure using mitochondrial (D loop) and nuclear DNA (microsatellites; n = 15) markers. We used tissue samples of 114 elephants from five different sub-populations, collected between 2005 and 2014. The genetic variation was moderate (H-O = 0.49-0.55) compared with other Indian elephant populations. Two mtDNA haplotypes were identified without strong spatial patterns across wTAL. Bayesian individual-based clustering algorithm identified two genetic clusters (K = 2) with high admixture (50% at Q < 0.7) and no spatial adherence. Though K = 1 was not supported by the Bayesian algorithm, multivariate analysis and sibship patterns did not indicate genetic differentiation. The lack of spatial genetic structuring suggests high levels of gene flow, indicating that this population is still panmictic. This suggests that the life history traits of elephants as well as the ecological features of this landscape influence genetic connectivity. However, ongoing land use changes necessitate regular genetic monitoring in wTAL to identify incipient structuring caused by anthropogenic barriers to movement.

S. Deb, R. Ravindran & S. K. Radhakrishnan
Design and field installation of automated electronic Asian elephant signage for human safety
J. of Threatened Taxa 16 (2024) 25482–25485
Abstract. Human-elephant interactions results in numerous deaths and injuries, often due to accidental encounters at elephant crossing points at night. Addressing this, the proposed electronic elephant signage, a solar-powered device, marks crossing points with a glowing elephant-shaped light. Successfully tested in the Sathyamangalam Tiger Reserve, it activates at dusk, blinking throughout the night, effectively reducing surprise encounters and promoting safer coexistence. © The Authors.

A. Devi, M. Sharma, R. Badola & S.A. Hussain
Unveiling the mysteries of Asian herbivores resource partitioning in tropical wet-grassland ecosystem
Global Ecology and Conservation 54 (2024) e03079
Abstract. Ecological niche partitioning is fundamental for the coexistence of sympatric species. However, the relationship between herbivore body size and forage availability on resource segregation and selection remains debatable. This study quantifies the niche differentiation and selectivity of forage species consumed by six Asian large herbivores (SLH), including mega-herbivores like greater one-horned rhino, Asian elephant and Asiatic wild buffalo, and meso-herbivores like swamp deer, hog deer and sambar in tropical wet-grasslands of the Brahmaputra floodplains. We hypothesized that body size influences dietary niche breadth and interspecific dietary similarities or dissimilarities, while forage availability influences forage selectivity among Asian herbivores. We used micro-histological technique, harvest method and Jacobs Index to quantify SLH foraging patterns, forage availability and preference, respectively. Results of the study revealed high niche breadth for elephant (0.56>B-s <= 0.74) among mega-herbivores and for sambar (0.49>B-s <= 0.64) among meso-herbivores. SLH showed a significant positive correlation between body size and niche breadth in wet season. High dietary overlap was recorded between buffalo and hog deer (0.79-0.86) and swamp deer and hog deer (0.75-0.86) among SLH, rhino and buffalo (0.80-0.83) among mega-herbivores, and swamp deer and hog deer (0.75-0.86) among meso-herbivores. High dietary dissimilarity was recorded between elephant and swamp deer (36-37 %), elephant and buffalo (27-33 %), and swamp deer and sambar (27-29 %). Compared to dry season (1354.54 ± 641.30 g m^{-2}, significantly higher biomass was recorded in wet season (3026.93 ± 1632.65 g m^{-2}; $p<0.05$). From dry to wet season, rhino, buffalo and hog deer shift their preferred forage from dicot to monocot. Dicot was the most preferred forage of elephant among mega-herbivores, and monocot of swamp deer and sambar among meso-herbivores. Mega- and meso-herbivores avoid invasives *Merremia umbellata* and *Mimosa* spp., while meso-herbivores avoid *Mikania micrantha*. Body size explains niche partitioning only for rhino, elephant and swamp deer. Forage availability contributed to niche breadth and forage preference. In conclusion, forage segregation, despite being challenging to interpret at taxonomic level, influences niche partitioning among mega- and meso-herbivores. © 2024 The Authors.

C. Dorji, R.K. Chhetri & T. Dorji

Impact of human-elephant conflict on the communities' livelihood: A study in Southern Bhutan

Geojournal 89 (2024) 184

Abstract. No permission to print abstract.

C. Doyle, H. Rally, L. O'Brien, M. Tennison, L. Marino & B. Jacobs

Continuing challenges of elephant captivity: the captive environment, health issues, and welfare implications

Peerj 12 (2024) e18161

Abstract. Although the well-being of elephants in captivity is of paramount importance, the confinement of these long-lived, highly intelligent, and socially complex animals continues to present significant challenges. Here, we provide an overview of the current state of elephant confinement (primarily in the West) by examining captive facilities, improvements, and continuing problems, and the clinical/behavioral/ neural issues that remain. Specifically, we examine quantitative and qualitative aspects of the enclosed space, sociocognitive factors, dietary differences, and health/ welfare concerns (e.g., stereotypies, physical health, nutrition, reproduction, life expectancy). The challenges of the captive environment become especially salient when juxtaposed next to the complex, multifaceted characteristics of the elephant's natural environment. Despite the best efforts of some facilities to improve the captive environment, serious welfare challenges remain. Such confinement issues thus raise important welfare and ethical concerns with regards to captive elephant well-being. © 2024 The Authors.

L. Galante, D.J.F. dos Santos, E. Mikkonen, J. Horak, Z. Stijepic, H. Demmelmair, A. Vielhauer, B. Koletzko, H.T. Zaw, W. Htut, V. Lummaa & M. Lahdenperae

Milk metabolite composition of a semi-captive population of Asian elephants

Royal Society Open Science 11(2024) e240930

Abstract. Lack of maternal milk commonly leads to Asian elephant calves' death in captivity. Currently, available supplements seem inefficient. Hence, we aimed at characterizing the composition of Asian elephant milk to provide information on calves' nutritional needs. Seventy milk samples from 22 Asian elephants living in semi-captivity in their natural environment in Myanmar were collected. Samples were analysed through various techniques including liquid chromatography tandem mass spectrometry, gas chromatography-flame ionization detector, and bicinchoninic acid assay to determine total protein content and various metabolites. Associations with lactation stage (months postpartum) were investigated through repeated measure mixed models. We identified 160 compounds: 22 amino acids, 12 organic acids of the tricarboxylic acid cycle, 27 fatty acids, 15 acyl-carnitines and 84 phospholipids. The milk contained substantial amounts of free glutamate (median: 1727.9, interquartile range (IQR): 1278.4 μmol l^{-1}) and free glycine (2541.7, IQR: 1704.1 μmol l^{-1}). The fatty acid profile was mostly constituted by saturated fatty acids, particularly capric acid (40.1, IQR: 67.3 g l^{-1}). Milk samples also contained high amounts of carnitines, phospholipids and organic acids. The wide array of metabolites identified and quantified, some of which present high concentrations in the milk from this species as opposed to other species, suggests underpinning physiological functions that might be crucial for the survival of Asian elephant calves. © 2024 The Authors.

R. Ghimire, J.L. Brown, C. Thitaram & P. Bansiddhi

Comparison of animal welfare assessment tools and methodologies: need for an effective approach for captive elephants in Asia

Frontiers in Vet. Science 11 (2024) e1370909

Abstract. Welfare is a fundamental aspect of animal management and conservation. In light of growing public awareness and welfare concerns about captive elephants, there is an urgent need for comprehensive, globally coordinated efforts for Asian elephants that participate in religious, logging, or tourist activities in range countries where the majority reside, and where welfare issues have been identified but not addressed. This review provides a comparative analysis of available animal assessment tools. Each offers distinct features for assessment that allow institutions to select criteria for specific needs and available resources. Most are applied to general animal welfare assessments, although some are tailored to particular species, including elephants. The tools span diverse formats,

from digital to primarily paper-based assessments. Assessments operate at individual and institutional levels and across multiple welfare domains. Methodologies rely on keeper ratings or expert evaluations, incorporate numerical scoring and Likert scales for welfare grading, and encompass inputs including behaviors, health, and physiological indicators. For tourist camp elephants, one challenge is that the tools were developed in zoos, which may or may not have application to non-zoological settings. Digital tools and assessment methodologies such as keeper ratings face logistical challenges when applied across tourist venues. As with any tool, reliability, validity, and repeatability are essential and must address the unique welfare challenges of diverse captive settings. We propose that a holistic, context-specific, evidence-based, and practical tool be developed to ensure elephant welfare standards in non-zoological facilities throughout Asia.

R. Ghimire, J.L. Brown, C. Thitaram, S.S. Glaeser, K. Na-Lampang, P. Kulnanan & P. Bansiddhi

Development of a welfare assessment tool for tourist camp elephants in Asia

Peerj 12 (2024) e18370

Abstract. Background: Approximately one-third of Asian elephants are managed under human care, participating in educational, cultural, religious, and tourist activities. Management conditions vary considerably among venues, raising questions about whether welfare needs are consistently being met, particularly for Asian tourist camp elephants. To evaluate the well-being of elephants engaged in tourist activities, an evidence-based tool is needed for routine assessments to identify potential welfare risks, aid in the development of better camp standards, and enable caretakers to address specific concerns. While many animal welfare tools exist, none have been designed to consider specific environments and management practices faced by elephants living and working in tourist camps. Methods: Using direct observations and interviews, the Elephant Welfare Assessment Tool (EWAT) was developed for tourist camp elephants using the Five Domains Model as a framework. Measures were selected based on peer-reviewed literature, existing standards and guidelines, and opinions from animal welfare experts working with zoo and tourist camp elephants. The EWAT differs from existing tools by including criteria on work activities and restraint methods (e.g., chaining and ankus use), factors common in Asia but not often encountered by western zoo elephants. Measures were scored using a 0-2 Likert Scale. The tool was tested in Thailand and determined by calculating a content validity index (CVI) and conducting inter-rater and test-retest reliability tests. Results: The initial tool included 18 animal-based and 21 resource-based measures across four domains: Nutrition (n = 5), Environment (n = 14), Health (n = 10), and Behavior and Mental State (n = 10). Index scores of content validity (CVI) (Item CVI (0.83), Scale CVI/Average (0.98), and Scale CVI/Universal (0.89)) were high. Measures scoring less than 0.83 were removed: the opportunity to mate, the mahout-elephant relationship, and mahout job satisfaction. The final tool consisted of 42 questions related to 36 measures, including 18 animal-based and 18 resource-based measures within the Nutrition (n = 5), Environment (n = 11), Health (n = 10), and Behavior and Mental State (n = 10) domains. Intraclass correlation coefficients (ICC) for inter-rater reliability (0.78-0.90, $p < 0.05$) and test-retest (0.77-0.91, $p < 0.05$) analyses conducted at two camps showed good agreement. Conclusions: This new assessment tool (EWAT) is a context-specific, holistic method designed to offer a practical means of conducting individual and institutional-level assessments of elephant welfare in tourist camps. It is based on the Five Domains Model using reliable and validated animal- and resource-based measures, data collection through direct observation and interviews, and a numerical scoring system. The tool includes several criteria applicable to tourist rather than zoo venues to make it more relevant to the challenges faced by working elephants in Asia.

S. Ghosh, M. Mandal, D. Das & S.K. Gayen

Modeling on the assessment of habitat suitability and conflicting nature nexus of human-elephant-environment at the Alipurduar district in India

Modeling Earth Systems and Environment 10 (2024) 7459-7478

Abstract. No permission to print abstract.

T. Giggin, K.D. Martin, S.K. Vebugopal, K.S. Anil, A.R. Sreeranjini & M.K. Narayanan

Comparative analysis of mathematical models and app-based measurement for estimating the cutaneous wound areas of captive Asian elephants

Cureus 16 (2024) e65533

Abstract. To evaluate the variation in the area estimation under different mathematical calculations against measurement by a smartphone application in estimating the cutaneous wound areas in captive Asian elephants. The study was conducted on captive Asian elephants (*Elephas maximus*) with cutaneous wounds reported to Veterinary Hospitals of Kerala Veterinary and Animal Sciences University and elephant camps within and outside Kerala state (mostly southern states of India, namely, Kerala and Tamil Nadu) over the period September 2019 to October 2022. Thirty-five clinical cases diagnosed with skin wounds of different aetiologies at various parts of the body were subjected to measurement, and 111 measurements were taken using a smartphone application, Imito Measure (Imito AG, Zurich, Switzerland). Based on the outer wound perimeters handmarked on the mobile screen over the image taken, Imito Measure calculated the length, width, perimeter, and area. The length and width measurements from this were applied to four mathematical models of wound measurements. Wound surface area calculations were further done by these models and were compared. The observed results indicated no significant difference between the five methods of area measurement in all the studied cases since the $P > 0.05$. The findings revealed no significant difference between the five techniques of wound area measurement. From the practical clinical utility point, the smartphone application has an edge over the mathematical methods in animals, especially captive Asian elephants, as it has the major advantage of being non-contact and thus addresses some major welfare concerns. © 2024 The Authors.

M. Guarnieri, G. Kumaishi, C. Brock, M. Chatterjee, E. Fabiano, R.K. Adefowora, A. Larsen, T.M. Lockmann & P.R. Roehrdanz

Effects of climate, land use, and human population change on human-elephant conflict risk in Africa and Asia

PNAS 121 (2024) e2312569121

Abstract. Human-wildlife conflict is an important factor in the modern biodiversity crisis and has negative effects on both humans and wildlife (such as property destruction, injury, or death) that can impede conservation efforts for threatened species. Effectively addressing conflict requires an understanding of where it is likely to occur, particularly as climate change shifts wildlife ranges and human activities globally. Here, we examine how projected shifts in cropland density, human population density, and climatic suitability-three key drivers of human-elephant conflict-will shift conflict pressures for endangered Asian and African elephants to inform conflict management in a changing climate. We find that conflict risk (cropland density and/or human population density moving into the 90th percentile based on current - day values) increases in 2050, with a larger increase under the high- emissions "regional rivalry" SSP3 - RCP 7.0 scenario than the low-emissions "sustainability" SSP1 - RCP 2.6 scenario. We also find a net decrease in climatic suitability for both species along their extended range boundaries, with decreasing suitability most often overlapping increasing conflict risk when both suitability and conflict risk are changing. Our findings suggest that as climate changes, the risk of conflict with Asian and African elephants may shift and increase and managers should proactively mitigate that conflict to preserve these charismatic animals. © 2024 The Authors.

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

Identifying human elephant conflict hotspots through satellite remote sensing and GIS to support conflict mitigation

Remote Sensing Applications-Society and Environment 35 (2024) e101261

Abstract. Human-elephant conflict (HEC) is a significant issue in Sri Lanka and many parts of the world where elephants and humans coexist. To address HEC, this study integrates remote sensing and GIS analysis, focusing on monitoring changes in greenery. The study prepared the latest land cover and land use (LCLU) maps with Sentinel-2 satellite data, correlating them with reported HEC incidents reported in 2021 and 2022 to identify HEC hotspots in two forest

-dominated regions of Southeast Sri Lanka. High-resolution Sentinel-2 satellite imagery were used to detect areas of human activities and elephant habitats in proximity to each other. Random Forest (RF) and Support Vector Machine (SVM) classification methods were used for LCLU classification. The overall accuracy of the classification was 97.31 and 94.62, and kappa was 0.95 and 0.90 for RF and SVM, respectively. Multi -temporal normalised difference vegetation index (NDVI) analysis provided insights into vegetation health and coverage, offering a clear picture of greenery changes. Monthly changes in vegetation cover readings were quantified using NDVI values derived from MODIS data, identifying suitable regions for elephants to forage frequently. Furthermore, Kernel density estimation identified high -density areas for reported incidents of human and elephant deaths. This process involved assigning weight to conflict incidents within a 5 km radius, considering the proximity to the forest, and evaluating greenery changes using NDVI values, revealing varying levels of HEC risk, ranging from very high to low. The LCLU map, created using the RF classifier, indicates that all potential HEC hotspots for very high and high HEC risks are closely aligned with forest boundaries. The findings support HEC mitigation strategies through community awareness, HEC hotspots mapping and restoration practices to ensure a sustainable human-elephant coexistence. This method will help policymakers in wildlife conservation to identify high risk HEC zones to support HEC mitigation. In conclusion, this study highlights the potential of integrating remote sensing and GIS techniques in demarcating HEC hotspots in Sri Lanka to support conflict mitigation efforts. © 2024 The Authors.

J. Haycock, T. Maehr, A. Dastjerdi & F. Steinbach

Immunostimulation of Asian elephant (*Elephas maximus*) blood cells by parapoxvirus ovis and CpG motif-containing bacterial plasmid DNA upregulates innate immune gene expression

Frontiers in Immunology 15 (2024) e1329820

Abstract. The immune system of Asian elephants (*Elephas maximus*) is poorly studied, compared to that of livestock, rodents or humans. The innate immune response has become a focus of interest in relation to Elephant endotheliotropic herpesviruses (EEHVs). EEHVs cause a fatal hemorrhagic disease (EEHV-HD) and are a significant threat to captive Asian elephant populations worldwide. Similar to other herpesvirus infections, nearly all animals become infected, but only some develop disease. As progression to EEHV-HD is often acute, a robust innate immune response is crucial to control EEHV infections. This is invariably true of the host in the first instance, but it can also potentially be modulated by intervention strategies. Here, two immunostimulant veterinary medicinal products, authorized for use in domestic species, were tested for their ability to induce innate anti-viral immune responses in Asian elephant blood cells. Sequence data were obtained for a range of previously unidentified Asian elephant immune genes, including C-X-C motif chemokine ligand 10 (CXCL10), interferon stimulated gene 15 (ISG15) and myxovirus GTPase 1 (Mx1), and were employed in the design of species-specific qPCR assays. These assays were subsequently used in analyses to determine fold changes in gene expression over a period of 24 hours. This study demonstrates that both immunostimulant medications are capable of inducing significant innate anti-viral immune responses which suggests that both could be beneficial in controlling EEHV infections in Asian elephants. © 2024 The Authors.

T.E.R.G. Huijsmans, A. Van Soom, K. Smits, J. Wauters, D. Hagan & T.B. Hildebrandt

Elephant gestation: Insights into idiopathic abortions and stillbirth

Zoo Biology 43 (2024) 575-579

Abstract. The declining African and Asian elephant populations emphasize the importance of a backup population. Successful reproduction in captivity plays a key role in maintaining such a genetically diverse ex situ population but is challenged by reproductive loss in the form of abortions and stillbirths. The elephants' biphasic prolactin pattern led us to predict a higher incidence of abortions during the time of reduced prolactin concentrations. Therefore, this study focuses on the identification of months during elephant gestation which are prone to loss of pregnancy. A metric was developed to identify

the fetal age of aborted calves based on the fetal mass using a regression model. Data on idiopathic abortions in captive and wild elephants collected from zoos, tourist camps, semi-captive, and free-ranging populations since 1974 were analyzed, revealing a significantly higher prevalence of abortions during the 15th and 17th month of gestation. Additionally, the prevalence of stillbirths in the 22nd month of gestation between 2000 and 2023 was assessed. Although stillbirths showed a declining trend over time, the average prevalence between 2019 and 2023 was still 2.8%. Consequently, the 15th, 17th, and 22nd month of gestation were identified as stages prone to pregnancy loss. These findings underscore the necessity of researching risk factors and preventative measures for pregnancy loss in these 3 months, especially exploring a possible link with prolactin during the 15th and 17th month of gestation. The identification of stages prone to fetal loss is a key step towards enhancing elephant reproductive success and welfare. Abortions in African and Asian elephants

M.Z. Islam & S. Wang

What triggered the human-wildlife conflicts in Bangladesh between forest proximity people and wildlife? A responsive study

Israel Journal of Ecology & Evolution 70 (2024) 159-171

Abstract. Reflecting upon the distressing situation of human-wildlife conflict (HWC), this study has identified numerous factors that exacerbate the HWC issue in Bangladesh, including a lack of awareness, a prevalent disregard for the law, inadequate punitive measures, institutional weaknesses, socio-economic challenges, a burgeoning population, a refugee crisis, rampant deforestation, encroachment upon natural habitats, migratory challenges faced by wildlife, and the influence of national and global politics. It is evident that these multifaceted elements significantly contribute to the escalation of HWC. The regions of Chittagong-Hill Tracts, the Sundarbans, and central-northern Bangladesh are facing a pressing HWC issue that demands our immediate attention. Tragically, over the past two decades, more than 118 elephants have lost their lives, while these creatures claimed 13 human lives in 2017-2018. Furthermore, tigers, an emblem of strength and beauty, have been responsible for the demise of approximately 50 individuals between 2009 and 2010. Astonishingly, the year 2022 has already witnessed a count of 375 HWCs. Therefore, this study delves deeper into the root causes of HWC in Bangladesh and proposes effective preventive measures to safeguard the endangered species, specifically the Asian elephants and Bengal tigers, who bear the brunt of these conflicts. © 2024 The Authors.

M.I.M. Jamaluddin, K.Z. Abidin, S.M. Nor, A. Shukor, A.I. Zainudddin, R. Illias & M.S. Mansor

Asian elephants involved in conflicts exhibit similar habitat use but travel farther than non-conflict individuals

Global Ecology and Conserv. 55 (2024) e03228

Abstract. Rapid development and deforestation in Peninsular Malaysia have degraded and fragmented the tropical forest, impacting the survival of many megafauna species. With reduced space to roam, Asian elephants may extend their range into the altered landscape, leading to human-elephant conflict (HEC). HEC is defined as any interactions between wild elephants and humans that result in negative effects on both humans and elephants. Although known as a keystone species in the region, spatial studies comparing conflict and non-conflict elephants have never been done before. In this study, we used GPS satellite collar data for five conflict and seven non-conflict elephants from 2012 to 2021. We mapped their home ranges, identified hotspots, and estimated the proportion of habitat use (area and time spent) across the Managed Elephant Ranges of Peninsular Malaysia. We found that nine of the 12 elephants spent >90 % of their time in their home range and >95 % of their time in hotspots in forested areas regardless of conflict status. redefining of conflict status as spending <53 % of the time in the home range and <41 % in hotspots in forested areas. However, conflict elephants moved significantly farther on the daily average than non-conflict elephants. Our findings highlight the importance of redefining the conflict status of elephants based on threat levels and habitat use to consider the rapidly degrading habitat that signals human-elephant coexistence. © 2024 The Authors.

J. Jue, Z.M. Thant & S. Shibata

GPS tracking reveals home range and habitat preference of semi-captive elephants in Myanmar

Landscape and Ecological Engineering 20 (2024) 213-221

Abstract. No permission to print abstract.

P. Kaswan & A. Roy

Unearthing calf burials among Asian elephants *Elephas maximus* Linnaeus, 1758 (Mammalia: Proboscidea: Elephantidae) in northern Bengal, India

J. of Threatened Taxa 16 (2024) 24615-24818

Abstract. Rampant environmental changes and forest destruction push elephants, both Asian and African, to explore human spaces to fulfil their dietary and ecological requirements and, consequently in shared spaces many 'novel' elephant behaviors come into the limelight. Elephant calf burial is reported in African literature but remains absent from the Asian context. We report calf burials by Asian elephants in the eastern Himalayan floodplains of the northern Bengal landscape. The study area consists of fragmented forests, tea estates, agricultural lands, and military establishments. Tea estates form the majority of elephant corridors, and we explain the burial strategy of elephants in the irrigation drains of tea estates. We present five case reports of calf burials by elephants. We aimed to understand the perimortem strategy and postmortem behavior of the Asian elephants. The major findings reflect that the carcasses were carried by trunks and legs for a distance before being buried in a 'legs-upright-position'. We further investigated the underlying reason for calf deaths through postmortem examinations. Direct human intervention was not recorded in any of the five deaths. Through opportunistic observation, digital photography, fieldnotes, and postmortem examination reports, we suggest that the carcasses were buried in an abnormal recumbent style irrespective of the reason for the calf's death. Through long-term observation, we further report that the elephants in this region clearly avoid the paths where carcasses were buried. We discuss and connect the literature of two distinct elephant species and also compare thanatological studies of other sentient nonhuman species. © 2024 The Authors.

A. Khan, M. Sil, T. Thekaekara, K.M. Garg, I. Sinha, R. Khurana, R. Sukumar & U. Ramakrishnan

Divergence and serial colonization shape genetic variation and define conservation units in Asian elephants

Current Biology 34 (2024) 4692-4703

Abstract. Asian elephants are the largest extant terrestrial megaherbivores native to Asia, with 60% of their wild population found in India. Despite ecological and cultural importance, their population genetic structure and diversity, demographic history, and ensuing implications for management/conservation remain understudied. We analyzed 34 whole genomes from most known elephant landscapes in India and identified five management/conservation units corresponding to elephants in Northern, Central, and three in Southern India. Our data reveal signatures of divergence and serial colonization and a potential dilution of genetic diversity from north to south of India. The northern populations diverged from others more than 70,000 years ago, have higher genetic diversity, and have low inbreeding (pi = 0.0016±0.0001; $F_{ROH>1\ MB}$= 0.09±0.03). Two of three populations in Southern India have low diversity and are inbred, with very low effective population sizes compared with census sizes (pi= 0.0014± 0.00009 and 0.0015± 0.0001; $F_{ROH>1\ MB}$= 0.25± 0.09 and 0.17± 0.02). Analyses of genetic load reveal the purging of potentially high-effect insertion/deletion (indel) deleterious alleles in the southern populations and a decreasing number of deleterious alleles from north to south. However, despite dilution and purging for the damaging mutation load in Southern India, the load that remains is homozygous. High homozygosity of deleterious alleles, coupled with low neutral genetic diversity, make southernmost populations high priority for conservation attention. Most surprisingly, our study suggests that patterns of genetic diversity and genetic load can correspond to genomic signatures of serial founding events, even in large, highly mobile, endangered mammals. © 2024 The Authors.

N. Kittisirikul, N. Bangkaew, W. Phimpraphai & S. Sripiboon

Unlocking insights: Mahout's perceptions and practices in managing elephant endotheliotropic herpesvirus (EEHV) infection

among captive Asian elephants in Surin province, Thailand

PLoS One 19 (2024) e0295869

Abstract. Surin, situated in the northeastern region of Thailand, has earned the reputation of being an "elephant village" due to its high captive elephant population and unique tradition of elephant rearing. However, the continuous occurrence of elephant endotheliotropic herpesvirus (EEHV) infection poses a significant threat to elephants, particularly the young ones. This study investigated various aspects of EEHV-related elephant care among ninety-two mahouts at the Surin Elephant Kingdom Project. This study used semi-structured interviews and observations to assess the mahouts' knowledge, attitude, and practice (KAP scores) toward EEHV transmission, prevention, and management. The result revealed knowledge and practice scores below expectations, indicating an insufficient understanding the nature of disease and preventive measures. However, the mahouts exhibited awareness of the severity of the disease and factors contributing to transmission risk. Regarding the relationship among KAP scores, a positive correlation was observed at a low level ($p < 0.05$) between the knowledge and practice scores. Interestingly, approximately 55% of the survey respondents were confident that their elephants would not receive EEHV, leading to inadequate prevention measures. From the result, it is crucial to provide comprehensive knowledge about the nature of the disease and preventive measures to all mahouts. This education should emphasize the importance of early monitoring signs, appropriate weaning age, and preventing viral transmission practices. The KAP survey offers valuable insights that can identify areas requiring improvement and guide the development of effective and targeted disease prevention programs within the specific population. Therefore, it is recommended that the KAP survey should be employed in other parts of the country where the elephant management system differs. © 2024 The Authors.

P. Kochprapa, C. Savini, D. Ngoprasert, T. Savini & G.A. Gale

Mitigating human-elephant conflict in Southeast Asia

Tropical Natural History 24 (2024) 70-83

Abstract. Human-elephant conflict (HEC) poses serious threats to humans and to elephants, and while HEC in Southeast Asia is increasing, mitigation effectiveness data are lacking. Previous assessments of available mitigation options have not compared relative benefits and impacts of each on a practical level to identify which factors should be considered by local agricultural communities and/or other stakeholders when choosing among mitigation options. Understanding which mitigation approach to apply in a given context is crucial for effective mitigation planning and can aid in the development of more holistic methods. We reviewed the literature regarding the strengths and weaknesses of 14 currently applied HEC mitigation methods in Southeast Asia, considering five key factors for each mitigation option: 1) effectiveness at reducing crop damage, 2) initial start-up costs, 3) maintenance/long-term costs, 4) potential impacts on humans and 5) potential impacts on elephants. Our results suggest there are considerable tradeoffs among these five factors for any given mitigation option and that none of the available mitigation methods are simultaneously highly effective in preventing crop damage and low cost while presenting minimal impact to people and elephants. Although our metric of comparison is not comprehensive, it may offer an initial set of guidelines for decision making. ©2024 Chulalongkorn University.

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

Factors driving human-elephant conflict: Statistical assessment of vulnerability and implications for wildlife conflict management in Sri Lanka

Tropical Natural History 33 (2024) 3075-3101

Abstract. Human-elephant conflict (HEC) is a serious social-ecological problem in Sri Lanka's elephant range regions, as between 200 and 400 elephants have been killed annually over the last years, and more than 1200 people have died from the consequences of elephant encounters within a decade. Crop foraging causes economic damage to farming households. The

study aims to understand factors driving vulnerability to HEC among the population. Employing a cross-communal multi-item large-N field survey (N = 651), authors were able to describe living conditions and perceptions of Sri Lankan villagers affected by HEC. By running a multiple regression analysis with correlated variables, the study is able to correlate independent variables to vulnerability, namely socio-economic conditions, environmental change and land-use, and awareness. Furthermore, a vulnerability map has been created, identifying Puttalam, Anuradhapura, Kurunegala, Matale, and Polonnaruwa districts as conflict hotspots. Private electric fences as a widespread protection measure were found to have unintended negative side-effects to non-protected households. The findings suggest the urgent need to upscale public policies mitigating the consequences of HEC on affected populations by reducing overall vulnerability to environmental hazards, including human-wildlife conflict. © 2024 The Authors.

H. Kopnina & L. Baker

Conservation, animal wellbeing, and indigenous participation at an elephant sanctuary in Mondulkiri, Cambodia

Society & Animals 32 (2024) 560-581

Abstract. This article focuses on the intersection of indigenous peoples, conservation, and elephant wellbeing in Cambodia. While social justice advocates emphasize the human cost of conservation in human-animal conflicts, those concerned with animal protection and rights have problematized the treatment of elephants. This critique stems from evidence that the human relationship to elephants, captive and wild, remains largely utilitarian or exploitive. In Cambodia, there is a record of wild Asian elephants coexisting with local communities, but more so a long history of elephants used for labor. This article discusses the possible areas of reconciliation between human and Asian elephant interests at a Mondulkiri elephant sanctuary in Cambodia, suggesting potential paths toward win-win scenarios for the local and indigenous people, as well as for the elephants and their habitats. © 2024 The Authors.

J. Kottwitz, U. Bechert, C. Cruz-Espindola, J.M. Christensen & D. Boothe

Single-dose, multiple-dose, and therapeutic drug monitoring pharmacokinetics of firocoxib in Asian elephants (*Elephas maximus*)

Journal of Zoo and Wildlife Medicine 55 (2024) 73-85

Abstract. Firocoxib is a COSyX-2-selective nonsteroidal anti-inflammatory drug (NSAID) with limited effects on COX-1, which means it likely has fewer side effects than typically associated with other NSAIDs. This study determined possible doses of firocoxib based on single- and multidose pharmacokinetic trials conducted in 10 Asian elephants (*Elephas maximus*). Initially, two single oral dose trials (0.01 and 0.1 mg/kg) of a commercially available tablet (n = 6) and paste (n = 4) formulation were used to determine a preferred dose. The 0.1 mg/kg dose was further evaluated via IV single dose (n = 3) and oral multidose trials (tablets n = 6; paste n = 4). Serum peak and trough firocoxib concentrations were also evaluated in Asian elephants (n = 4) that had been being treated for a minimum of 90 consecutive days. Key pharmacokinetic parameters for the 0.1 mg/kg single-dose trials included mean peak serum concentrations of 49 ± 3.3 ng/ml for tablets and 62 ± 14.8 ng/ml for paste, area under the curve (AUC) of 1,332 ± 878 h*mg/ml for tablets and 1,455 ± 634 h*mg/ml for paste, and half-life (T-1/2) of 34.3 ± 30.3 h for tablets and 19.9 ± 12.8 h for paste. After 8 d of dosing at 0.1 mg/kg every 24 h, pharmacokinetic parameters stabilized to an AUC of 6,341 ± 3,003 h*mg/ml for tablets and 5,613 ± 2,262 for paste, and T-1/2 of 84.4 ± 32.2 h for tablets and 62.9 ± 2.3 h for paste. Serum COX inhibition was evaluated in vitro and ex vivo in untreated elephant plasma, where firocoxib demonstrated preferential inhibition of COX-2. No adverse effects from firocoxib administration were identified in this study. Results suggest administering firocoxib to Asian elephants at a dose of 0.1 mg/kg orally, using either tablet or paste formulations, every 24 h. © 2024 American Assoc. of Zoo Veterinarians.

C.A. LaDue, J.L. Brown, M. Davis, G. Kibe &W.K. Kiso

Relationship between testosterone and sperm motility in Asian elephants (*Elephas maximus*): Potential implications during the sexual state of musth

Theriogenology Wild 4 (2024) e100072

Abstract. Male elephants regularly undergo a unique sexual period of musth that is characterized by elevated testosterone, analogous to the heightened reproductive seasonality of other mammals but distinct because it is nonseasonal and asynchronous among males. Our knowledge of male reproductive biology in elephants is limited compared to females, restricting our ability to effectively manage breeding and ensure optimal welfare, especially during musth. In this study, we analyzed the relationship between serum testosterone concentrations and sperm motility, a measure of semen quality. Semen (n = 152 samples) was collected from four male Asian elephants aged 8 to 47 years housed at the Denver Zoo between 2018 and 2022. For approximately half of the samples (n = 72), serum was also collected within a week of semen collection. Using paired semen and serum samples, we identified significant positive relationships between testosterone concentration and sperm motility in three elephants; the relationship in a fourth elephant trended towards significance. Three elephants exhibited musth during the study; in one elephant, sperm motility was significantly higher during musth, while in the other two, although samples were too limited for statistical analysis, patterns trended the same. Furthermore, two males exhibited increasing motility approaching the start of musth or as musth progressed. Together, these results provide the first evidence of a relationship between testosterone (and perhaps by extension, musth status) and a measure of semen quality in elephants. While further systematic research is warranted, this study has implications for understanding male reproductive activity in a non-seasonally breeding species and motivates innovation in semen collection techniques among Asian elephants to obtain high quality samples even during musth.

C.A. LaDue, M. Davis, R. Emory & R.J. Snyder

Male elephant management in AZA institutions: Current status and priorities for the future

Zoo Biology 43 (2024) 325-339

Abstract. Asian elephant and African savanna elephant populations collectively managed by ex-situ facilities accredited by the Association of Zoos and Aquariums (AZA) face sustainability challenges. Among the priorities to strengthen animal wellbeing and population sustainability is male elephant management. We conducted a survey of AZA facilities currently housing male elephants to assess the status, challenges, and priorities in three areas of male elephant management: musth, socialization, and semen collection. Surveys were administered to elephant care teams at AZA-accredited institutions between November 2022 and February 2023, and we received responses from 34 institutions (91.9% of AZA-accredited facilities holding adult male elephants), housing 32 adult male Asians and 26 adult male Africans. Most facilities prioritized breeding and male socialization over musth management and semen collection (although most facilities acknowledged that all these efforts are important), citing leadership support and staffing as most important to achieve male management goals. Behaviors most commonly accompanying musth included reduced appetite, difficulty training or shifting, human-directed aggression, and interest in females. Musth timing was variable between males and facilities. Most males were well-socialized with females and/or other males, though elephant compatibility and facility design were limiting factors in managing socialization. Although 60.6% of facilities collected semen or were training for semen collection, very few male elephants could reliably provide viable semen samples, challenging assisted reproductive efforts that could bolster population sustainability in both species. Together, our results provide a better understanding of the state of male elephant management, offering specific areas deserving of research and development to enhance wellbeing and sustainability. Our survey of male elephant management across AZA-accredited facilities revealed variation in practices related to musth, socialization, and semen collection, indicating areas for further capacity building. image We surveyed 34 AZA institutions to measure status, priorities, and challenges of major components of male elephant management (musth, socialization, semen collection). Musth management and socialization practices widely varied between institutions, and additional research is needed to characterize implications of this variation for wellbeing and sustainability. Further capacity building is needed to enhance semen collection efforts at the population level.

S. Lee, S. Hong, J. Kim & Z.M. Meng

Exploring the role of ethical experiences and psychological well-being in travel satisfaction: An animal welfare perspective in elephant-based tourism

Tourism Management Perspectives 51 (2024) e101248

Abstract. No permission to print abstract.

W. Li, P. Liu, N. Yang, S. Chen, X. Guo, B. Wang & Li Zhang

Improving landscape connectivity through habitat restoration: Application for Asian elephant conservation in Xishuangbanna Prefecture, China

Integrative Zoology 19 (2024) 319-335

Abstract. Habitat restoration is an effective method for improving landscape connectivity, which can reduce habitat fragmentation. Maintaining landscape connectivity could promote connections between habitat, which is extremely essential to preserve gene flow and population viability. This study proposes a methodological framework to analyze landscape connectivity for Asian elephant habitat conservation, aiming to provide practical options for reducing habitat fragmentation and improving habitat connectivity. Our approach involved combining a species distribution model using MaxEnt and landscape functional connectivity models using graph theory to assess the impact on connectivity improvement via farmland/plantation restoration as habitat. The results showed that: (1) there were 119 suitable habitat patches of Asian elephant covering a total area of 1952.41 km^2. (2) The connectivity between habitats improved significantly after vegetation restoration and the gain first decreased and then increased with the increase of dispersal distance. (3) The first few new habitat patches that were identified played an important role in improving connectivity, and the variation rate of connectivity gradually leveled off as the number of new habitats increased. (4) Prioritization of the 25 best new habitat patches increased connectivity from 0.54% to 5.59% as the dispersal distance increased and mainly was located between two Asian elephant distribution regions and two components. Establishment of new habitat patches was effective for improving or restoring connectivity. Our findings can be used as guidance for improving the studied fragmented Asian elephant habitats, and they can also be used as a reference for the habitat restoration of other endangered species heavily affected by habitat fragmentation.

G. Maurer, M. Chandelier, B. Mulot & O. Gimenez

Polarized media coverage of conflicting, yet emblematic species: The ambivalent portrayal of the Asian elephant

Biological Conservation 289 (2024) e110391

Abstract. Species involved in human-wildlife conflicts are likely to generate polarized framings in the media. Because media contribute to shaping public opinion, an analysis of wild species in the media helps documenting perceptions and attitudes towards wildlife. The case of the Asian elephant is illustrative because of its ambivalent perception, holding strong cultural and symbolic dimensions, but also feared due to increasing damages and casualties. Through this case, we investigate how media portray an endangered species, both feared and revered. We used text mining, social network and lexical analysis to analyze 11,000 news articles dealing with Asian elephants over 13 years. We found a multifaceted image of the species with various framings. Most prevalent topics were local events recounting damages on crops, villagers' and elephants' deaths. Media also covered various topics from international traffic to conflict mitigation and conservation programs. Thematic articles depicted an institutional representation of human-elephant interactions focusing on global trends and management schemes, using a technical and sanitized lexicon. Conversely, event-driven reports were anchored in spatial and temporal lexicon, recounting elephant encounters and their specific behaviors, while quoting inhabitants with a highly emotional narrative. Our study suggests that event-driven articles highlighted the emotional response to damages caused by individual elephants rather than the demonization of the species. We suggest that, in the context of human-wildlife conflicts, fear and trauma should be better acknowledged to help reducing discrepancies found in media narratives before it fosters other sentiments such as anger and frustration that may impede conservation efforts.

G. Maurer, M.-P. Dubois, Z.M. Oo, V. Chanthavong, B. Mulot, O. Gimenez & F. Kjellberg

Genetic structure and diversity of semi-captive populations: The anomalous case of the Asian elephant

Conservation Genetics 25 (2024) 973-984

Abstract. Wild species living in captivity are subject to loss of genetic diversity, inbreeding depression, and differentiation among populations. Only very few species have been under human care for centuries but have not been selectively bred, have free-ranging movements most of the time, and retain porous barriers to gene flow between wild and captive populations. Such captive populations are expected to retain high levels of genetic diversity and anthropogenic factors should result in a limited genetic differentiation from wild populations. Asian elephants have been trained and used by humans for at least 4000 years as war animals, mounts of kings and draught animals. In Myanmar and Laos, elephants are still being used for hauling timber in the forest while retaining traditional management practices including seasonal release, free mating and movement. However, habitat fragmentation, isolation and reduced gene flows are threatening both semi-captive and wild pools. We genotyped 167 semi-captive elephants from Laos and Myanmar using a panel of 11 microsatellite loci to estimate the genetic diversity and population structure. We found that elephants of both countries presented high levels of genetic diversity and a low degree of inbreeding, if any. This agrees with the expected high level of genetic diversity in semi-captive populations. We found a weak differentiation along a geographical gradient from southern Laos to northern Myanmar but no differentiation between wild-caught and captive-born pools. The potential value for conservation of a large population of semi-captive elephants has been recognized but the conservation community has yet to fully explore the potential role semi-captive elephants could play in maintaining gene flows.

A. McGuire, M. Kienlen, R. Emory & C.A. LaDue

Overnight monitoring reveals the behavioral rhythms of a geriatric male elephant: An animal-centered case study of rest and stereotypy

Frontiers in Conservation Science 5 (2024) e1362313

Abstract. Monitoring overnight behavior is important in assessing the overall wellbeing of ex-situ elephant populations, with recumbent rest and stereotypy as key indicators of welfare. However, there have been few studies that address the overnight behavior of singly housed male elephants with a history of stereotypy. We conducted an opportunistic case study of the overnight behavior (i.e., rest and stereotypy) of a singly housed geriatric male Asian elephant at the Oklahoma City Zoo to identify his overnight behavioral rhythms in response to physiological (musth) and environmental changes (habitat access, automatic timed feeders) and guide management strategies. Infrared cameras were utilized to conduct continuous focal-animal sampling of the elephant's behavior between 20:00 and 08:00 in indoor and outdoor habitats. Sampling occurred from January 2023 to October 2023, with a total of 179 overnight observations. The elephant exhibited recumbent rest for 175.66 +/- 6.80 (mean +/- SE) minutes per night and was engaged in stereotypy for 175.88 +/- 9.68 minutes per night. While there was no significant relationship between stereotypy and the sexual state of musth, musth was associated with reduced durations of recumbent rest. Access to both indoor and outdoor habitats was significantly related to decreased stereotypy compared to indoor-only treatments. Recumbent rest occurred most frequently between 02:00 and 05:00, and stereotypic behavior was most common between 06:00 and 08:00. Contrary to our expectations, automatic feeders did not significantly reduce stereotypy. The results of this study provide insight into the behavioral patterns of a geriatric male Asian elephant, demonstrating the importance of implementing an animal-centered approach to enhance animal wellbeing. As the zoo-housed Asian elephant population grows and continues to age, this case study emphasizes the importance of developing comprehensive welfare strategies for the elephants in our care.

P. Mohandas, J.S. Anni, T. Choudhury & R. Thanasekaran

Elephant movement mapping in Hosur forest border areas to detect the elephant intrusion pattern and mitigation measures to resolve

human-elephant conflict
GeoJournal 88 (2023) S3-S14
Abstract. No permission to print abstract.

H. Moullec, V. Berger, D.J. Santos, S. Ukonaho, L. Yon, M. Briga, U.K. Nyein, V. Lummaa & S. Reichert
Testosterone variation in a semi-captive population of Asian elephants in Myanmar
Conservation Physiology 12 (2024) coae076
Abstract. Hormones are known to be involved in life-history trade-offs as systemic signals that establish functional links among traits and regulate key behavioural and physiological transitions between states in organisms. Although major functions of many steroid hormones such as testosterone are conserved among vertebrates, circulating concentrations vary widely both within and across species, and the degree to which observed hormone concentrations mediate life-history responses to environmental variation is less understood. In this study, we investigated how faecal testosterone metabolite (FTM) concentrations varied with extrinsic and intrinsic factors. To do so, we took advantage of a 6-year period of longitudinal sampling of FTM, indicators of stress and oxidative status in a semi-captive population of Asian elephants (n = 3163 samples from 173 individuals) in Myanmar. We determined how the variation in FTM is associated with age, sex, origin (captive-born or wild-caught), seasonality of the environment, individual stress level [measured by faecal glucocorticoid metabolite (FGM) and heterophil to lymphocyte ratio (H/L)] and oxidative status (reactive oxygen metabolite concentrations and superoxide dismutase activity). We reported that FTM increased with age from juvenile to adulthood for both sexes, with higher FTM concentrations in males than females. Moreover, elephants showed significantly higher FTM concentrations during the hot season and monsoon than in the cold season. However, for the physiological indicators, we found contrasting results. While FTM concentrations were strongly positively correlated with FGM concentrations, FTM concentrations were not related to H/L ratios. Finally, we found no relationship between FTM and the oxidative status of individuals. Our study provides new insights on the factors associated with variation in testosterone concentrations-a key hormone for reproduction and fitness of individuals-in Asian elephants living in their natural environment, which has relevance for effective conservation measures of this endangered species. © 2024 The Authors.

L. Natarajan, P. Nigam & B. Pandav
Impacts of passive elephant rewilding: Assessment of human fatalities in India
Environmental Conserv. 50 (2023) 186-191
Abstract. No permission to print abstract.

C. Negus, A. Pinyopummin, S. Mahasawangkul, R. Hobbs & R. Bathgate
Asian elephant (*Elephas maximus*) seminal plasma: Establishing the proteome and effect on spermatozoa when added to cryomedium
Reproduction Fertility and Development 36 (2024) QC12106
Abstract. The removal or supplementation of ejaculates with seminal plasma (SP) can affect cryotolerance and post-thaw survival of spermatozoa in many species. In the Asian elephant, elucidation of the SP proteome and investigation of how it affects spermatozoa may enable improvement of cryopreservation protocols. Herein, we characterise the Asian elephant SP proteome and investigate the impacts of SP on sperm cryotolerance in the presence of conspecific or heterospecific SP. Proteomic analysis of Asian elephant SP was performed using mass spectrometry on nine samples from three individuals. In a separate study, SP was removed from six ejaculates and spermatozoa were resuspended in Tris extender supplemented with: no seminal plasma (NOSP), conspecific SP from ejaculates exhibiting 'good' (GSP, >60%) or mixed sperm total motility (MSP), or horse SP (HSP). Samples underwent cryopreservation, and sperm parameters were compared prior to cryopreservation and after thawing (0 and 2 h). Mass spectrometry identified 155 proteins from an array of families. Significant differences were observed in post-thaw sperm quality between SP treatments: high concentrations of MSP (25%, v/v) displayed greater average path and straight-line velocity immediately after thawing ($P < 0.05$) and greater sperm motility index and beat cross frequency than NOSP after 2 h post-thaw incubation ($P < 0.05$). The addition of HSP improved sperm kinematic parameters compared to NOSP and GSP treat-

ments ($P < 0.05$). These preliminary findings suggest the potential of SP to enhance the cryosurvival of Asian elephant spermatozoa, with HSP showing particularly promising results compared to conspecific SP (GSP). Further research into the specific effects of Asian elephant SP proteins is warranted. © 2024 The Authors.

R. Noda, M.F. Mechenich, J. Saarinen, A. Vehtari & I. Zliobaite

Predicting habitat suitability for Asian elephants in non-analog ecosystems with Bayesian models

Ecological Informatics 82 (2024) e102658

Abstract. Rewilding is an ambitious approach to conservation aiming at restoring and protecting natural processes. As the world is rapidly transitioning into conditions that have not been observed before, we need to be able to extrapolate and predict how natural processes would act under new conditions. Species distribution models have a good potential to inform rewilding decisions by the predictive modelling of potential species presence under various habitat conditions. A critical requirement when utilizing these models is to be able to express the uncertainty in the environment or its predictions. This study demonstrates the use of Bayesian statistical models to address this challenge. As a case study, we explore Bayesian logistic regression and Bayesian generalized additive models in order to predict suitable habitats for Asian elephants until the year 2070 under the worst case working scenario of climate change. In this comparative study predictions of habitat suitability are solely based on climatic conditions. The results of the two Bayesian models are compared to two benchmark models, maximum-likelihood estimated logistic regression and random forest. We analyze and discuss trade-offs, relative advantages, and limitations of these modelling choices. The results of our analysis suggest that one configuration of Bayesian logistic regression gives the most robust predictions in this setting, which tend to correspond with the distribution of woodland biomes broadly similar to those in the species ' historical range. © 2024 The Authors.

C. E. O'Connell-Rodwell, J.L. Berezin, A. Dharmarajan, M.E. Ravicz, Y. Hu, X. Guan, K.N. O'Connor & S. Puria

The impact of size on middle-ear sound transmission in elephants, the largest terrestrial mammal

PLoS One 19 (2024) e0298535

Abstract. Elephants have a unique auditory system that is larger than any other terrestrial mammal. To quantify the impact of larger middle ear (ME) structures, we measured 3D ossicular motion and ME sound transmission in cadaveric temporal bones from both African and Asian elephants in response to air-conducted (AC) tonal pressure stimuli presented in the ear canal (PEC). Results were compared to similar measurements in humans. Velocities of the umbo (VU) and stapes (VST) were measured using a 3D laser Doppler vibrometer in the 7-13,000 Hz frequency range, stapes velocity serving as a measure of energy entering the cochlea-a proxy for hearing sensitivity. Below the elephant ME resonance frequency of about 300 Hz, the magnitude of VU/PEC was an order of magnitude greater than in human, and the magnitude of VST/PEC was 5x greater. Phase of VST/PEC above ME resonance indicated that the group delay in elephant was approximately double that of human, which may be related to the unexpectedly high magnitudes at high frequencies. A boost in sound transmission across the incus long process and stapes near 9 kHz was also observed. We discuss factors that contribute to differences in sound transmission between these two large mammals. © 2024 The Authors.

S. Pahari, R. Joshi & U. Paudel

Navigating coexistence: Addressing human-elephant encounters in the buffer zone of Bardiya National Park, Nepal

Journal of Resources and Ecology 15 (2024) 412-421

Abstract. The Asian elephant is one of the important megafaunas in protected areas of the Terai (lowland) region of Nepal. They often encounter humans and their livelihood-supporting activities in the proximity of forest boundary within the protected area. The human-elephant conflict (HEC) has been one of the major issues in the human settlement close to the protected area, which has caused economic losses and poised a threat to human lives every year. The issue has obstructed sustainable management initiatives within the protected areas. The ob-

jective of the study is to analyze the cause of the HEC in the Buffer Zone of Bardiya National Park and to assess people's perception of this megafauna. The structured questionnaire survey was done in three municipalities within the Buffer Zone of Bardiya National Park. Besides, key informants' interview was done to supplement the questionnaire survey. The result shows that 93% of the respondents have been a victim of elephant attacks in the past three years. Last year, on average, each household lost approximately NRs 9690 (USD 1 = NRs 132.72) worth of stored harvest due to the elephant attack. Most of the attack occurs during the season between July to September, followed by the season between October to December. It also indicates that the preference of elephants for crops is the primary cause of elephant attacks/raids in the study area. The second important cause of the elephant attack is insufficient food base which is followed by the expansion of agricultural fields towards the forest. Ninety percent of respondents react to the elephant attack by chasing them (using fire or noise). Fifty-one percent of respondents accept the human-elephant coexistence because of their biological and economic values. However, 40% of them reject the coexistence because of the threat posed by the elephant upon the local people and their livelihood. HEC hinders the management campaign and therefore has to be resolved through collaboration of the protected area, the local people and the administrative stakeholders. It is suggested that more study has to be made to acknowledge the pattern of residing as well as migrating elephants around forest boundaries and adjacent settlements.

H.S. Palei, A.K. Jangid, D.D. Hanumant, N.C. Palei & A.K. Mishra

On the elephant trails: Habitat suitability and connectivity for Asian elephants in eastern Indian landscape

Peerj 12 (2024) e16746

Abstract. Identifying suitable habitats and conserving corridors are crucial to the long-term conservation of large and conflict-prone animals. Being a flagship species, survival of Asian elephants is threatened by human-induced mortality and habitat modification. We aimed to assess the habitat suitability and connectivity of the Asian elephant habitat in the state of Odisha in eastern India. We followed the ensemble of spatial prediction models using species presence data and five environmental variables. We used least-cost path and circuit theory approaches to identify the spatial connectivity between core habitats for Asian elephants. The results revealed that normalized difference vegetation index (NDVI; variable importance 42%) and terrain ruggedness (19%) are the most influential variables for predicting habitat suitability of species within the study area. Our habitat suitability map estimated 14.6% of Odisha's geographical area (c. 22,442 km^2) as highly suitable and 13.3% (c. 20,464 km^2) as moderate highly suitable. We identified 58 potential linkages to maintain the habitat connectivity across study area. Furthermore, we identified pinch points, bottlenecks, and high centrality links between core habitats. Our study offers management implications for long-term landscape conservation for Asian elephants in Odisha and highlights priority zones that can help maintain spatial links between elephant habitats. © 2024 The Authors.

A. Pandit, J. Thapa, A. Sadaula, Y. Suzuki, C. Nakajima, S.K. Mikota, N. Subedi, B.K. Shrestha, M. Shimozuru, B. Shrestha, B. Raya, S. Chaudhary, S. Paudel & T. Tsubota

Epidemiology and molecular characterization of *Mycobacterium tuberculosis* including a drug-resistant strain associated with mortality of Asian elephants in Nepal 2019–2022

Tuberculosis 148 (2024) e102550

Abstract. No permission to print abstract.

U. Paudel, K.C. Rabin Bahadur, R. Kadariya, A. Karki, B. P. Shrestha, S. K. Shah, N. Subedi & S.K. Thapa

Human-wildlife conflict in Bardia-Banke Complex: Patterns of human fatalities and injuries caused by large mammals

Ecology and Evolution 14 (2024) e70395

Abstract. Human fatalities and injury from wildlife attacks often result in a negative attitude toward conservation. This research was undertaken to investigate the patterns and conflict-causing factors of human killing and injury by large mammals, especially by Asian elephant, common leopard, and Bengal tiger in the Bardia-Banke Complex of western Nepal. We collected human death and injury records

caused by wildlife in the Bardia-Banke Complex between 2019 and 2023, based on relief applications submitted by the victim's family. Additionally, camera trap monitoring was conducted following incidents of human-tiger and human-leopard conflicts. A total of 76 incidents involving human casualties and injuries were considered for analysis. Incidents of livestock depredation, crop raiding, and property damage were excluded from the analysis. Most of the attacks on humans were caused by tigers (75%), followed by elephants (16%) and leopards (9%). Almost all incidents occurred in daytime (97%). The highest number of conflicts were recorded in 2021, with 20 incidents. Most of the cases (84%) occurred within 1 km of forest edge. Khata corridor and the western side of the Bardia National Park, i.e., Karnali River corridor, were identified as high-conflict areas. The primary causes of the conflict manifested in cattle grazing (28%), grass cutting (28%), firewood collection (11%), fishing (8%) and vegetable collection (5%). To promote human-wildlife coexistence, community-based patrols (33%), habitat restoration (26%), electric fencing (26%), and insurance (7%) were identified as the preferred strategies. Therefore, we recommend that stakeholders and concerned bodies increase awareness among local community about the use of forest resources, wildlife behavior, and human-wildlife conflict mitigation strategies. © 2024 The Authors.

A. Purathekandy, M.A. Oommen, M. Wikelski & D.N. Subramani

An agent-based model of elephant crop raid dynamics in the Periyar-Agasthyamalai complex, India

Ecological Modelling 496 (2024) e110843

Abstract. No permission to print abstract.

A.K. Ram, B.R. Lamichhane, N. Subedi, N.K. Yadav, A. Karki, B. Pandav, C. Brown, T.B. Khatri & C.B. Yackulic

Dynamic occupancy modelling of Asian elephants (*Elephas maximus*) reveals increasing landscape use in Nepal

Scientific Reports 14 (2024) e20023

Abstract. Large mammals with general habitat needs can persist throughout mixed used landscapes, however, human-wildlife conflict frequently leads to their restriction to protected areas. Conservation efforts, especially for reducing conflicts with humans, can enhance tolerance of humans towards species like Asian elephants in human-dominated landscapes. Here, we examine how elephant use in the Chure Terai Madhesh Landscape (CTML) covering the entire elephant range of Nepal changed between 2012 and 2020 in relationship to protection status and environmental conditions. We systematically surveyed similar to 42,000 km^2 of potential habitat, by dividing the study area into 159 grid cells of 15 x 15 km^2 and recorded elephant signs during the cool, dry season in three years (2012, 2018 and 2020). We analyzed the survey data in a single-species, multi-season (dynamic) occupancy modeling framework to test hypotheses regarding the influence of environmental conditions and protected area status on landscape use by elephants over time. The best-supported model included protected area effects on initial use, colonization, and detection probability as well as temporal variation in colonization and detection probability. Initial use and colonization rates were higher in protected areas, however elephants increasingly used cells located both inside and outside the protected areas, and the difference in use between protected areas and outside declined as elephants use became prevalent across most of the landscape. While elephant use was patchily distributed in the first year of surveys consistent with past descriptions of four sub-populations, elephant use consolidated into a western and eastern region in subsequent years with a gap in their distribution occurring between Chitwan and Bardiya National Parks. Our manuscript highlights the increasing landscape use by elephants in both protected areas and areas outside protected areas and suggests that management interventions that focus on reducing conflicts can promote greater use of both protected areas and areas outside of protected areas. © 2024 The Authors.

G. Rich, R. Stennett, M. Galloway, M. McClure, R. Riley, E.W. Freeman & K.E. Hunt

Nailing it: Investigation of elephant toenails for retrospective analysis of adrenal and reproductive hormones

Conservation Physiology 12 (2024) coae048

Abstract. Hormone monitoring of at-risk species can be valuable for evaluation of individual

physiological status. Traditional non-invasive endocrine monitoring from urine and faeces typically captures only a short window in time, poorly reflecting long-term hormone fluctuations. We examined toenail trimmings collected from African and Asian elephants during routine foot care, to determine if long-term hormone patterns are preserved in these slow-growing keratinized tissues. We first measured the growth rate of elephant toenails biweekly for one year, to establish the temporal delay between deposition of hormones into nail tissue (at the proximal nail bed) and collection of toenail trimmings months later (at the distal tip of the nail). In African elephants, toenails grew similar to 0.18 ± 0.015 mm/day (mean ± SEM) and in Asian elephants, toenails grew similar to 0.24 ± 0.034 mm/day. This slow growth rate, combined with the large toenail size of elephants, may mean that toenails could contain a 'hormone timeline' of over a year between the nail bed and nail tip. Progesterone, testosterone and cortisol were readily detectable using commercial enzyme immunoassays, and all assays passed validations, indicating that these hormones can be accurately quantified in elephant toenail extract. In most cases, variations in hormone concentrations reflected expected physiological patterns for adult females and males (e.g. ovarian cycling and musth) and matched individual health records from participating zoos. Progesterone patterns aligned with our calculations of temporal delay, aligning with female ovarian cycling from over six months prior. Unexpectedly, male testosterone patterns aligned with current musth status at the time of sample collection (i.e. rather than prior musth status). Though this sample type will require further study, these results indicate that preserved hormone patterns in elephant toenails could give conservationists a new tool to aid management of elephant populations. © 2024 The Authors.

M. Salas, O. Tallo-Parra & X. Manteca
Evidence-based zoo animal welfare assessment: Putting science into practice
Journal of Zoo and Aquarium Research 12 (2024) 205-211
Abstract. This comprehensive review explores evidence-based strategies for assessing and enhancing animal welfare in modern zoos and aquariums. The two primary objectives are to explore the ways in which understanding behavioural biology and natural history of a given species can enhance zoo animal welfare assessments and discuss how current knowledge of fundamental principles regarding animal behaviour and physiology can help identify and validate welfare indicators. Species-specific protocols, generic protocols and risk assessment methods are examined and the complexities of using natural behaviour as a welfare indicator are explored, acknowledging the inherent challenges of comparing captive and wild behaviours. Behavioural indicators as predominant tools in welfare assessment are analysed for their selection, development and validation. Challenges such as observer bias and external influences are discussed, highlighting the importance of ongoing research and collaboration for refining behavioural indicators. The review extends to physiological indicators, focusing on their diversity and complementarity with behavioural assessments. The selection process involves consideration of species-specific characteristics, biological matrices and sampling methodology. Challenges in the validation of physiological indicators are discussed, underlining the need for comprehensive studies. In conclusion, this review advocates for an integrated, evidence-based approach that combines behavioural and physiological indicators, acknowledging the challenges and offering practical insights for advancing animal welfare in zoo settings.

C. Schiffmann, L. Schiffmann, P. Prager, J. Pastorini, M. Clauss & D. Codron
Face to face: Human recognition of Asian elephant facial features
Mammalian Biology 104 (2024) 389-394
Abstract. No permission to print abstract.

Schulz, A. K., L. V. Kaufmann, N. Reveyaz, C. Ritter, T. Hildebrandt and M. Brecht (2024)
Elephants develop wrinkles through both form and function
Royal Society Open Science 11(10).
Abstract. The trunks of elephants have prominent wrinkles from their base to the very tip. But neither the obvious differences in wrinkles between elephant species nor their development have been studied before. In this work, we char-

acterize the lifelong development of trunk wrinkles in Asian and African elephants. Asian elephants have more dorsal major, meaning deep and wide, trunk wrinkles (approx. 126 +/- 25 s.d.) than African elephants (approx. 83 +/- 13 s.d.). Both species have more dorsal than ventral major trunk wrinkles and a closer wrinkle spacing distally than proximally. In Asian elephants, wrinkle density is high in the 'trunk wrapping zone'. Wrinkle numbers on the left and right sides of the distal trunk differed as a function of trunk lateralization, with frequent bending in one direction causing wrinkle formation. Micro-computed tomography (microCT) imaging and microscopy of newborn elephants' trunks revealed a constant thickness of the putative epidermis, whereas the putative dermis shrinks in the wrinkle troughs. During fetal development, wrinkle numbers double every 20 days in an early exponential phase. Later wrinkles are added slowly, but at a faster rate in Asian than African elephants. We discuss the relationship of species differences in trunk wrinkle distribution and number with behavioural, environmental and biomechanical factors. © 2024 The Authors.

T.T. Shameer, P. Routray, A. Udhayan, N. Ranjan, M. G. Ganesan, A. Manimozhi & D. Vasanthakumari

Understanding the patterns and predictors of human-elephant conflict in Tamil Nadu, India

European Journal of Wildlife Research 70 (2024) e95

Abstract. No permission to print abstract.

K. Sharma, K. Mathesh, P. Janmeda, S. Nautiyal, P.S. Lakshmi, A. Subash, S. Mahajan, R. Agrawal, A.M. Pawde & G.K. Sharma

Production and characterization of biologicals for disease diagnosis and pathological evaluation of elephant endotheliotropic herpesvirus (EEHV)

J. of Virological Methods 329 (2024) e114970

Abstract. No permission to print abstract.

R. Sharma, R. De, J.-P. Puyravaud, J. Parida, A. Sedhupathy, T. Kalam, A. Rahim, K.M. Selvan, N. Arumugam, S. P. Goyal & P. Davidar

Patterns of genetic diversity, gene flow and genetic structure of three Peninsular Indian elephant populations indicate population connectivity

Conservation Genetics 25 (2024) 1175-1193

Abstract. No permission to print abstract.

M. Shi, F. Chen, S.K. Sahu, Q. Wang, S. Yang, Z. Wang, J. Chen, H. Liu, Z. Hou, S.-G. Fang & T. Lan

Haplotype-resolved chromosome-scale genomes of the Asian and African savannah elephants

Scientific Data 11 (2024) e63

Abstract. The Proboscidea, which includes modern elephants, were once the largest terrestrial animals among extant species. They suffered mass extinction during the Ice Age. As a unique branch on the evolutionary tree, the Proboscidea are of great significance for the study of living animals. In this study, we generate chromosome-scale and haplotype-resolved genome assemblies for two extant Proboscidea species (Asian Elephant, Elephas maximus and African Savannah Elephant, Loxodonta africana) using Pacbio, Hi-C, and DNBSEQ technologies. The assembled genome sizes of the Asian and African Savannah Elephant are 3.38 Gb and 3.31 Gb, with scaffold N50 values of 130 Mb and 122 Mb, respectively. Using Hi-C technology similar to 97% of the scaffolds are anchored to 29 pseudochromosomes. Additionally, we identify similar to 9 Mb Y-linked sequences for each species. The high-quality genome assemblies in this study provide a valuable resource for future research on ecology, evolution, biology and conservation of Proboscidea species. © 2024 The Authors.

R. Singh, R. Negi, A.I. Gonji, N. Sharma & R.K. Sharma

Past shadows and gender roles: Human-elephant relations and conservation in Southern India

Journal of Political Ecology 31 (2024) 604-623

Abstract. Some conceptual thinking about human-wildlife relations has lacked translations into empirical studies with an in-depth enquiry into social, cultural, economic and ecological aspects. This study explores human-elephant relations in a cohabited landscape in the Western Ghats of India, with a focus on 'more than conflict' relations. The Valparai plateau, in the Indian Western Ghats, is a landscape dominated

by tea estates and remnants of rainforest fragments where human communities cohabit and closely interact with wildlife. We offer an empirical contribution on the variegated and paradoxical relation between care and fear, between empathy and hate and between the residents and elephants of Valparai. Where conflicts occur between elephants and humans, they have multiple meanings. Gender and unpleasant memories serve as drivers of negative attitudes towards wildlife. A conservation intervention based on engagement and collaboration with local people was perceived as highly effective. Preventive and mitigative, rather than reactive conflict mitigation strategies may have a significant role to play in maintaining the social carrying capacity of local communities towards elephants. We explore the many facets of human-elephant relations, and the numerous entanglements between them, thereby adding multiple layers to the extant knowledge of human-animal relations in the Western Ghats.

J. Supanta, J.L. Brown, P. Bansiddhi, C. Thitaram, V. Punyapornwithaya, K. Punturee, P. Towiboon, N. Somboon & J. Khonmee

Physiological changes in captive elephants in northern Thailand as a result of the COVID-19 tourism ban-stress biomarkers

Frontiers in Vet. Science 10 (2023) e1303537

Abstract. The international travel ban instituted by the Thai government in March 2020 in response to the COVID-19 pandemic greatly affected how tourist camp elephants were managed, with reductions in exercise opportunities, longer chaining hours, and diminished food provisioning. This study was conducted to determine how those changes affected health and welfare biomarkers in individual elephants over the 2 years of the countrywide lockdown (April 2020-April 2022). Blood and fecal samples were collected from 58 elephants at six camps (monthly in Year 1, quarterly in Year 2) and analyzed for stress biomarkers - fecal glucocorticoid metabolites (fGCM), serum oxidative stress [malondialdehyde (MDA) and 8-hydroxy-2 '-deoxyguanosine (8-OHdG)], and stress leukograms. Overall, fGCM concentrations increased within the first few months and remained higher than pre-COVID levels, as did the H/L ratio, a measure affected by cortisol. Serum 8-OHdG, an indicator of DNA oxidative damage, also increased over time, while monocytosis and lymphopenia further suggested alterations in immune function as a result of stress. By contrast, another marker of oxidative stress, serum MDA, declined, possibly in response to reduced roughage and supplement intake. A notable finding was a seasonal pattern of fGCM that was significantly different from previous studies. Whereas higher fGCM during the rainy season were observed in this study, previously, concentrations were highest during the winter, high tourist season. Thus, ironically, both the presence and absence of tourists have been associated with increased fGCM concentrations, albeit for different reasons. Camp management factors negatively affecting stress outcomes included shorter chain lengths, longer chain hours, lack of exercise, and reduced roughage and supplements. Overall, it was clear that camps struggled to maintain adequate care for elephants during the COVID-19 pandemic, highlighting the importance of tourist income and need for contingency plans to cope with potential future disruptions to tourism.

K. Suresh, C. Wilson, A. Quayle, S. Managi & U. Khanal

Are farmers willing to accept compensation from tourism revenue for elephant crop damage and coexistence support? Evidence from Sri Lanka

Ecological Economics 224 (2024) e108300

Abstract. No permission to print abstract.

N. Sutthiboriban, A. Simcharoen, G.A. Gale, D. Ngoprasert, W. Chutipong & N. Tantipisanuh

Factors affecting crop damage by elephants in the buffer zone of Huai Kha Khaeng, a world heritage site

Pacific Conserv. Biology 30 (2024) PC23061

Abstract. Human-elephant conflict is a growing global problem. To mitigate such conflict, understanding factors affecting elephant intrusions into human-dominated areas is crucial. These factors are, however, complex because they are site specific and context dependent. This study aimed to identify factors associated with crop damage incidents from elephants in a buffer zone of a protected area in western Thailand. Interviews were conducted with local people to quantify crop damage by elephants

between November 2020 to April 2021. We used compositional analysis to determine whether different crop types received different damage from elephants, and logistic regression analysis to examine environmental factors associated with crop damage incidents. Although it was previously thought that elephants focus on dominant palatable crops, we found that small patches of highly preferred crops can influence where elephants choose to feed. Distance from village was also a significant factor in crop foraging. Crop damage was not different between dry and wet seasons, probably because key crops were available year-round. Crop damage occurred across multiple crop types but mainly those with higher sugar content. The damage mostly occurred in fields farther from villages, suggesting that presence of humans may alter elephant crop foraging. No specific seasonal period of crop damage was observed. Changing crop types from species preferred by elephants to less preferred species and growing mixed species (multi-crop systems) instead of single species (mono-crops) may reduce elephant incursions. However, this needs field testing, including market-based assessments to evaluate the economic viability for farmers. Human-elephant conflicts occur frequently across countries within the elephant species range, but solutions remain elusive and are probably site-specific. In our study in western Thailand, pineapple received the most damage. Plantations further away from villages and those with larger areas of corn (an elephant-preferred crop) were associated with more crop damage. Based on local experience, planting multiple crops less preferred by elephants may reduce conflicts.

H. Sylvester, J. Raines, A. Burgdorf-Moisuk, M. Connolly, S. Wilson, L. Ripple, S. Rivera, S. McCain & E. Latimer

Selected instances of elephant endotheliotropic herpesvirus shedding in trunk secretions by African elephants (*Loxodonta africana*) in comparison to shedding by Asian elephants (*Elephas maximus*)

Journal of Zoo and Wildlife Medicine 55 (2024) 182-194

Abstract. This study examined the viral shedding kinetics of elephant endotheliotropic herpesvirus (EEHV) in African elephants compared to viral shedding behavior in Asian elephants. Little is known about the transmission dynamics and epidemiology of this disease in African elephants. In light of recent clinical cases and mortalities, this paper aims to identify trends in viral biology. Trunk wash samples were collected from 22 African elephants from four North American zoological institutions that had recently experienced herd viremias or translocations. Processing of these samples included DNA extraction followed by qPCR to quantitate viral DNA load. The results were then compared with available literature that chronicled similar cases in Asian and African elephants. Minimal EEHV shedding was detected in response to varied herd translocations. Increased shedding was recorded in herds in which an elephant experienced an EEHV viremia when compared to baseline shedding. These index infections were followed by subsequent viremias in other elephants, although it is not known if these were recrudescence, transient controlled viremias, and/or primary infections via transmission to other elephants. When compared to historically published data, it was observed that EEHV3 cases in African elephants and EEHV1A cases in Asian elephants had consistently higher levels of viral DNA in the blood than were shed in trunk secretions, a fact that is seemingly inconsistent with such severe cases of disease and the high mortality rates associated with those respective types. The findings produced in this study highlight the need for more routine monitoring of viral shedding in African elephant herds to elucidate possible EEHV transmission and recrudescence factors for ex situ population management. © 2024 American Association of Zoo Veterinarians.

K. Takehana, T.E. Hoornweg, W. Schaftenaar, V.P. Rutten, C.A. De Haan & K. Matsuno

Elephant endotheliotropic herpesvirus gB-specific antibody levels in sera of Asian elephants (*Elephas maximus*) in Japanese zoos

Journal of Veterinary Medical Science 86 (2024) 1279-1283

Abstract. Prevalence of elephant endotheliotropic herpesvirus (EEHV) infections in Asian elephants in Japan was assessed by determination of EEHV gB specific antibody levels. Among 28 healthy Asian (sub) adult elephants from 11 zoos, 27 animals exhibited intermediate

to high antibody levels. Like elsewhere worldwide, this suggested exposure of Asian elephants in Japan to at least one EEHV (sub) species. Longitudinal observations of two elephants monitored from birth to 30-month of age showed consistent high antibody levels. Another juvenile showed antibody levels that decreased to undetectable levels prior to death at 13 months of age. This fatal case supports earlier reports that low antibody levels are a risk factor for development of EEHV hemorrhagic disease.

N.R. Talukdar, P. Choudhury & F. Ahmad
Human-elephant conflict hotspots in Assam: A rapid appraisal method
Biodiversity and Conserv. 33 (2024) 2231-2245
Abstract. No permission to print abstract.

H.B. Tilley, D. Murphy, K. Wierucka, T.C. Wong, A. Surreault-Chable & H.S. Mumby
Physical activity and temperature changes of Asian elephants (*Elephas maximus*) participating in eco-tourism activities and elephant polo
PLoS One 19 (2024) e0300373
Abstract. Captive and domestic animals are often required to engage in physical activity initiated or organised by humans, which may impact their body temperature, with consequences for their health and welfare. This is a particular concern for animals such as elephants that face thermoregulatory challenges because of their body size and physiology. Using infrared thermography, we measured changes in skin temperature associated with two types of physical activity in ten female Asian elephants at an ecotourism lodge in Nepal. Six elephants took part in an activity relatively unfamiliar to the elephants-a polo tournament-and four participated in more familiar ecotourism activities. We recorded skin temperatures for four body regions affected by the activities, as well as an average skin temperature. Temperature change was used as the response variable in the analysis and calculated as the difference in elephant temperature before and after activity. We found no significant differences in temperature change between the elephants in the polo-playing group and those from the non-polo playing group. However, for both groups, when comparing the average skin body temperature and several different body regions, we found significant differences in skin temperature change before and after activity. The ear pinna was the most impacted region and was significantly different to all other body regions. This result highlights the importance of this region in thermoregulation for elephants during physical activity. However, as we found no differences between the average body temperatures of the polo and non-polo playing groups, we suggest that thermoregulatory mechanisms can counteract the effects of both physical activities the elephants engaged in.

L. Urban, R. Becker, A. Ochs, F. Sicks, M. Brecht & L.V. Kaufmann
Water-hose tool use and showering behavior by Asian elephants
Current Biology 34 (2024) 5602-5606
Abstract. Since Jane Goodall's famous observations of stick tool use by chimpanzees,1 animal tool use has been observed in numerous species, including many primates, dolphins, and birds. Some animals, such as New Caledonian crows, even craft tools. Elephants frequently use tools and also modify them. We studied water-hose tool use in Asian zoo elephants. Flexibility, extension, and water flow make hoses exceptionally complex tools. Individual elephants differed markedly in their water-hose handling. Female elephant Mary displayed sophisticated hose-showering behaviors. She showed lateralized hose handling, systematically showered her body, and coordinated the trunk-held water hose with limb behaviors. Mary usually grasped the hose behind the tip, using it as a stiff shower head. To reach her back, however, she grasped the hose further from the tip and swung it on her back, using hose flexibility and ballistics. Aggressive interactions between Mary and the younger female elephant, Anchali, ensued around Mary's showering time. At some point, Anchali started pulling the water hose toward herself, lifting and kinking it, then re- grasping and compressing the kink. This kink-and-clamp behavior disrupted water flow and was repeated in several sessions as a strict sequence of maneuvers. The efficacy of water flow disruption increased over time. In control experiments with multiple hoses, it was not clear whether Anchali specifically targeted Mary's showering hose.

We also observed Anchali pressing down on the water hose, performing an on- hose trunk stand, which also disrupted water flow. We conclude that elephants show sophisticated hose tool use and manipulation. © 2024 The Authors.

P. Vineetha, S. Sarun, S. Selvakumar & R. Rajesh

Geospatial based AHP analysis for habitat suitability of elephants and the effects of human elephant conflict in a tropical forest of Western Ghats in India

European Journal of Wildlife Research 70 (2024) e82

Abstract. No permission to print abstract.

Y. Wang, Y. Wang, J. Zhou, M. Bao, T. Shah, S. Yang, J. Zheng, Q. Li, Y. Hou, B. Wang & R. Yuan

Exploring the gut microbiota of healthy captive Asian elephants from various locations in Yunnan, China

Frontiers in Microbiology 15 (2024) e1403930

Abstract. The Asian elephant is a giant herbivore classified as an endangered wildlife species by the International Union for Conservation of Threatened Species. This study aims to investigate and compare the core gut microbiota of captive Asian elephants from three different locations in Yunnan Province, China, to explore the impact of environmental and husbandry factors on microbial diversity. We collected fecal samples from 29 captive Asian elephants from three locations and performed full-length 16S rRNA gene sequencing. Microbial diversity was assessed using alpha diversity (Chao1 and Shannon indexes) and beta diversity (Bray-Curtis and Euclidean distance metrics). Principal coordinate analysis (PCoA) was used to visualize microbial variation among groups. Alpha diversity analysis showed that the microbial diversity in the Yexianggu group was higher than that in the other groups. Bray-Curtis and Euclidean metrics revealed significant differences among the microbial communities. Bacteroidetes and Firmicutes, which are key cellulose-degrading bacteria, were the dominant phyla in all groups. Synergistaceae was the most abundant family in the Menghai group, while Lachnospiraceae and Pirellulaceae were more abundant in the Yexianggu and Yuantongshan groups, respectively. Genus p-1008-a5-gut-group was more abundant in Yexianggu, and Prevotella was predominant in Menghai. These results indicate that habitat and husbandry practices significantly influence the gut microbiota of captive Asian elephants. The identification of bacterial species highlights the potential role of specific microbes in maintaining host-microbial interactions. Promoting microbial diversity through improved captive conditions could enhance the health of these endangered animals. © 2024 The Authors.

H. Xu, L. Jiang & Y. Liu

Mapping the potential distribution of Asian elephants: Implications for conservation and human-elephant conflict mitigation in South and Southeast Asia

Ecological Informatics 80 (2024) e102518

Abstract. Asian elephants play a pivotal role in their ecosystem. Understanding the potential distribution area of this species is vital for effective conservation efforts and mitigation of human-elephant conflicts. In this study, we used the maximum entropy to simulate the potential distribution area of Asian elephants across South and Southeast Asia, leveraging Maximum Entropy (MaxEnt) and presence data sourced from the Global Biodiversity Information Facility (GBIF). The analysis revealed that the potential distribution area of Asian elephants spans 530,418 km^2 (10.59% of the study area), with significant potential distribution areas observed in Indonesia (136,890 km^2) and Malaysia (119,497 km^2). Vegetation type emerged as the dominant environmental factor influencing model outcomes, encompassing aspects such as broadleaved evergreen tree coverage, broadleaved deciduous closed tree coverage and EVI. The potential distribution area of Asian elephants overlaps with regions inhabited by 55.25 million people, with 6.07 million people residing in highly suitable habitats. India and Malaysia have high potential for human-elephant conflict due to the high number of people living in potential and highly suitable habitats for elephants. Bangladesh and Nepal, on the other hand, have fewer people living in these habitats suitable for elephants, but they face relatively high human population density in these areas. © 2024 The Authors.

H. Yildiz, O. Heise, B. Gerhardt, G. Fritsch, R. Becker, A. Ochs, F. Sicks, P. Buss, L.-M. de Klerk-Lorist, T. Hildebrandt & M. Brecht

Macrovibrissae and microvibrissae inversion and lateralization in elephants

Annals of the New York Academy of Sciences 1538 (2024) 85-97

Abstract. Elephants are known for strongly lateralized trunk behaviors, but the mechanisms driving elephant lateralization are poorly understood. Here, we investigate features of elephant mouth organization that presumably promote lateralization. We find the lower jaw of elephants is of narrow width, but is rostrally strongly elongated even beyond the jaw bone. Elephant lip vibrissae become progressively longer rostrally. Thus, elephants have two lateral dense, short microvibrissae arrays and central, less dense long macrovibrissae. This is an inversion of the ancestral mammalian facial vibrissae pattern, where central, dense short microvibrissae are flanked by two lateral macrovibrissae arrays. Elephant microvibrissae have smaller follicles than macrovibrissae. Similar to trunk-tip vibrissae, elephant lip microvibrissae show laterally asymmetric abrasion. Observations on Asian zoo elephants indicate lateralized abrasion results from lateralized feeding. It appears that the ancestral mammalian mouth (upper and lower lips, incisors, frontal microvibrissae) is shaped by oral food apprehension. The elephant mouth organization radically changed, however, because trunk-mediated feeding replaced oral apprehension. Such elephant mouth changes include the upper lip-nose fusion to the trunk, the super-flexible elongated lower jaw, the loss of incisors, and lateral rather than frontal microvibrissae. Elephants' specialization for lateral food insertion is reflected by the reduction in the centering effects of oral food apprehension and lip vibrissae patterns. This study explores the macro- and microvibrissae found on the elephant jaw. Compared to ancestral mammals, the elephant jaw has an inversion of oral macro- and microvibrissae with macrovibrissae located anteriorly and microvibrissae located posteriorly. Abrasions of microvibrissae were asymmetrical and appeared to be related with trunk laterality during feeding. The unique location and pattern of elephant vibrissae may reflect its evolution of their specialized method of food acquisition. © 2024 The Authors.

S.H. Youn, E. Jung, K.Y. Shin & K.-T. Kim

Musth cases in two captive male Asian elephants (*Elephas maximus*) Korea

Journal of Veterinary Science 25 (2024) e76

Abstract. When male elephants reach sexual maturity, they exhibit excessive sexual behaviors called musths. The musth period is important in the management of elephant herds. However, the timing of the musth and the effect of musth elephants on non-musth elephants in Korea have not been clearly analyzed. In our observations, one male elephant (Koshik), who had been alone with a female, was observed to be on musth from age 15, while another young male elephant (Udara), who joined the group later, was not observed to be on musth at age 15, moreover the male elephants that were found to be on musth earlier had a longer duration of musth after the introduction of the other male. Furthermore, we also found that Koshik's testosterone levels increased approximately 200-fold during musth (the lowest level was 0.93 ng/mL) compared to before musth (the highest level was 214 ng/mL). We found that the duration and behavior of musth in captive male elephants were affected by the introduction of other growing male elephants. © 2024 The Korean Society of Veterinary Science.

N. Zakaria, H. Juahir, S.M.M. Nor, N.H.M. Hanapi, H.H.W. Jusoh, N.Z.M. Afandi & M.T. Abdullah

Elephant research challenges and opportunities: A global bibliometric analysis

Ecological Informatics 82 (2024) e102662

Abstract. The Asian elephant, also known as Asiatic elephant is facing a significant decline in its wild populations due to habitat loss, fragmentation and degradation, leading to increased conflicts between humans and elephants. Preserving this iconic species is crucial, prompting researchers to explore various aspects of its biology, behavior, ecology and conservation efforts. In light of the profound importance of this subject, this study utilizes a descriptive systematic literature review (SLR) to examine global research trends on Asian elephants. Analyzing a dataset of 1780 articles spanning from 1914 to 2022, the study reveals a notable increase in publications, particularly since 2000, with 142 articles published in 2022 alone. This research provides a comprehensive overview of ad-

vancements in Asian elephant studies, promoting international collaboration and knowledge exchange among researchers. While research from leading scientific countries can aid in conservation efforts, there is a call for more inclusive, participatory and fair approaches. The study demonstrates a commitment to Equity, Inclusion and Diversity (EID) by adopting a multifaceted approach that considers the needs, perspectives and contributions of diverse stakeholders. By addressing disparities and advocating for social justice within elephant conservation, the study emphasizes the urgent need for collective action in conservation, welfare improvement, conflict resolution, ecosystem balance and overall enhancement of understanding about Asian elephants. Serving as a valuable resource for policymakers, conservation organizations and researchers, the study not only synthesizes existing literature but also identifies research gaps, highlights areas requiring immediate attention, and offers collaborative opportunities for global scientists to contribute to the well-being and preservation of this majestic species.

F. Zeng, M. Huang, K. Huang, J. Sa, S. Zhang & X. Chen

Potential contribution of alpha-fetoprotein level to biomarker of pregnancy outcome in Asian elephants

Vet. Medicine and Science 10 (2024) e1583

Abstract. Alpha-fetoprotein (AFP) is a structural serum glycoprotein that plays vital roles in reproduction and mammalian development. Analysis of serum prolactin (PRL) is considered one of the useful methods for diagnosing pregnancy in Asian elephants. However, the expression profiles of AFP in pregnant and nonpregnant Asian elephants remain unclear, nor is the relationship with PRL. In this study, serum seven gonadal hormones and AFP in three pregnant and seven nonpregnant Asian elephants were analysed by via radioimmunoassay (RIA) and enzyme-linked immunosorbent (ELISA) assay. We found that the mean (± SD) concentration of prolactin (PRL) in pregnant (136.782 ± 30.987 ng/mL) elephants was significantly higher than that in nonpregnant elephants (52.803 ± 21.070 ng/mL; $p \leq 0.0005$). The mean (± SD) concentration of AFP in pregnant elephants (11.598 ± 0.824 ng/mL) was significantly higher than that in nonpregnant elephants (7.200 ± 2.283 ng/mL; $p \leq 0.05$). Furthermore, the AFP concentration was positively correlated with the PRL concentration in the 10 Asian elephants studied. In conclusion, our findings suggest that serum AFP concentration is a potential biomarker of pregnancy outcomes in Asian elephants. Alpha-fetoprotein (AFP) is a structural serum glycoprotein that plays vital roles in reproduction and mammalian development. Analysis of serum prolactin (PRL) is considered one of the useful methods for diagnosing pregnancy in Asian elephants. We found the AFP concentration was positively correlated with the PRL concentration in the 10 Asian elephants studied. Therefore, we suggest that the serum AFP concentration is a potential biomarker of pregnancy outcomes in Asian elephants. © The Authors.

F. Zhou, M. Bao, X. Guo, Q. Shen, J. Chen, D. Li, H. Bao & L. Zhang

Heart rate patterns of captive Asian elephant (*Elephas maximus*) in their natural habitat at Wild Elephant Valley, Xishuangbanna of China

Heliyon 10 (2024) e25720

Abstract. There are few studies on the changes of heart rate of the Asian elephant, one of the largest tropical terrestrial mammals, with its self-factors and external environment. By measuring the heart rate (HR) of 35 Asian elephants, ranging in age from 4 months to 52 years, using a non-invasive electrocardiogram sensor in their natural habitat at Wild Elephant Valley, Xishuangbanna of China, we found factors that significantly influenced the HR were season, phase of the day, age, body weight, and the interaction between some of the above factors. We also observed that Asian elephants had lower resting heart rate in the morning of hot season than the cold and mild season, and the differences were significant, but the heart rate increased to similar levels in the afternoon regardless of the season. HR also decreased with age in all seasons and phases of the day. However, there was no significant effect of sex. This study reveals the adaptability of Asian elephant to tropical environment, and provides a basic reference for heart rate of Asian elephant under various natural conditions. © 2024 The Authors.

Instructions for Contributors

Gajah welcomes articles related to Asian elephants, including their conservation, management, and research, and those of general interest such as cultural or religious associations. Manuscripts may present research findings, opinions, commentaries, anecdotal accounts, reviews etc. but should not be mainly promotional. All articles will be evaluated by the editorial board of *Gajah* and research papers will be subject to peer review, in addition. Word limits for submitted articles are for the entire article (title, authors, abstract, text, tables, figure legends, acknowledgements and references).

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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.

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

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