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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This publication was proudly funded by Taronga Conservation Society Australia which operates Taronga Zoo, Sydney and Taronga Western Plains Zoo, Dubbo, Australia. Taronga is home to nine Asian elephants and supports in situ conservation of Asian elephants at Elephant Conservation Centre, Way Kambas, Sumatra.
Editorial Note

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

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Cover

Young bull approaching a waterhole in the Bannerghatta National Park, India
Photo by Avinash Krishnan
(See article on page 4)

Layout and formatting by Dr. Jennifer Pastorini
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Editorial

Jennifer Pastorini (Editor)

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In Gajah 56 you can find five research articles and one short communication presenting new findings on Asian elephants. The research on wild elephants was conducted in Bangladesh, India, Nepal and Sri Lanka and on captive elephants in Europe and Sri Lanka. The news and briefs section includes workshop and meeting reports as well as a book review and a compilation of abstracts.

In Research Articles Avinash Krishnan and co-authors present a survey of an elephant corridor in southern India. They found elephants used it regularly, particularly the areas with natural habitat. Shorf u A. Chowdhury and colleagues conducted an interview survey in southeastern Bangladesh. The data shows that people considered house damage and crop raiding by elephants to be the main cause of human-elephant conflict. Mihiran Medawala et al. describe the captive breeding program at the Pinnewala Elephant Orphanage, Sri Lanka. With 70 births in 38 years the program proved to be very successful. Michelle Szydłowski described the situation of a wild bull causing conflict, while approaching captive females held near the Chitwan National Park. The owner then allowed his elephants to range free in the park's buffer zone, enabling the male to visit the herd without going through human settlements. Christian Schiffmann and co-authors describe a simple method to evaluate particle size in dung. The size of the fibres found in dung gives information about the elephant's chewing efficiency, which varies with body size and may change with age. They found their simplified method was as informative as more complex lab analysis.

In Short Communications G.D.K. Samaranayake et al. reports on constructing electric fences to prevent intrusion of elephants into private properties. They erected 60 fences around houses and/or cultivations. All owners had relief from elephant damage after fence installation, even though elephants remained in the immediate neighbourhood.

In News and Briefs Benjamin Christ and Nilanga Jayasinghe describe a new approach to holding virtual workshops, developed during the Covid-19 pandemic when WWF was forced to hold online workshops for developing new strategic plans for elephant conservation. Prajna P. Panda and Vivek Menon provide a summary of topics concerning Asian elephants, discussed at last year's CITES meeting (CoP19). The AsESG also organised a side event where they presented the Kathmandu Declaration and discussed other issues regarding Asian elephant conservation. Vicki Renner was kind enough to review Alexander Mossbrucker's book “Island Elephants: The Giants of Sumatra”, which gives detailed information on many aspects of Sumatra's elephants. As usual there is also a compilation of abstracts giving an overview of research conducted on Asian elephants in the last year.

This Gajah is the first issue with DOI numbers. Such Digital Object Identifiers have become the norm in many journals and are also now commonly used in citations. DOIs provide a stable link to the document, even if the website where it was originally published changes. I would like to thank Gabriela Hidalgo, the librarian at IUCN, for patiently helping me through the process to get Gajah registered.

I am thankful to the authors and editorial board members who have worked hard to get the articles ready for this Gajah. The Taronga Conservation Society Australia has generously funded the printing and postage of this Gajah. We are most grateful to them for being able to send out hard copies of Gajah free of charge to our readers across the globe.
Dear Members

I am happy that this year has started with the successful organisation of the 11th Asian Elephant Specialist Group (AsESG) meeting from 14th to 17th March 2023 in India. I would like to convey my sincere thanks to all the 128 people who participated and particularly to those who helped in its organisation. Today, the AsESG is a team of 115 members from 21 countries – including all the 13 range states – with the inclusion of 4 new members as approved by the Chair on advice of the Membership Advisory Committee earlier this year.

The meeting included 67 AsESG members, representatives from 11 Asian elephant range countries, 11 conservation partners, and special invitees from the Ministry of Environment, Forests and Climate Change, Government of India, the Forest Department of the State of Uttarakhand and the Wildlife Trust of India. I would like to specially thank the Government of India and the Uttarakhand Forest Department for collaborating with IUCN SSC AsESG and extending all support in organising the meeting. It was wonderful that Shri. Subodh Uniyal, Hon’ble Minister of Forest & Environment, Uttarakhand took keen interest and joined us at the closing ceremony at Corbett. I would also like to convey my sincere thanks to our donors; majorly International Fund for Animal Welfare (IFAW), the principal sponsor and Mr. Kaushik Barua for hosting the icebreaker dinner, Mandai Nature, WWF (US), Kölner Zoo, Colossal Biosciences, Japan Tiger and Elephant Fund, White Oak Conservation, Albuquerque Bio Park, American Zoo Association and AZA SAFE, Denver Zoo, African Lion Safari and Asian Elephant Trust.

In this meeting, there were 57 plenary presentations in total with participation from 51 AsESG members actively involved in presenting, chairing and co-chairing the sessions. My special thanks to Dr. Jon Paul Rodriguez, Chair IUCN SSC, Ms. Kira Mileham, Director, IUCN SSC Strategic Partnerships and Ms. Heidi Riddle, Vice Chair, IUCN SSC AsESG in linking the conservation partners into the strategic priorities and activities of the AsESG. I also like to thank Ms. Heidi Riddle for chairing the session on the stocktaking of the Kathmandu Declaration and Dr. Ee Phin Wong, Deputy Chair,
IUCN SSC AsESG for leading the speed talks and Southeast Asian range state networking.

What was interesting to note is the energy in the group, especially amongst the younger members, to work towards several new and emerging issues. We have noted two or three different areas of work that can be developed into new Working Groups in this year. Currently we have nine Working Groups to complete their outcome documents and I request all the members of the groups, especially the convenors, to please work with your group members on getting it completed as soon as possible, preferably by December 2023. While I am happy that we have come out with first volume of the “Action Elephant” including six National Elephant Action Plans, I urge the members of Indonesia, Peninsular Malaysia, Nepal, Sri Lanka and India particularly to work with their governments to get their action plans completed.

Earlier last year, the AsESG assisted the Nepal Government in organising the Third Asian Elephant Range States Meeting that concluded with the drafting of the “Kathmandu Declaration for Asian elephant conservation” charting out nine key priority actions underlined and agreed upon by all range states to attempt to fulfil by 2025. Taking the way forward, IUCN SSC AsESG organised a side event at the CoP 19 of CITES on “Kathmandu Declaration and its implication for conservation of Asian elephants” on 16th November 2022 at Panama Convention Centre, Panama City. About 100 people participated at the side event. The resource persons besides me at the event were Dr. Jon Paul Rodriguez, Chair IUCN SSC; Mr. Azzedine Downes, President IFAW; Dr. Maheshwar Dhakal, DG, Govt. of Nepal; Dr. S. P. Yadav, ADG, Govt. of India; Ms. Rahmah Illias, Principal Assistant Director, Govt. of Malaysia; Ms. Tanya McGregor, MIKE Coordinator, CITES; Dr. Benson Okita-Ouma, Chair AfESG and Ms. Rose Mayienda, AfESG. This event brought together the Asian range countries as well as other stakeholders to an agreement to establish transboundary collaboration, create pan India Asian elephant database, complete national elephant conservation plans and establish an Asian Elephant Conservation Fund.

The important thing moving forward is to see how we lead in the six areas of work that the Kathmandu Declaration has wanted of our group, some such as the range wide mapping and priority setting for the elephant, for the establishment of an Asian Elephant Fund and also the publication of guidelines on human-elephant conflict as well as linear infrastructure amelioration, which we have been tasked to do as well as others where our participation with national governments are vital. I look forward to leading on these and exhort the entire membership to come forward and participate in various parts of these large exercises.

I would like to end this message to Gajah by also giving a shout out to our member and the Chair of the IUCN Human Wildlife Conflict Mitigation Specialist Group. Dr. Alexandra Zimmermann successfully organised a mammoth international conference on Human-Wildlife Conflict and Coexistence from 30th March to 1st April 2023 at Oxford, UK with representatives from conservation organisations, academia, governments, businesses and indigenous and local communities from six continents and 70 countries. They also launched the publication of the IUCN SSC guidelines on human-wildlife conflict and coexistence. Although I am sorry to have missed it myself, I am happy that many of our AsESG members also attended and actively participated at the event.

Vivek Menon
Chair IUCN SSC AsESG
Road for Elephants: Elephant Use of the Karadikkal-Madeshwara Corridor, Southern India

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Abstract. Wildlife corridors play an important role in connecting elephant habitats across India. Monitoring them is essential to assess their usage by elephants and to identify the anthropological risks to their persistence. We present the results of a grid-based survey of elephants for the Kardikkal-Madeshwara corridor in Bannerghatta National Park. Our findings indicated high use by elephants, with more observations recorded within grids which overlay natural habitats of the park than those that overlay human dominated land. The corridor remains under high human pressure, indicating the need for continued attention to maintaining corridor function.

Introduction

Approximately 12,000 Asian elephants (*Elephas maximus*) inhabit southern India, accounting for 40% of the country’s population (MoEF & CC 2017). Elephants require extensive habitats. Their home-ranges in India usually vary between 105 to 350 km² (Sukumar 1989) but may extend to over 4000 km² in highly degraded and fragmented landscapes like those found in Central India (Datye & Bhagwat 1995). The annual rate of forest cover loss in India between 1975–2005 was 5.8% (Reddy et al. 2013). Rapid fragmentation and shrinking of their habitat threaten their long-term survival (Sukumar 2006). Consequently, wildlife corridors are increasingly important in connecting tracts of land elephants use (Green et al. 2018). A total of 101 elephant corridors have been identified across India (Menon et al. 2017).

Establishing and maintaining corridors poses a number of challenges, such as providing legal protection and preventing encroachment, degradation from cattle grazing, and fragmentation by roads. Of the 101 identified corridors in India, 28.7% have been encroached for human settlement, and 66.3% have roads/highways running across them. Only 12.9% of the corridors consist completely of forest, and most are surrounded by agricultural land and settlements, which heighten the risk of human-elephant conflict (Menon et al. 2017). Agrarian lands that encroach on elephant corridors represent food sources for elephants, who wait on corridor edges during the day and raid croplands at night, leading to increased human-elephant conflict (Graham et al. 2009).

The Bannerghatta National Park (BNP) in southern Karnataka facilitates elephant migration between the Western and Eastern Ghats (Varma et al. 2009). BNP possesses three elephant corridors to allow movement of elephants between key areas of the park, one of which is the Karadikkal-Madeshwara corridor (Ramkumar et al. 2017).

This study assesses the pattern of use of the Karadikkal-Madeshwara corridor by elephants and identifies threats to the corridor.

Methodology

Study area

The BNP’s dominant vegetation is tropical scrub and deciduous forest. The area received
around 625–750 mm rain annually with the main rain fall occurring between June and November. The dry season extends from January to April and the wet season from May to December.

The Karadikkal-Madeshwara corridor (12°41’ 29” – 12°42’30” N, 77°33’46” – 77°34’49” E) has an east-west orientation and connects the Harohalli and Anekal wildlife ranges of BNP. The corridor is hourglass shaped and is 1 km in length and 0.5 – 0.7 km in width (Figs. 1 & 2). The corridor lies between the settlements of Jaipurddodi and Bilanganakuppe, which are connected by a road running through the eastern section of the corridor (Fig. 1). The main livelihoods of the people in these settlements are livestock farming and cultivating *Eleusine coracana* (finger-millet) and *Oryza sativa* (rice), both of which are very attractive to elephants. Livestock grazing is common around the corridor as there are approximately 880 head of cattle in the flanking villages. Elephant barriers consisting of elephant-proof trenches and electric fences have been erected on the boundary of BNP including on either side of the corridor (Fig. 2).

Parts of the natural habitat of the national park have been converted to agriculture (Fig. 2). Such converted land within the park was not protected by the elephant barriers, as the barriers were on the park boundary. Google Earth satellite images were used to identify natural habitat and agricultural lands within survey grids. Scrub and forest vegetation were taken to represent natural habitat.

**Monitoring**

Monitoring was based on a 1x1 km grid overlay provided by Wildlife Trust of India as part of the national elephant corridor monitoring scheme. It consisted of 24 grid cells covering the corridor and surrounding area. (Fig. 2). Each grid cell was visited three times in 2019, once during the dry season (May/Jun) and twice in the wet season (Aug/Sep & Nov/Dec).

![Figure 1. BNP and the Karadikkal-Madeshwara elephant corridor.](image-url)
Four to five grids were surveyed each day, starting at 9 am and ending at 5 pm. Pre-existing animal trails were walked in the natural areas, footpaths were used in developed land and agricultural areas. The distance along the trail was measured using the odometer function in a GPS device. The length of trail surveyed per grid was 1 km. Each trail survey took between 20–40 min. No particular direction was followed in traversing a trail.

Usually four persons consisting of two researchers and two forest-watchers formed the survey team. If the grid surveyed was dense forest or if there was recent elephant movement, a 5th person joined for extra security. One researcher took part in all the surveys, the other participants varied.

On each survey along a trail, the team recorded the presence of anthropogenic pressure and elephant sign. All observations were entered in data sheets. Presence or absence data was recorded based on observation of elephants, dung piles, feeding signs, sleeping areas, feeding evidence, mud baths, urination or footprints.

If a group of elephants were observed, it was taken as a single sighting. When a dung bolus was detected, the boli within 90 cm were examined and if the size and freshness of the boli were similar, then it was counted as a single dung pile. If the size and freshness of boli differed, then it was counted as two dung piles. Only dung deposited within one week, as judged by its appearance of freshness were recorded.

The presence of anthropogenic sign was recorded as indicated by observation of crops, livestock, estate plantations, fences, trenches, linear infrastructure, mining, quarrying or stone crusher units.

The data was analysed in MS Excel and QGIS. Chi-square analyses were conducted to test whether the differences in the number of elephant observations across different grid cells were significantly different. Correlation analyses were undertaken between observations of elephants and human pressure and natural habitat.
Results

Signs of elephant presence were recorded in all 24 grid cells (Fig. 2), while dung was recorded in 19 grid cells. A similar number of dung piles were counted in the dry season and the first wet season visits, but significantly less during the later visit (dry season vs second wet season; p = 5.15 x 10^{-6}, Fig. 3).

There was a positive correlation between the number of dung piles in each grid cell and the percentage of natural habitat within the cell, r = 0.82 (Fig. 4). A significantly greater amount of dung piles was recorded in cells with >50% natural habitat than those with >50% human habitat (p = 1.65 x 10^{-5}) and in grid cells with an area of >50% within the park than those with >50% outside (p = 4.2 x 10^{-5}).

There were a greater number of dung piles in the narrowest part of the corridor (GN24) when compared to the grid cells neighbouring it to the north (GN31 vs GN24, p = 7.07 x 10^{-10}) and south (GN17 vs GN24, p = 1.25 x 10^{-6}), and no difference between GN24 and cells to its East (GN11,18,25,26,27 & 33) (p = 0.88) and West (GN15,22,23,29,30) (p = 0.43).

No significant difference was found in the number of dung piles counted in cells within the park boundary which were cut through by a road and those that were not.

Anthropogenic signs were encountered in all grid cells (Table 1).

Discussion

The results from this survey of the Karadikkal-Madeshwara corridor suggest that it is being used by elephants in their movements across the Harohalli and Anekal ranges of BNP. We found a strong correlation between elephant observations and grids with a high extent of natural habitat, which applied to even the narrowest part of the corridor confirming the importance of maintaining natural corridors for habitat connectivity. However, elephants also used agrarian land outside the elephant barriers on the park boundary. Agricultural land in Malaysia was found to represent prime habitats for elephants, rather than marginal areas (de la Torre et al. 2021). Therefore, it is possible that a similar situation exists in our study area. The presence of elephants outside the park boundaries, also highlight limits of the elephant barriers currently in place.

We found that the highway that runs through the park, is regularly crossed by elephants and that it did not to affect their use of the area. However, further studies are needed to establish if the road poses a threat due to elephant mortality or injury due to traffic-related accidents.

The number of dung piles observed did not vary between the dry season and the first wet season and decreased in the second wet season. Influx of elephants into the area has been reported during the monsoon when crops are harvested (Varma et al. 2009). While this could be expected to increase elephant activity in the survey area and movement through the corridor, hence increase in dung density during the wet season,
this was not the case. The comparatively high number of dung piles observed in the dry season could also be related to low food or water availability, which could cause elephants to move between resource points more frequently.

Livestock grazing was the biotic pressure most often observed within the park. This is a troubling sign that could threaten primary vegetation in the area, by reducing forest cover within the corridor in the long-term through reduced survival of seedlings. The presence of cattle can also lead to complications such as, spread of diseases and man-animal conflict from livestock predation by leopards and tigers.

Anthropogenic pressures were greater and more varied outside park boundaries. The presence of crops such as *Eleusine coracana* and *Musa paradisiaca* adjacent to the park boundary could attract elephants to move outside the park.

We found that elephants used forest tracts more than anthropogenic habitat. Yet, the impact of elephant raiding affects the attitudes of the people living around the corridor towards elephants, as they believed that 65% of their crops were damaged every year by elephants (Pavani 2009).

Overall, the patterns of use observed by us, indicates that the corridor is effective as a passage for elephants. However, it may face serious threat from livestock grazing and other biotic pressures in the years to come. Our findings justify the corridor’s importance in the national park and argue for its urgent conservation, as there are no alternative movement routes across this landscape for elephants. The issues in the Karadikkal-Madeshwara corridor are likely to be representative of the pressures on many of the 101 elephant corridors that are currently identified across India.

<table>
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<th>% within park</th>
<th>% natural habitat</th>
<th>Crops</th>
<th>Livestock</th>
<th>Plantations</th>
<th>Fence/trench</th>
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<td>52</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
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</tr>
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<td>GN33</td>
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<td>99</td>
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<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>GN34</td>
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<td>7</td>
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<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
</tbody>
</table>

* Mining/ quarrying/stone crusher units
Acknowledgements

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References


Introduction

Conflict between humans and elephants has occurred for centuries (Nelson et al. 2003). Elephant crop raiding has been recorded in Asia as early as 300 BC (Sukumar 1994). Records in Africa show colonial farmers incurred huge losses from elephant depredation (Schweitzer 1922). As human populations grow, elephant habitat is converted into agriculture and other land uses which leads to increased contact with elephants, and subsequent conflict. Understanding the reasons, nature, extent and implications of conflict are useful for long-term conservation strategies.

The Asian elephant (*Elephas maximus*), once found throughout Asia, now exists in a limited number of localities in 13 countries in south and southeast Asia (IUCN 2014). Threats to elephants are largely due to (1) habitat loss, fragmentation and degradation, mostly due to agricultural demands; (2) illegal killing for ivory, skin or calves; and (3) conflict with people. Direct conflict between humans and elephants perhaps is the most challenging threat, resulting in the loss of human and elephant life. Human-elephant conflict (HEC) affects large numbers of people (Barua et al. 2013) and generates anti-conservation sentiment among local communities (Desai & Riddle 2015).

At the time of the study, there were thought to be around 210–330 elephants in Bangladesh (Motaleb et al. 2016) with HEC occurring wherever there were elephants (Sarker & Røskaft 2010). At least 231 people were killed from 2003–2015 and 92 elephants from 1992–2015 due to HEC (unpublished data, Bangladesh Forest Department 2016). Villagers responded to raiding by elephants by killing them through poisoning, electrocution and shooting. This study was conducted to document villagers’ experiences and perceptions of HEC, and attitudes towards elephant conservation in south-eastern Bangladesh.

Methods

Study area

The study was conducted in the Chittagong and Cox’s Bazar Districts of south-eastern Bangladesh within elephant habitat (Figs. 1 & 2).

The study area was around 1904 km² in extent, of which around 1370 km² were hilly areas. There were around 1.5 million people in the area and the literacy rate was approximately 52% (BBS 2010). Most residents in the area were subsistence rice farmers. The climate was tropical with monsoon rains occurring from...
in 109 of the 306 villages from mid-May to September 2015 (Fig. 2), selected in consultation with the Forestry Department and local government officials, as it was essential to secure local support to administer the survey. Selected villages were classified into 3 categories according to location in relation to elephant habitat as (i) inside forest (ii) at forest edge and (iii) outside forest.

In each village surveyed, a household was selected every 0.5 km to administer the questionnaire. Rice, wheat, maize, vegetables and sugarcane were considered ‘crops’ and fruit trees considered a separate category. Verbal consent to the interview was requested before the interview. Respondents were informed that they could refrain from answering any question and/or stop the interview at any time if they became uncomfortable. An interview took 25–45 minutes.

Quantitative data were analysed using IBM SPSS Statistics version 23. An alpha value of 0.05 was used to determine significance.

Figure 1. Map showing elephant distribution in Bangladesh.

June to October resulting in a dry season extending from December to May. The temperature range was 11–32°C. Although the area was once rich in wildlife, it has been degraded over time, with all primary forests removed and only secondary forest cover remaining.

Survey

The questionnaire was designed to collect data on (i) respondent background, (ii) experience with elephants over the past three years, (iii) types of problems created by elephants, (iv) consequences of local elephant incursions, (v) feelings and perceptions about elephant incursions, and (vi) thoughts about elephant conservation, using open- and close-ended questions. Interviews were conducted in Bangla and responses recorded on prepared forms. The Research Ethics Board at Thompson Rivers University approved the survey design.

There were around seven elephant-habitat patches, namely Teknaf, Inani, Himchari, Medakachapia, Fasiakhali, Chunati and Dudpukuria-Dhopachari, and 306 villages in the survey area (Fig. 2). The survey was conducted

Figure 2. Map showing survey distribution near elephant habitat patches (green dots) and villages (red dots).
Results

Answers were received from 171 respondents from 109 villages (1–4 respondents/village).

Respondent characteristics

A total of 171 people participated in the survey ranging from 18 to >60 years of age. Eighty percent (137) of the respondents were male. Most respondents (83%) earned less than US$ 2000 per year. People earning less than US$ 394 per year are considered living below the poverty line in Bangladesh (United Nations 2009). Ninety-one percent were either illiterate or possessed only basic education (i.e. < secondary school). The respondents consisted of 104 farmers (61%), 13 labourers (8%), 29 housewives (17%), and 10 businessmen (6%). Respondents were evenly distributed within the three geographical strata – home relative to the forest (Table 1).

Table 1. Characteristics of survey respondents.

<table>
<thead>
<tr>
<th>Descriptor</th>
<th>Response</th>
<th>Respondents</th>
<th>#</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>District</td>
<td>Chittagong</td>
<td>93</td>
<td>54</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Cox’s Bazar</td>
<td>78</td>
<td>46</td>
<td></td>
</tr>
<tr>
<td>Age</td>
<td>18–28 years</td>
<td>29</td>
<td>17</td>
<td></td>
</tr>
<tr>
<td></td>
<td>29–39 years</td>
<td>59</td>
<td>35</td>
<td></td>
</tr>
<tr>
<td></td>
<td>40–50 years</td>
<td>46</td>
<td>27</td>
<td></td>
</tr>
<tr>
<td></td>
<td>50–60 years</td>
<td>28</td>
<td>16</td>
<td></td>
</tr>
<tr>
<td></td>
<td>&gt; 60 years</td>
<td>9</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>Sex</td>
<td>Male</td>
<td>137</td>
<td>80</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Female</td>
<td>34</td>
<td>20</td>
<td></td>
</tr>
<tr>
<td>Yearly income</td>
<td>&lt; US$ 2000</td>
<td>142</td>
<td>83</td>
<td></td>
</tr>
<tr>
<td></td>
<td>US$ 2000–2990</td>
<td>25</td>
<td>15</td>
<td></td>
</tr>
<tr>
<td></td>
<td>&gt; US$ 2990</td>
<td>4</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>Education</td>
<td>&lt; Secondary school</td>
<td>156</td>
<td>91</td>
<td></td>
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<tr>
<td></td>
<td>High school</td>
<td>12</td>
<td>7</td>
<td></td>
</tr>
<tr>
<td>Livelihood</td>
<td>Farmer</td>
<td>104</td>
<td>61</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Labour</td>
<td>13</td>
<td>8</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Housewife</td>
<td>29</td>
<td>17</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Businessman</td>
<td>10</td>
<td>6</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Other</td>
<td>15</td>
<td>9</td>
<td></td>
</tr>
<tr>
<td>Homestead</td>
<td>Inside forest</td>
<td>61</td>
<td>36</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Edge of the forest</td>
<td>51</td>
<td>30</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Outside forest</td>
<td>59</td>
<td>34</td>
<td></td>
</tr>
</tbody>
</table>

Experience with elephants

Elephant incursion into crops occurred throughout the year, with two peaks in April – June, and October – November (Fig. 3). In response to the question “How often do elephants come into your village?”, 165 (97%) of respondents indicated incursions occurred every year. All but one reported that incursions occurred at night, and 32 (19%) of respondents reported incursions taking place during dusk. Elephants were considered a problem by 86% of the respondents.

Problems created by elephants

Crop raiding was identified as a major problem by 164 (96%) respondents, followed by house damage 65 (38%) and raiding of fruit trees 51 (30%). Rice was the crop most frequently impacted by elephants (141 (83%) respondents). Ninety four percent of respondents reported damage to mature crops and 46% to immature crops. Damages caused by elephant raids between 2013 and 2015 to respondents, affected a total land area of ~67 ha.

Human death and injury, and property damage

A total of 50 people (45 men and 5 women) were reported killed and 51 injured by elephants during 2013–2015 in the study region (Table 2). Farmers (25) and firewood collectors (13) were the majority of people killed. More people were killed within forest habitat and on the edge of the forest than outside ($\chi^2 = 14.9$, df = 2, $P = 0.001$). These findings were compared to government records for the study region and found

Figure 3. Number of respondents reporting the occurrence of elephant incursions for each month of the year.
to match the number of officially recorded deaths, with a slight discrepancy in the number of injuries reported. The respondents reported 18 elephant deaths during 2013–2015, of which 15 were females.

In addition to crop raiding and death and injury to both humans and elephants, 65 respondents (38%) reported house damage, 51 fruit tree damage (30%) and 3 reported livestock death.

Perceptions of elephant incursions and human response of respondents are given in Table 3.

All but 2 respondents ‘agreed’ or ‘strongly agreed’ that there is a ‘declining food base’ and ‘shrinking habitat’ for elephants. Without prompting, six respondents identified bamboo masting as responsible for an increase in elephant incursions.

Views of respondents about elephant conservation and measures to mitigate conflict are given in Table 4. Most respondents (73%) favoured elephant conservation, with no difference by respondent village location ($\chi^2 = 3.952$, df = 2, $P = 0.139$). Sixty-five percent of female (N = 34) favoured elephant conservation compared to 75% of male (N = 137) respondents.

In addition to the options provided on the survey, the respondents suggested relocation of elephants (25% of respondents) and the cessation of exotic crop planting (1% of respondents). A small number of respondents in one village indicated that relocating a nearby army-training zone would result in fewer elephants being frightened into settlements by artillery firing practice.

Government responsibility toward elephant incidents

Few respondents were aware of any role played by the Forest Department in the case of elephant incidents. When asked “What role did the

Table 2. Human death and injury caused by elephants in 2013–2015 by forest proximity. Data from Bangladesh Forest Department (2016).

<table>
<thead>
<tr>
<th></th>
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<tbody>
<tr>
<td>Inside forest</td>
<td>3</td>
<td>9</td>
<td>9</td>
<td>21</td>
<td>7</td>
<td>11</td>
<td>1</td>
</tr>
<tr>
<td>Forest edge</td>
<td>8</td>
<td>10</td>
<td>7</td>
<td>25</td>
<td>11</td>
<td>8</td>
<td>13</td>
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<tr>
<td>Outside forest</td>
<td>1</td>
<td>3</td>
<td>0</td>
<td>4</td>
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<td>22</td>
<td>16</td>
<td>50</td>
<td>18</td>
<td>19</td>
<td>14</td>
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Table 3. Perceptions of elephant incursions and human response.

<table>
<thead>
<tr>
<th>Descriptor</th>
<th>Response</th>
<th># respondents</th>
<th>% respondents</th>
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<tr>
<td>Incursion rate</td>
<td>Increasing</td>
<td>153</td>
<td>90</td>
</tr>
<tr>
<td></td>
<td>No change</td>
<td>18</td>
<td>10</td>
</tr>
<tr>
<td>Single and/or group of elephants</td>
<td>Single &amp; group</td>
<td>70</td>
<td>41</td>
</tr>
<tr>
<td></td>
<td>Group</td>
<td>163</td>
<td>95</td>
</tr>
<tr>
<td>Most common group</td>
<td>Female elephant</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>Bull elephant</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Mixed herd</td>
<td>164</td>
<td>96</td>
</tr>
<tr>
<td>Peoples’ response to elephant incursion</td>
<td>Firecrackers</td>
<td>97</td>
<td>57</td>
</tr>
<tr>
<td></td>
<td>Drumming</td>
<td>68</td>
<td>40</td>
</tr>
<tr>
<td></td>
<td>Nothing</td>
<td>5</td>
<td>3</td>
</tr>
<tr>
<td>Condition of elephant habitat</td>
<td>Moderate</td>
<td>29</td>
<td>17</td>
</tr>
<tr>
<td></td>
<td>Bad/poor</td>
<td>139</td>
<td>81</td>
</tr>
<tr>
<td></td>
<td>Not aware</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>Reason for elephant incursion</td>
<td>In search of food</td>
<td>169</td>
<td>99</td>
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Table 4. Methods to prevent or mitigate elephant incursions.

<table>
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<tr>
<th>Method</th>
<th>Not useful</th>
<th>Useful</th>
<th>Very useful</th>
<th>Don’t know</th>
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<tbody>
<tr>
<td></td>
<td>#</td>
<td>%</td>
<td>#</td>
<td>%</td>
</tr>
<tr>
<td>Habitat improvement</td>
<td>0</td>
<td>0</td>
<td>6</td>
<td>4</td>
</tr>
<tr>
<td>Community awareness</td>
<td>1</td>
<td>1</td>
<td>14</td>
<td>8</td>
</tr>
<tr>
<td>Erection of physical barrier</td>
<td>8</td>
<td>5</td>
<td>48</td>
<td>28</td>
</tr>
<tr>
<td>Electric or solar fence</td>
<td>3</td>
<td>2</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>Chili cultivation</td>
<td>0</td>
<td>0</td>
<td>75</td>
<td>44</td>
</tr>
<tr>
<td>Apiculture</td>
<td>0</td>
<td>0</td>
<td>41</td>
<td>24</td>
</tr>
<tr>
<td>Tourism (elephant viewing)</td>
<td>0</td>
<td>0</td>
<td>75</td>
<td>44</td>
</tr>
<tr>
<td>Tourism revenue sharing</td>
<td>0</td>
<td>0</td>
<td>41</td>
<td>24</td>
</tr>
</tbody>
</table>

Bangladesh Forest Department play following the last elephant incident that involved death and/or injury?", most respondents (84%) felt the Forest Department did “nothing”. Also, most respondents (64%) were unaware of compensation provided by the Forest Department for elephant damage.

Discussion

The respondents typified the population living in the south-eastern region of Bangladesh at the time of the study. Most respondents were men, due to the village culture dissuading women from conversing with outsiders. The respondents were characterised by having low income, engaging in subsistence farming and their agricultural lands being situated in or on the periphery of elephant habitat. All respondents had direct or near-direct experience with elephant conflict indicating that interaction with elephants was a common occurrence, and such interaction is primarily described in terms of conflict versus compatible co-existence.

Results showed a year-round pattern of elephant incursions and HEC in south-eastern Bangladesh. Year round raiding by elephants could be explained by the presence of both ‘push factors’ (reduced native forage pushing elephants to raid) and ‘pull factors’ (crops pulling elephants toward alternative food resources). Elephant incursions tended to increase during the transition between dry and wet seasons in April-June and October-November. Two rice harvesting seasons occur in Bangladesh: Aman (December – January) and Boro (April – June). Vegetables are mostly cultivated during September – January, with jackfruit ripening during April – June. Wild forage contains less nutrients compared to cultivated crops, and hence elephants likely maximise quality as well as quantity in their nutrient intake by raiding crops (Sukumar 1994).

Most respondents reported that incursions mostly involved both male and female elephants. This differs from suggestions that elephant incursions tend to be dominated by males for example in Uganda (Chiyo & Cochrane 2005), Sri Lanka (Ekanayaka et al. 2011) and Botswana (Jackson et al. 2008) but consistent with other studies stating that bulls, cows, and entire herds take part in crop raiding, for example in southwest Uganda (Musaasiza et al. 2005) and south India (Ramkumar et al. 2014). Cows would be expected to benefit from nutritional gains from raiding, with improved nutrition leading to shorter inter-birth intervals and healthier babies (Chiyo & Cochrane 2005).

The consequences of elephant incursions represent a significant cost to people residing in and around elephant habitats of south-eastern Bangladesh, particularly in view of their poor economic status. We found that farmers and firewood collectors were the primary victims. Because such persons are often the breadwinners of the family, their death and/or injury represents a major economic cost on the affected families. Injured workers also may suffer from depression, post-traumatic stress disorder or other psychological impacts. In certain cultures, death or injury caused by elephants maybe considered a foreordained punishment (Jadhav & Barua 2012) with accompanying implications for future well-being. All told, the losses generated from HEC are likely to have immediate as
well as long-term negative impacts on the people in proximity to elephant habitat in southeastern Bangladesh.

Drumming and firecrackers were the most common measures used to deter elephant incursions, but some farmers believed that any kind of disturbance created by noise, yelling or other means made the elephants aggressive and resulted in more damage to properties. Participants were sceptical or not knowledgeable of elephant-conflict mitigating measures attempted in other countries, such as erection of physical barriers, electric fences, chili cultivation, and apiculture. These measures were reported to be effective at least for short durations or in some contexts but ineffective over extended periods of time (Santiapillai & Suprahman 1986). A few respondents recommended non-traditional measures of mitigation, such as relocating elephants, and not planting exotic species such as acacia. These approaches may contribute to a larger HEC mitigation plan but are unlikely to succeed on their own within the current economic and cultural environment of Bangladesh.

Results confirmed that elephants get killed every year, consistent with regional unpublished data (Bangladesh Forest Dept. 2016). Although villagers openly recounted the number of elephants killed in their locality, they were reluctant to reveal details about actions such as poisoning, electrocution and shooting. Possibly such reluctance is due to knowing that such action is punishable under Bangladeshi law.

Despite the increasing trend of incursions, a large portion of respondents expressed support for elephant conservation locally. A similar finding was observed in a study in Myanmar (Sampson et al. 2021), while a study in India found only 57% of respondents favoured elephant conservation (Jasmine et al. 2015). While the result in Bangladesh is encouraging, it can only be transformed into conservation action when HEC is reduced. Villagers will not care about elephant conservation from a moral or ecological–evolutionary argument when their subsistence and wellbeing are not secured (Balmford & Whitten 2003). Therefore, continued losses from HEC will eventually exceed the limits of tolerance for elephant incursions.

Participants showed varied support for HEC mitigation options. Habitat improvement was rated ‘very useful’ by most villagers, thus positive for conservation efforts directed at elephant habitat. ‘Community awareness’ was equally rated as ‘very useful’ thus suggesting villager’s desire for maintaining or improving awareness of HEC mitigation options and elephant conservation.

Compensation has been the most visible HEC mitigation tactic adopted by the Bangladesh government, and it appeared to be attractive to participants. The policy “Human-wildlife conflicts: Wildlife Compensation Policy, 2010” empowers the government to compensate victims of wildlife. Under this, any death/injury/damage caused by wildlife occurring on private lands are compensable. At the time of this study, families experiencing a death due to elephant attack were compensated with US$ 1250 and injuries with US$ 625. However, deaths on government land (public land) were not addressed. People may also not apply for compensation because they have to sacrifice work time and travel considerable distances to government offices to register a complaint, and crop and property damage alone are currently not compensated. In some areas in Africa, compensation has proven to be an ineffective elephant conservation strategy as it addresses the outcome rather that the root cause of conflict (Hoare 1995). Moreover, compensation will not deter future elephant incursions.

Acknowledgements

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References


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Introduction

The Asian elephant (Elephas maximus) has been an important cultural symbol since ancient times (Santiapillai et al. 2010). At present, Asian elephants are found in 13 countries including Bangladesh, Bhutan, China, Nepal, Vietnam, Cambodia, Laos, Thailand, Indonesia, India, Bhutan, and Sri Lanka (Fernando & Pastorini 2011). However, in many of these countries, their numbers have drastically declined (Fernando & Pastorini 2011). Consequently, the Asian elephant has been classified as ‘endangered’ by the IUCN, and an Appendix-I species by CITES (CITES 2020). Sri Lanka has around 5,825 wild elephants (Fernando 2015), and around 360 in captivity (Pushpakumara et al. 2016). Elephants have been captured from the wild since ancient times (Nijman 2014). Elephant capturing and taming were a central feature in ancient Sri Lanka and kings maintained thousands of elephants including war elephants (Wisumperuma 2004; Kurt & Garai 2007). However, the captive elephant numbers in Sri Lanka have decreased as work animals are increasingly being replaced by machines (Fernando & Pastorini 2011). Nevertheless, their use in tourism is increasing (Prakash et al. 2020). Elephants held in captive facilities in Asian countries are mostly used for tourism (Nijman 2014). At present in Sri Lanka, captive elephants are kept by temples, private owners, and by the government at the National Zoological Gardens at Dehiwala, the Pinnawala Elephant Orphanage (PEO), the Ridiyagama Safari Park, and the Elephant Transit Home at Udawalawe. There have been very few captive births in Sri Lanka with the exception of the PEO (Jayantha 2011). Improving the facilities and care for elephants is important for their captive management. However, studies on elephant reproduction are limited due to the length of the reproductive cycle, safety concerns, and ethical considerations (Thitaram 2012).

Pinnawala Elephant Orphanage

The PEO is located in the Kegalle District about 88 km away from Colombo. It was established in 1975 by the Department of Wildlife Conservation to manage orphaned wild elephants and was initiated with five such baby elephants. Subsequently, orphaned elephants from different parts of the country were received and integrated into the herd at PEO. The elephants are managed within a 10.52-ha area close to the river Ma Oya. In 1982, the management of PEO was transferred to the Department of National Zoological Gardens (DNZG 2021). The first captive-bred elephant was born at the PEO in 1984. Orphaned elephants were received exclusively by the PEO until 1995 when the Elephant Transit Home was set up, after which they were taken to both PEO and Elephant Transit Home.
Home. From inception till 2022, a total of around 80 orphaned elephants have been received by the PEO. The last time wild-born orphaned calves were received by the PEO was in 2013 when five were received from the Department of Wildlife Conservation.

The objective of the PEO has changed from being an orphanage to a centre for elephant conservation, welfare, captive breeding, research, education, and recreation. It averaged about 60,000 visitors and generated 296,845 US$ per month during 2016–2020. In 2022, a total of 73 elephants including 32 males of which 15 are adults and 41 females of which 32 are adults were housed at PEO including 27 that were born in-house. Individuals that are born at the PEO and received as orphaned are integrated into the existing herd (Fig. 1).

Elephants are managed as a herd and individually in PEO. The herd comprises females of all ages and males up to around 10 years old. Males are then separated from the herd and cared for individually. A team of 3–5 mahouts is assigned daily to take care of around 5–6 male elephants. They walk the elephants to the river Ma Oya for bathing from 09:45 to 11:00 and 13:45 to 15:00. The herd is released to a free-roaming area around 3 ha in extent from 08:30 to 10:00 (Fig. 2) and herded to the river from 10:00 to 12:00, and 14:00 to 16:00 (Fig. 3), under the supervision of 5–6 mahouts. All elephants are housed in sheds at 16:00.

Old females whose body condition is deteriorating, females who have difficulty in walking or are suspected of being harmed by other elephants in the herd, and sick females are separated from the herd and form a “day-care group”, which usually consists of a few individuals and currently, this group has five individuals. When the main herd is in the free-roaming area, the day-care group is taken to the river Ma Oya and vice versa. Once they come back from the river at 14:00, they are housed in separate sheds near the veterinary office.

Calves born at PEO are not bottle-fed unless rejected by the mother or the mother does not have enough milk. Around 400–500 kg of fresh fodder is provided daily for the herd, in the free-roaming area. Fresh fodder is provided to each elephant equal to 9% of its body weight in the evening for the night. The fodder consists of kithul (*Caryota urens*) logs and leaves, coconut (*Cocos nucifera*) leaves, jack (*Artocarpus heterophyllus*) leaves and many varieties of other leaves and some grass species such as *Brachiaria ruziziensis*, *Brachiaria brizantha* and *Pennisetum purpureum*. In addition, some elephants are being given watermelon (*Citrullus lanatus*), banana (*Musa* spp.), pineapple (*Ananas comosus*), and animal pellets as per the recommendation of the veterinarian. The PEO spends about 40 US$ on an adult elephant per day for food.

Most elephants in the main herd are not fully tame and cannot be ridden nor made to work. However, mahouts can lead them to the water, free-roaming area, and sheds. Around 10–15 adult elephants are trained for basic work, such as carrying and distributing fodder and riding by the mahout. Training is essential especially for males as it makes them more manageable. When an elephant turns 8–10 years old, ma-
houts separate it from the herd and train it in basic commands under the supervision of curators and veterinarians. It takes around 1–3 months to train an elephant.

**Methods**

Records of elephants maintained at the PEO from 1984 to September 2022, were analysed. The records were maintained by the curator who is the head of the animal section. Events related to elephants such as births, deaths, their origin, and release from PEO were recorded. For births, details of the mother and father and time of birth were recorded, for new arrivals the time and date received from the wild, place of capture, and characteristics at the time of receiving such as height and weight were recorded. Information was also obtained from discussions with officers of the PEO.

**Results and discussion**

*Selecting breeding individuals*

Selecting females for breeding was based on observing changes in behaviour and external signs of oestrous by mahouts. The main behavioural signs observed were; the female approaching a male and turning her back to him, the male following the female and touching the vagina with the trunk, and when a male is released to the herd in the free-roaming area, the female approaching the male or vice versa. Specific behaviour such as increased clitoris-directed, underbody tail flicking reported in oestrous (Rasmussen & Krishnamurthy 2000), was not observed at the PEO. The main external sign of oestrous looked for at the PEO was vaginal discharge. Female elephants may not show clear and distinct morphological genital changes or obvious behavioural changes due to oestrus (Thitaram 2012). Consequently, identifying oestrous by behavioural changes and signs is not very effective. Detection of oestrous by hormone monitoring is more reliable (Thitaram 2012). However, it was not done at the PEO due to the lack of laboratory facilities.

Wild-origin individuals were preferred for breeding in order to maintain high genetic diversity. Since the majority of adults at the PEO were of wild-origin, mating between most males and females was not contraindicated. In choosing a pair for mating, the elephants’ behaviour was also considered. Some females avoided some males and some individuals both male and female, attack certain individuals and hence were not used for mating even though of wild origin. A male's behaviour such as aggressiveness towards people, other elephants, and preference towards particular females was also considered based on the experience of the staff. Given that the PEO was a public place, aggressive bulls were difficult to use for mating due to safety concerns for visitors and therefore only the controllable bulls were used for breeding. There was also a preference to use males that were more successful in sexual interactions, for breeding. Sometimes, if there were additional matching males to a female in oestrus, the males were switched each day but only one male was
put in at a time. The time and number of days each male received depended on how successful the sexual interaction was with the female. In such cases, paternity could not be attributed accurately. Males and females with signs of disease were not used for mating.

**Mating**

The oestrus cycle in elephants at PEO was between 3–3.5 months and females were in receptive condition for 1–3 days (Rajapaksa 2007). When a female in oestrus was identified, a selected male was released to the herd in the free-roaming area from 08:30 onwards and at the river from 10:00 onwards. If the male was aggressive, the pair were released to an isolated area or the free-roaming area before releasing the other elephants between 06:00 to 08:30. Sexual contact with the female could last from 3 days to a week or more (Fig. 4). Depending on the response shown by a male and female, the same or a new male was introduced the next day. If there was good sexual interaction between them and the male was not aggressive, the pair was allowed to have interactions for a few days until the end of oestrus. If sexual interaction did not occur, or a male behaved aggressively, that male was not put in the next day.

**Births**

From 1984 to 2022, 70 births and 5 stillbirths were recorded. The birth rate was $1.8 \pm 2.92$ per year and the births per reproducing female were 0.06 per year. Of the 32 females that reproduced, 25 wild-origin females gave birth to 59 calves (0.06 births/female/year) while 7 captive-origin females gave birth to 11 calves (0.04 births/female/year). In north-east India, the birth rate was 0.04 calves/adult female/year (Jerang et al. 2020). Less than 20% of Asian and 10% of African elephants have given birth in North American zoos (Brown et al. 2004; Keele et al. 2010). Although some western zoos have used methods including artificial insemination, success was low (Thitaram 2012). Thus, breeding success at the PEO has been comparatively high. However, in Myanmar, the country with the largest number of captive elephants (Sukumar 2006), captive breeding was much more successful and 25% of captive elephants in Myanmar were born in captivity (Mar 2013).

The births at PEO consisted of 38 male and 32 female calves giving a M:F sex ratio of 1:0.84 (Fig. 5). The sex ratio in Myanmar timber elephants was almost 1:1 (Mar 2013) and in Thailand, 1:0.75 (Toin et al. 2020).

The number of births at the PEO varied between years and 2011 had the highest with 15 births. After 2015 there were no births despite numerous breeding attempts until 2021, with four calves being born between 2021 and 2022. The longest inter-birth interval recorded at PEO was 12.25 years and the shortest was 2.34 years. In Myanmar, the longest and the shortest interbirth intervals were 21.44 and 1.52 years for captive-born mothers and 19.29 and 1.71 years for wild-caught mothers (Mar 2013).

Although calving was recorded at the PEO in all months, 30 out of 70 births (42.8%) were

**Figure 4.** Mating attempt in the free roaming area by a male put together with an oestrus female.

**Figure 5.** Number of calves born and stillbirths from 1984 to 2022.
from July to September (Fig. 6). In captive elephants in Myanmar, although births were recorded throughout the year, the rate was lower from May to August and highest from December to March (Mar 2013).

The stillbirth rate at the PEO was 6.7 per 100 births. (Fig. 5). In contrast, the stillbirth rate in Myanmar timber elephants was around 4% (Mar et al. 2012).

A total of 12 deaths were recorded of ages less than 15 years at the PEO from 1984 to 2022, mostly from natural causes. Four died due to disease. Information on disease conditions was available only for two – a female born on 10.01.2007 that died on 14.04.2021 due to a growth defect and a male born on 9.07.2015 that died on 27.11.2018 due to respiratory issues. One calf was killed by the mother, one died in an accidental drowning in a pit in the river, and one died due to rejection by the mother with not feeding the calf and hitting it. Calf killing by mothers has also been reported in some western zoos (Saragusty et al. 2009). All the deaths of calves at the PEO were of wild-born mothers.

Of 975 births among captive elephants in Myanmar 25.6% of calves died before reaching the age of five (Mar et al. 2012). In Myanmar the major cause of death for calves under five years age was accidents (42.4%) (Mar et al. 2012). In contrast, PEO recorded 8.3% of deaths due to accidents.

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References


Introduction

Human-elephant conflict is a concern throughout Asian elephant (*Elephas maximus*) ranges, and inequitably affects landless or otherwise disadvantaged community members (Acharya *et al.* 2016; Lamichhane *et al.* 2018). Near Chitwan National Park, Nepal, many such conflicts are due to rapid human population growth in elephant ranges which results in the narrowing of natural migratory corridors. Villages which lie within national park ‘buffer zones’ (areas surrounding national parks, set aside for local use to prevent overconsumption of park resources) are most heavily affected, due to their proximity to protected areas and the community’s reliance upon agriculture for survival. These buffer zones house marginalized communities, which bear a burden from human-elephant conflict (HEC) (Acharya *et al.* 2016; Lamichhane *et al.* 2018).

Conflicts arise when wild elephants are attracted to water sources or human-cultivated crops (Yadav *et al.* 2014). Agricultural crops offer higher palatability and greater nutritional or mineral content than wild-growing flora (Pokharel *et al.* 2018). Crop raiding also occurs when herds simply ‘happen across’ agricultural lands during regular movement, with fields lying alongside protected areas offering easy accessibility (Sukumar 2003; Yadav *et al.* 2014). These incursions may result in the destruction of croplands, fencing or housing, and injuries or fatalities to humans (Sukumar 2003). Within the buffer zones of Chitwan National Park, for example, wild elephants have caused more than 26 human fatalities, 30 injuries, and damaged over 300 homes over the last 20 years (Lamichhane *et al.* 2018). In response, elephants face retributory injury or death (Yadav *et al.* 2014).

A little studied contributor to HEC may be the presence of captive female elephants in residential or touristic areas, which attracts wild bulls. For example, a bull elephant was documented following a captive female into one of Nepal’s buffer zone villages (Pant *et al.* 2016). Bulls in musth actively seek out females for mating (but are believed to remain with the herd only if females are in estrus), but non-musth bulls are thought to remain solitary or travel in male-only herds (Sukumar 2003; Srinivasaiah *et al.* 2019). In African elephants (*Loxodonta africana*) and Asian elephants, males exhibit short term, non-musth association with female groups (Evans & Harris 2008; Srinivasaiah *et al.* 2019; Keerthipriya *et al.* 2020, Madsen *et al.* 2022). These interactions are often related to the overlap of ranges, watering holes, forest cover (Fernando *et al.* 2008; Fishlock & Lee 2013) or loose associations with family herds during adolescence and dispersal (Sukumar 2003).

Documentation of longer-term association of adult males with non-cycling females is lacking.

Abstract. Human-elephant conflict in the areas surrounding Chitwan National Park, Nepal, remains a concern. A unique cause of such conflict is the incursion of wild bull elephants into human-dominated landscapes in search of female elephants. One elephant owner adopted a novel method to mitigate conflict arising from such incursions by housing a female and her offspring within the community forest protected area. While this eliminated male incursion into human-dominated areas, it had to be abandoned after eight months, as authorities did not permit it.

One Stable’s Novel Approach to Mitigating Human-Elephant Conflict Near Chitwan National Park, Nepal

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Abstract. Human-elephant conflict in the areas surrounding Chitwan National Park, Nepal, remains a concern. A unique cause of such conflict is the incursion of wild bull elephants into human-dominated landscapes in search of female elephants. One elephant owner adopted a novel method to mitigate conflict arising from such incursions by housing a female and her offspring within the community forest protected area. While this eliminated male incursion into human-dominated areas, it had to be abandoned after eight months, as authorities did not permit it.

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However, according to interlocutors in an ongoing study (including mahouts, owners, foreign veterinary personnel and veterinary medical staff from the Nepalese government and the National Trust for Nature Conservation), wild bull association with non-cycling captive females is commonly seen in the hattisars (elephant stables) surrounding Chitwan National Park. Interlocutors reported that wild bulls spend extended time in both governmental and private hattisars. While some visits of males could be attributed to the proximity of food or water storage near stables (Lenin & Sukumar 2011), others lacked clear explanation.

One reason for association of wild bulls with captive females may be due to traditional practices aimed at encouraging captive elephant reproduction. Government-owned breeding facilities rely upon wild bulls to impregnate captive females, often chaining cycling females just beyond the stable perimeter to prevent escape and make them ‘more accessible’ (Varma & Ganguly 2011; Gairhe 2012). Captive-wild pairings have been the primary method of government-owned elephant reproduction in Nepal for decades, in part due to the difficulty of managing male elephants in captivity (Varma & Ganguly 2011). Therefore, encouraging incursions by wild bulls is traditional practice within governmental breeding facilities (Gairhe 2012; GoN 2015).

While the practice of stabling captive females near protected areas (PAs) has resulted in births among government owned elephants, it may also have resulted in the habituation of wild bulls to human activity and may be responsible for increasing HEC (Gairhe 2012; Pant et al. 2016). While electric fences, fires, noisemaking, and the planting of unpalatable crops have been employed to prevent wild elephant incursions onto human-occupied lands surrounding the park, they have had little success (Yadav et al. 2014; Acharya et al. 2016). In many cases, attempts by humans to dissuade elephants from entering settlements has backfired, with numbers of fatalities increasing as humans attempted to drive off elephants with loud noises, bright lights, or firecrackers (Ram et al. 2021). Privately-owned female elephants have not experienced a similar reproduction rate from wild bull incursions, with only three successful births in the past two decades (Gairhe 2012).

Wild bulls may also ‘release’ captive elephants from their stables, chasing or leading them into the jungle. These escapes force mahouts to follow on foot into protected areas, locate, and recapture the females (Varma & Ganguly 2011; Szydlowski 2021). Such releases and subsequent searches are dangerous both for the captive female, who has little experience with life outside the stable, and her mahouts, who face casualties from wildlife living within or near PAs. In fact, an average of 9.3 annual human fatalities occur within the PAs near Chitwan National Park, and mahouts on foot are at a much higher risk (Lamichhane et al. 2018; Rimal 2020; Mandal 2021).

**Methodology**

This case study is part of an ongoing project focused upon privately-owned elephants and their mahouts housed in villages adjacent to Chitwan National Park. These teams provide elephant-backed safari for tourists through the buffer zones of the national park (see below). Data were collected through a series of semi-structured face to face interviews with individual elephant owners, members of the United Elephant Owners’ Cooperative, mahouts, community members, and I/NGO staff from the Jane Goodall Institute-Nepal and the National Trust for Nature Conservation, participant observations (of elephants, owners, and mahouts), and interviews via phone, email, and messaging applications from 2019–2022. Photographic evidence of wild-captive elephant interactions was obtained from mahouts, owners, and other community members. This study is part of a larger project which was granted ethics approval by the University of Exeter College of Social Science and International Studies Ethics Committee.

**Study area**

This study took place on the edge of the Kumroj Community Forest (CF), in the Khairhani municipality of the Chitwan district in southern Nepal. Kumroj CF is located just north of the central area of Chitwan National Park, and
southeast of the park’s main entry point of Sauraha (Figs. 1 & 2).

Chitwan National Park is surrounded by buffer zones (Fig. 2). Tourist safaris are not allowed to operate within the boundaries of CNP, nor are privately owned elephants allowed to enter or graze within the national park. Instead, elephant-backed tourist safaris travel through the first of the buffer zones, the conservation zone, which serves as an extension of the national park and is managed by government agencies. This buffer zone area can only be used for governmentally regulated tourist activities, and the removal of forest products is severely restricted. Fees from conservation zone safaris are split between the government and elephant owners.

The next buffer area, the sustainable-use zone, is managed by local populations and used for community-based tourism practices, including additional elephant-backed safaris (which uses the same group of elephants as in conservation zone activities). These safari fees, however, are split between community forest users’ groups and elephant owners. The use of the forest and forest products in this zone is controlled by local households. Some mahouts have permission to enter the Kumroj community forest for grass cutting, but private elephant owners are forbidden from housing their elephants within the national park or any of its buffer zones (GoN 2015). As community forests are locally governed, some user-groups have recently begun granting fee-based access to non-residents for grazing.

Case study

In January 2022, a wild bull, Govinda Gaj, repeatedly broke through the barrier fence separating the Kumroj community forest from human neighborhoods. Govinda, according to interlocutors, was attracted to a 25-year-old captive female (‘Dira Kali’) being housed in a hat-tisar located approximately 100 yards from the barrier fence. The female was housed with her offspring, consisting of two females (~9 and 12 years old) and a one-year-old male. The wild bull and captive female are said to share a history; Govinda regularly visited Dira’s former stable near the Meghaulii community forest, and sired Dira’s youngest calf. This calf is unique, as wild bull pairings with privately owned females are rarely successful in producing offspring (Kharel 2002).

The female and offspring were purchased in 2019 by an owner who has been keeping tourist-backed safari elephants in Sauraha for a decade. He relocated all eight of his elephants to the rural Kumroj area in 2020 to reduce their daily commute to the tourist safari gates, and to escape the noise and traffic which surrounded his old stable. In Kumroj, the herd was housed in larger, chain-free corrals. Mahout housing was available near each, which helped maintain close contact with elephants and helped build positive human-elephant bonds. Such bonds have been shown to improve handler satisfaction as well as improve elephant health and welfare (Desai 2008; Carlstead et al. 2019; Kontogeorgopoulos 2020).

Ongoing conflicts

In January 2022, Govinda began regularly crossing through neighborhoods and farmlands...
to reach the private hattisar, and neighbors became concerned about crop loss, housing damage, and their physical safety. The bull repeatedly broke sections of the forest barrier fence, which is intended to keep non-local humans out of the buffer zone and potentially dangerous wildlife within. Later that month, Govinda ‘released’ the family herd from their corral and mahouts followed on foot hoping to recapture them. While the mahouts were able to locate the herd, Govinda showed no signs of moving off. In the hope of protecting his mahouts while assuaging the fears of his neighbors and minimizing damage to their crops and homes, the owner allowed the herd to remain within the buffer zone near the wild bull. The owner and several mahouts continued to follow the family group, and the herd eventually settled near an observation tower two km from the boundary of the PA. This structure, located on the border between the community forest and the national park, offered safety for the mahouts when Govinda became defensive or curious, and for staff to spend their nights.

The elephant-human group stayed in the community forest for six months with few issues. Eight mahouts continued to care for the elephants, making kushis (rice and molasses wrapped in grass), observing the herd, carrying water, and taking turns returning to the hattisar for supplies and rest. They continued to split shifts, allowing them to rest or return to their family’s village for visits. Govinda and the family herd spent time trunk-wrestling, group browsing, resting, and he was seen ‘playing’ with the calf. Rather than exhibiting signs of anxiety or disrupted sleep patterns, which would be expected following a change in herd structure and daily schedule (Evison et al. 2020), the elephants instead began to lie down en masse at night. Group sleep indicates a high level of herd cohesion and decreased stress (Evison et al. 2020). Being allowed to spend the night within ‘more natural settings,’ such as jungle, has also been documented to lower levels of stress hormones in captive individuals (Banshiddhi et al. 2020).

After six months, another wild bull, Ronaldo, began to approach, fought with and eventually chased Govinda off. Ronaldo led the family to another part of the PA (or possibly to the interior of the national park, the mahouts were unsure), and mahouts were unable to locate them for eight weeks. Renaldo finally moved off, and mahouts found and relocated the family to the watch tower, where they remained for two more months until forced to leave by authorities in September. While this elephant owner had been granted access for grazing within the community forest, the government prohibits keeping elephants within the PA.

No property damage occurred in the village during their tenure in the jungle; neighborhood complaints stopped, and there were no injuries to humans or elephants. Other unintended benefits of the jungle ‘occupation’ were reported. For example, participants in jeep safaris (which take place within the PA) thought they were viewing wild elephants rather than a captive herd (even though the captive females had neck ropes). Ability to see elephants is a major selling point for the government and tourism providers. While solitary males are sometimes seen in the PAs near town, spotting a herd typically requires an all-day walk into the jungle. Due to the low number (fewer than 200) of wild elephants left in Nepal (Yadav et al. 2014), sighting wild individuals is rare. Having this family ‘loose in the jungle’ offered tourists the opportunity to see elephants and observe natural herd behaviors.

Lastly, mahouts reported that the elephants were ‘happier’ when allowed to freely roam during their time in the forest, eat when desired, and socialize with wild males. Mahouts felt that while their elephants ‘loved’ and ‘needed’ them, the elephants exhibited more signs of happiness when removed from chains and allowed extended time away from safari duties in which to rest, eat, and spend time with ‘family’. The mahouts, while describing that it is ‘more dangerous’ to be near male elephants, likely also benefitted from the decreased need to keep their elephants under tight control. This control is necessary for the safety of mahouts and tourists on safari, and a break from safari work can lower mahout and elephant stress (Szydlowski 2022).
Discussion

This case study provided insight into the potential danger of housing captive females near wild bull ranges and highlighted a novel solution for decreasing incursions by males into human croplands or villages. Various efforts (tusk trimming, aversion with fire, patrols) have failed to mitigate conflict between humans and the wild males whose ranges include the Kumroj forest area. However, during the time Govinda and the captive herd were socializing within the forest, neighbors reported zero conflicts with bulls. While this could be considered a success for preventing HEC in Kumroj, further quantitative studies are needed to assess reductions in conflict over time and in other areas.

The case also highlights ways in which elephant well-being might be increased through access to the community forest. Having greater agency to decide when and where to eat, rest, or walk has been shown to increase elephant welfare (Kagan et al. 2015). An increase in elephant happiness may be due to the increased availability of food within the PA. Fodder supply issues are common in Nepal, due to the lack of available space to graze outside PAs, and the low availability of browse items for collection, especially during the winter months. While a few owners have garnered fee-based access to the community forest, most elephant owners are not allowed to enter forests for fodder collection or grazing. Local elephant owners have long sought access to buffer zones, including community forests, but have been unable to come to an agreement with users’ groups or government agencies. Several have drafted plans which would allow elephant stables to be relocated within the buffer zones, but such collaborative projects have yet to materialize. If community forest users’ groups and elephant owners can come to an agreement on access rights, then perhaps use of the forest can serve to reduce incursions by bulls into populated areas, increase the variety of fodder for captive individuals, and allow for tourist viewing of elephants in natural settings without the need to venture deeper into protected areas. Of course, such access rights must consider the needs of all residents of the community forest, lest they further marginalize groups of humans or other animals (Campbell 2007). Allowing more access for female elephants to protected areas may keep wild bulls out of more populous areas, while also placing marginalized human populations (those reliant upon the community forest for survival provisioning) at greater risk (Acharya et al. 2016; Lamichhane et al. 2018). Likewise, increasing human access to these areas might result in habituation by resident wildlife or movement of wildlife away from protected areas, increasing their risk (Curry et al. 2001; Geffroy et al. 2015). A consideration of greater passage of transmissible disease should also be considered, as Nepal faces increasing numbers of fatalities among wildlife which are likely due to disease passage along the captive-wild interface (Szydlowski 2022).

While this owner allowed his herd and mahouts to follow a bull elephant into the jungle to pacify and protect his neighbors, this novel approach might provide simple solutions to ongoing problems within Nepal. Due to the lack of appropriate grazing lands outside of PAs, lack of access to large plots of land for stable, and inability to collect a wide variety of plant materials for provisioned feeding, mahouts and elephants in private stables face daily challenges.

While allowing his herd to reside within protected areas is still illegal (and potentially dangerous for mahouts), the experiences of this captive herd offer novel insight into possible future options for reducing bull elephant entry into villages. Semi-wild elephant management has proven successful in other SE Asian countries and could offer options within Nepal which might decrease wild elephant damage to residential areas. Of course, any wild-captive elephant interactions within Nepal must be considered carefully, as disease spread along this interface is of increasing concern for wild populations.

Likewise, the practice of keeping female elephants near residential areas may need to be reconsidered in light of ongoing incursions by wild males, especially if these incursions occur even when captive females are not in estrus. Private stables, and the breeding center, may need to be relocated to less populous areas as human density continues to increase in buffer zones.
Likewise, limiting human expansion along elephant migratory routes is important.

If this owner is successful in continuing to bring in tourist dollars while improving elephant welfare, perhaps other owners will embrace these approaches to husbandry practices. Increasing stable footprints, allowing for longer and more varied consumption times, permitting access to conspecifics, and allowing agency for captive elephants is key to increasing health and welfare. As these elephants share landscapes with ever-decreasing numbers of wild individuals, their health is key to ensuring both populations remain viable within Nepal.

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References


Introduction

Asian elephants are megaherbivores feeding on a variety of browse and grass species. Their digestive tract contains a voluminous stomach and small intestine followed by a voluminous large intestine (Clauss et al. 2007). The latter presents a fermentation chamber for the high-fibre diet of the elephant and is characteristic for the group of ‘hind-gut-fermenters’. Due to their low-energy diet and relatively short mean retention time of 20–40 hours (Hackenberger 1987; Clauss et al. 2003; Beirne et al. 2019), elephants need to feed almost continuously. In herbivores, chewing to reduce food particle size is considered important for digestive efficiency. As elephants are non-ruminants, chewing is only one-step of digestion and chewing efficacy is possibly critical. In contrast to most mammalian species, elephants do not replace their deciduous with permanent teeth once. Instead, they express a life-long dentition change called molar progression, with a continuous change in size of the grinding surface (Laws 1966; Roth & Shoshani 1988; Lee et al. 2012). Although no measurements of the grinding surface in relation to an elephant’s age are available, a correlation between chewing efficacy and body mass cyclicity has been hypothesised in zoo-kept elephants under a constant diet (Schiffmann et al. 2019). Previous work has reported mean faecal particle size in 18 Asian and 13 African elephants without taking into account their age (Fritz et al. 2009), and assessed mean faecal particle size against body mass (Clauss et al. 2015). These studies determined faecal particle size by a wet-sieving procedure conducted in the lab.

The measurement of an average particle size of a sample of particles (such as a lump of faeces, or a cup of food) is usually performed using a combination of a sieve analysis and a subsequent calculation step. Methods may differ in the kinds of sieves used; in whether the sieving is performed ‘dry’ (as e.g. done for meal-type feed samples, but not applicable to pelleted feeds or faeces) or ‘wet’ with water being sprayed on the sieves (as e.g. done for pelleted feeds or faeces, which require soaking prior to sieving); whether the sieve column is shaken or not; whether the material passing the finest sieve is accounted for or not; and in how the results are used to calculate a certain measure of ‘average particle size’ (Fritz et al. 2012; Bertsch et al. 2022). For example, for samples of which some portion remains on the largest sieve, it has been recommended to measure the size of the
largest particles on that sieve, to estimate the upper limit of particle size that is used in certain measures of ‘average particle size’ (Fritz et al. 2012). Depending on the nature of the sample and the question asked, only results from selected sieves might be used to have a closer look at a certain fraction of the overall sample (Weary et al. 2017; Bertsch et al. 2022). A major disadvantage of the wet-sieving procedure is its laborious and time-consuming nature. For each sample analysed, all material from all sieves must be manually transferred to either tared petri dishes or filter paper, which can easily take half an hour. These individual sub-samples then need to be dried to constant weight, cooled down without gathering moisture, and then weighed again. Hence, a more simple and practical monitoring method would be welcome.

We determined the faecal particle size of four Asian elephants of various age and molar status, using a simple method and compared the results to the standard wet-sieving laboratory method to assess its reliability and consistency.

Material and methods

The study was conducted with four female Asian elephants (Elephas maximus) at Terra Natura Benidorm in Spain. They were all wild-born individuals with a life history of several inter-zoo transfers across Europe after importation. They were unrelated and none of them had ever had any offspring. They were fed a hay-based diet and weighed between 2960 and 3700 kg at the time of the study (Table 1).

Determination faecal particle size by simple method

A sample was taken from the inside of an excreted dung bolus avoiding the outside that has bedding, soil or dirt attached to it (Fig. 1). Of the collected sample 60 ± 5 g was weighed out, put in a kitchen sieve and rinsed under cold water until the fibres were clean (usually around 1 minute). The sieve was agitated gently, taking care not to break the fibres. Then the sample was spread out on a clean surface and the 10 longest fibres taken out. They were lined up on a sheet of paper and labelled with the elephant’s name and date (Fig. 2). Bent fibres were straightened, measured and the mean length of fibres calculated. The paper was photographed for reference. This procedure was conducted by the elephant keeper team at Terra Natura Benidorm, once a week for 10 continuous weeks from October 2022, providing a total of 40 samples. The diet of the elephants, consisting mainly of hay, remained identical during the course of sampling. The hay originated from one single batch.

Determination faecal particle size by wet-sieving procedure in the lab

The first two authors collected faecal samples according to the same protocol as the simple method on two consecutive days following the week of the last sampling by the keepers, from six different defecations per day from each of the four elephants. The samples were frozen at -16°C immediately after collection and shipped to the lab two days later.

Table 1. Date of birth, body mass and relevant notes for the elephants investigated here.

<table>
<thead>
<tr>
<th>Elephant</th>
<th>Age [years]</th>
<th>Body mass [kg]</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Female 1 (K)</td>
<td>40</td>
<td>2990</td>
<td>severe molar disorder in 2017</td>
</tr>
<tr>
<td>Female 2 (L)</td>
<td>40</td>
<td>3700</td>
<td>none</td>
</tr>
<tr>
<td>Female 3 (M)</td>
<td>37</td>
<td>3530</td>
<td>none</td>
</tr>
<tr>
<td>Female 4 (P)</td>
<td>50</td>
<td>2960</td>
<td>suffered from trunk paralysis</td>
</tr>
</tbody>
</table>

Figure 1. Sample collection from inside the faecal bolus.
At the lab, 20 g of each sample was used for dry matter determination by drying at 103°C for 24 h, and 40 g used for sieve analysis. For wet sieving, samples were first soaked under stirring in 1 l of water until they were completely thawed, and coherent fibre masses were dissolved. Then, the material was submitted to wet sieving under vibration following the protocol of Fritz et al. (2012), using a series of 16, 8, 4, 2, 1, 0.5, 0.25, 0.125, 0.063, 0.040 and 0.025 mm sieves (linear dimensions of holes) using a Retsch AS 200 digit wet sieving machine (Retsch, Haan, Germany). The machine consists mainly of a heavy base that includes a vibrating platform on which the sieve column is placed. Water is sprayed on the top of the sieve column and flows out of it at the bottom, carrying particles that pass the finest sieve. Particles passing the finest sieve were discarded. The vibration amplitude used was approximately 2 mm, water was applied at 2 l/min, and sieving was conducted for 10 min per sample.

The particles caught on each sieve were transferred onto pre-weighed petri dishes. From the material retained on the largest sieve, the 10 largest particles were measured individually. This is not necessarily part of the routine lab wet sieve analysis protocol, although it has been recommended for samples, such as elephant or giant tortoise faeces, of which relevant portions are caught on the largest sieve; this is not done to report their length, but for inclusion in the overall calculation method of the average particle size of the sample (Fritz et al. 2012). All dishes were then dried at 103°C for 24 h and weighed after cooling to room temperature in a desiccator using an analysis balance with measuring accuracy of 1 mg (Model AE160; Mettler-Instrumente, Gießen, Germany).

Results are presented as the mean length of the ten largest particles, the mean particle size (MPS) calculated as the dMEAN procedure from Fritz et al. (2012) using the material retained on the sieves; we calculated the MPS either using the actually measured largest particle size or setting it at 40 mm for all animals. Additionally, we expressed the results in the % of all particles retained above the 4 or the 8 mm sieve, and as MPS based only on sieves up to 4, 2 or 1 mm. The particles lost through the finest sieve were estimated by subtracting the sum of dry matter retained on the sieves from the calculated amount of dry matter submitted to sieve analysis. Results are presented as means ± standard deviation.

As the sampling was non-invasive and no study-related diet adaptations were conducted, no approval for experiments involving animals was required.

Results

Animals differed in the various particle size measurements (Table 2). The longest fibres occurred in female 1 and female 3. Female 2 and female 4 showed a shorter mean fibre length (Table 2). This pattern between the four animals can be observed with considerable consistency between all methods applied here that include, or focus only on, larger particles (Table 2, Fig. 3). By contrast, MPS measures that considered only the smaller particle size classes did not show the same systematic differences between the animals (Table 3, Fig. 4). When plotting the average individual results for all individual sieves, it is evident that the main difference between the animals was in the largest particle class (Fig. 5), which is also evident when comparing sieve remains in two individual animals (Fig. 6).

Discussion

Our investigation of mean particle sizes in the faecal fibres of four female Asian elephants revealed consistency between the two methodolo-
gical approaches. The methods differ greatly in their simplicity and thus practicality. While the simple method requires hardly any equipment and can be conducted in the field, including at zoos, the more sophisticated one requires a laboratory.

We found consistent results, independent of the method applied to determine faecal particle size in zoo elephants, as long as the larger particle fraction of the faeces is included in the particle size calculation. By contrast, using the smaller particles in the faeces does not lead to a consistent ranking of the animals. These discrepancies underline the importance of the large particle fraction in quantifying elephant chewing efficacy: all animals produce fine particles to some degree, but it is in the amount of large particles that have undergone minimal size reduction by chewing, that individuals differ. Therefore, the ‘simple method’ of only measuring the top 10 large particles repeatedly over several weeks

Table 2. Faecal mean particle size (MPS) measurements (mean ± SD) that include or are based only on large particles.

<table>
<thead>
<tr>
<th>Measurement</th>
<th>Female 1 (K)</th>
<th>Female 2 (L)</th>
<th>Female 3 (M)</th>
<th>Female 4 (P)</th>
</tr>
</thead>
<tbody>
<tr>
<td>MPS of ten largest fibres - zoo [mm]</td>
<td>87.5 ± 20.3</td>
<td>70.3 ± 12.9</td>
<td>98.0 ± 19.9</td>
<td>54.0 ± 6.0</td>
</tr>
<tr>
<td>MPS of ten largest fibres - lab [mm]</td>
<td>66.1 ± 7.8</td>
<td>58.8 ± 8.7</td>
<td>83.7 ± 14.6</td>
<td>49.7 ± 3.3</td>
</tr>
<tr>
<td>MPS whole faeces (max. size set to 40 mm) [mm]</td>
<td>16.7 ± 1.7</td>
<td>9.6 ± 3.4</td>
<td>17.7 ± 1.3</td>
<td>10.7 ± 3.1</td>
</tr>
<tr>
<td>MPS whole faeces (actual maximum size) [mm]</td>
<td>23.6 ± 2.6</td>
<td>12.2 ± 5.0</td>
<td>31.0 ± 6.1</td>
<td>12.2 ± 4.4</td>
</tr>
<tr>
<td>Particle mass retained on 4 mm sieve and higher [%]</td>
<td>67 ± 4</td>
<td>45 ± 7</td>
<td>66 ± 4</td>
<td>51 ± 8</td>
</tr>
<tr>
<td>Particle mass retained on 8 mm sieve and higher [%]</td>
<td>61 ± 4</td>
<td>35 ± 11</td>
<td>63 ± 4</td>
<td>46 ± 9</td>
</tr>
</tbody>
</table>

Figure 3. Different faecal particle size measures that all include large particles in four elephants: The largest 10 particles measured in faecal samples by keepers at the zoo (top10 zoo, in mm), the largest 10 particles measured in faecal samples in the lab (top10 lab, in mm), the mean particle size (MPS) calculated with the actually largest particles (MPSmax, in mm), or with assuming a standard maximum particle size of 40 mm (MPS40mm, in mm), or the percentage of particles retained on the 4 mm sieve and all sieves above (>4mm, in %) or those retained on the 8 mm sieve and the sieve above (>8mm, in %). Note that animals K and M are consistently recorded with larger particles than animals L and P across methods.

Figure 4. Different faecal particle size measures that all exclude the largest particles in four Asian elephants: The mean particle size (MPS) calculated with all sieves up to 8 mm (MPSto8), up to 4 mm (MPSto4), up to 2 mm (MPSto2) and up to 1 mm (MPSto1). Note the overall lack of consistency in the ranking of the animals.

Figure 5. The average distribution of particulate mass on the sieves in four Asian elephants. Note the difference between individuals with respect to the largest sieve size.
per individual appears adequate to differentiate between animals, and to possibly monitor changes in chewing efficacy over time.

A limiting aspect of this research is the small sample size. Finding keeper teams motivated and able to take the additional workload of such an investigation is not that easy, hence increasing the number of individuals participating in this kind of research is challenging. The fact that one of the elephants with particularly large faecal particles had a history of cheek tooth disorder suggests that faecal particle monitoring might reflect, dental status and health.

Reports on individual, live elephants’ molar grinding surface are lacking, most probably due to the challenge of taking standardised pictures and/or measurements of a living elephant’s molar teeth (Weihs 2001). In addition, knowledge on mastication parameters in elephants is very scarce. von Koenigswald (2016) provides an accurate description of the biomechanical chewing pattern in the African and Asian elephants and Weihs (2001) recorded chewing frequency in captive and free-ranging Asian elephants in Sri Lanka. The latter found a negative correlation between chewing frequency and age but was not able to investigate the impact of the molar grinding surface because inspection was not possible. A general decrease in chewing frequency with body size is well-known across mammal species (Gerstner & Gerstein 2008) and is explained by the fact that larger jaws, like larger pendulums on clocks, do not move as fast as smaller jaws or smaller pendulums. However, to which degree individual elephants differ in their chewing intensity, as e.g. demonstrated for individual cows (Zhang et al. 2022), has so far not been investigated.

Studies investigating the individuality of chewing frequency and intensity in elephants have not been conducted so far on the level of individual elephants with known age. It is reasonable to assume that not only the size of the grinding surface itself, but also chewing intensity in terms of chews per food bolus will impact faecal particle size. Animals with a smaller chewing surface might compensate by chewing a food bolus more intensively. In addition, the impact of varying food structure on faecal particle size is also unknown. The simple method to determine faecal particle size demonstrated here can be used for conducting such studies and longitudinal monitoring of chewing efficacy in captive elephants. It provides a practical and straight-forward approach for elephant care teams to regularly check the chewing efficacy of individual elephants non-invasively.

Table 3. Faecal mean particle size (MPS) measurements (mean ± SD, in mm) that are based only on particles ≤8mm.

<table>
<thead>
<tr>
<th>Measurement</th>
<th>Female 1 (K)</th>
<th>Female 2 (L)</th>
<th>Female 3 (M)</th>
<th>Female 4 (P)</th>
</tr>
</thead>
<tbody>
<tr>
<td>MPS whole faeces (up to sieve size 8 mm)</td>
<td>3.48 ± 0.86</td>
<td>3.30 ± 0.44</td>
<td>2.30 ± 0.51</td>
<td>4.24 ± 1.22</td>
</tr>
<tr>
<td>MPS whole faeces (up to sieve size 4 mm)</td>
<td>2.04 ± 0.11</td>
<td>2.00 ± 0.20</td>
<td>1.50 ± 0.19</td>
<td>1.76 ± 0.24</td>
</tr>
<tr>
<td>MPS whole faeces (up to sieve size 2 mm)</td>
<td>1.37 ± 0.07</td>
<td>1.30 ± 0.08</td>
<td>1.05 ± 0.12</td>
<td>1.26 ± 0.11</td>
</tr>
<tr>
<td>MPS whole faeces (up to sieve size 1 mm)</td>
<td>0.59 ± 0.04</td>
<td>0.58 ± 0.05</td>
<td>0.51 ± 0.02</td>
<td>0.56 ± 0.04</td>
</tr>
</tbody>
</table>

Figure 6. Wet-sieving residues in the lab from female 3 (upper row) and female 2 (lower row). Note the different distribution of the amount of fibres between the sieving stages, representing – from left to right, the 16, 8, 4, 2, 1, 0.5, 0.25, 0.125, 0.063, 0.040 and 0.025 mm sieves.
hence contribute to preventive health in elephant husbandry.

Acknowledgements

We wish to thank the management of Terra Natura Benidorm for approving and supporting this research project.

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Private Electric Fences: A Novel and Effective Approach to Preventing Elephant Depredation

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Introduction

Increasing human-elephant conflict (HEC) has been attributed to the rising human population, their needs including agriculture, and the fragmentation and reduction of forest cover (Fernando et al. 2011). Nineteen administrative districts out of 25 in Sri Lanka have reported HEC (Prakash et al. 2020). During 2010 to 2019, a total of 14,516 incidents of HEC have been reported in Sri Lanka including the death of 807 people, injuries to 579 people, 10,532 incidents of property damage and 2,631 elephants deaths (Prakash et al. 2020). HEC mitigation attempts by the state include distributing elephant thunder flashes (large firecrackers), capture and translocation, elephant drives, erecting electric fences and paying compensation (Prakash et al. 2020). Electric fences are one of the most effective methods for mitigating HEC (Fernando et al. 2008). However, in Sri Lanka they have been mostly erected around protected areas of the Department of Wildlife Conservation (DWC) restricting elephant movements (Fernando & Leimgruber 2011). In addition to the impossibility of restricting elephants to protected areas using electric fences, some elephants whose movements are obstructed by electric fences may search for new locations and thereby electric fences could even aggravate HEC (Gunaratne & Premarathne 2005). Wild elephants occur on both sides of many of the electric fences that have been constructed by the DWC, hence do not prevent elephant depredation (Fernando et al. 2008). Because the fences are constructed by the DWC, people have no sense of ownership of the fences and do little to maintain them and many such fences become dysfunctional after a few years (Fernando 2020).

Many of the weaknesses in the current approach to electric fences as a HEC mitigation measure could be remedied if electric fences were erected around human dwellings (Fernando 2020) and especially if individuals had full ownership of them. Here we present the results of 60 electric fences erected around private properties of villagers frequently affected with HEC.

Materials and methods

The fences were constructed by the Nano Vision Company (NVC), Anuradhapura, Sri Lanka. Publicity for this initiative by NVC was gained through various state organised public exhibitions and by word of mouth. All fences were erected on HEC affected individuals’ requests, around their properties, except for one fence, which was erected around an office. All houses and paddy fields included within fences were permanent. Some fences included ‘chenas’ in which slash and burn method was practiced seasonally. The mean length of the fences was $1228.7 ± 680.5$ m, range 250–3500 m. The area enclosed was not measured nor its ownership questioned. The mean duration the fences were in place was $3.5 ± 2.6$ years, range 0.5–13 years. Fences were constructed by NVC workers. Customers were given training on electric fence maintenance by the NVC as part of the process.

Two main designs of fences were used: screen (hanging) and regular. In screen fences 15-foot-high galvanised iron (GI) posts were used. A horizontal high tensile 2.5 mm gauge GI wire

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was strung between the highest points of the posts. Vertically hanging 1.8 mm gauge, GI wires of around 13 feet in length were attached every 2 feet along the length of the top horizontal wire. Screen fences were used without an Earth where the ground was moist and with an Earth where it was dry. The cost of a screen fence was 2105 USD per km (calculated at 1 US$ = SL Rs. 200).

In regular fences, posts were 8 feet tall with 2 feet buried in the ground. Wooden, concrete or GI posts were used. The fences had two live wires and an earth wire in the middle, all of which were 2.5 mm gauge GI. In locations which already had a non-electrified fence with concrete posts, the same posts were used to reduce the cost. They were modified by connecting iron bars to which the live wires were attached (Fig. 1). If the pre-existing fence had barbed wires, they were not removed during the modification. In places where elephants damaged posts regularly, bent GI posts were used. An electric supply was given to the bent post with a 2–3 foot polyvinyl chloride (PVC) socket used in the bottom of the posts to prevent current leakage or vertical guard wires hung from the top of the post. The top of bent GI posts was 6–7 feet height from the ground and 2 feet of the post was buried under the soil. At a height of 2 feet from the ground, the posts were bent 45° to 30° (Fig. 2). The cost for a fence using timber posts was 1086 USD per km and with GI posts 1613 USD per km.

The energiser used was manufactured by NVC. The input was 12 V and the output had a pulse rate of 40–72 per minute at 9–12 kV at an amperage of less than 25 mA and 4–19 joules. The energiser was powered by main grid (domestic) power and a step-down transformer to reduce input voltage to 12 V or with a solar panel system and a rechargeable 7 Amp 12 V battery. Where there was no access to grid power and a solar system was not installed (in slash and burn (chena) cultivation fields), the battery was brought home to recharge and fixed back to the electric fence at night. Main grid electricity supply was the source of power for the energiser in 23 fences, another 16 used main grid supply and when possible solar power, and 21 fences used only solar power. All customers were given an extra energiser and educated on changing the energisers on their own.

**Figure 1.** Modified concrete post.

**Figure 2.** Galvanised bent post. A = PVC socket applied to the post.
The 60 electric fences were located in the Anuradhapura (n = 31), Kurunegala (n = 9), Polonnaruwa (n = 8), Badulla (n = 8), Matale (n = 3) and Hambantota (n = 1) Districts. A total of 50 fences included cultivated land with 24 including paddy fields and 5 seasonal agriculture lands. A total of 39 electric fences included a house. Whenever a fence breakdown was identified, the first author was informed by the customer. According to the electric fence installation agreement with NVC, it was attended to within 3 days or depending on the nature of the complaint, instructions given over the telephone.

Information on elephant sightings, conflict experienced by fence owners before and after fence implementation and fence functioning was obtained by telephone interviews.

**Results**

None of the fence owners had conflicts with elephants, after fence installation. Before the fences were erected 24 (40.0%) had observed elephants once a week and the remainder less frequently. After erecting the electric fences, 30 (50%) of respondents sighted elephants weekly or more frequently and 5 (8.3%) about once a month. Most frequently observed type of elephants before the electric fence was installed were herds, which were observed by 54 (90.0%). Lone male elephants were observed by 50 (83.3%) and male groups by 29 (48.3%), before fences were erected. After the electric fences were erected, 16 (26.7%) had not seen elephants around their property, 45 (75.0%) had seen herds, 49 (81.7%) had seen lone males and 28 (46.7%) had seen male groups. In the opinion of the respondents, most probable reason (n=47) for frequent elephant visits was the presence of palatable food either in their cultivated lands, home garden, paddy fields, in chenas or stored at home.

Malfunctioning or break downs in the fence were observed by 20 (33.3%) respondents, up to date. A total of 3 (5.0%) of respondents experienced such malfunctioning 4 times, two respondents (3.3%) 3 times, three respondents (5.0%) twice and 12 (20.0%) once, after installation. A total of 57 (95.0%) respondents indicated that their fence is currently fully functional and are satisfied with it. A total of 37 (61.6%) respondents indicated that crop damage by other animals including wild boar, deer, giant squirrel and porcupine also have been reduced after the electric fence was installed.

**Discussion**

Our results demonstrate that erecting electric fences around private properties is very effective, as no HEC incidents were experienced after erecting the electric fences and none of the respondents had given it up. The types of elephants and frequency in which respondents observed elephants around their protected property did not substantially change after erecting the electric fences. This suggests that the elephants did not change their movement patterns due to the fences, hence that the fences did not obstruct elephant movement. These privately erected electric fences have continued to work well over the years possibly because fence maintenance is the responsibility of the owner who is also the investor. As a result, they have a high sense of ownership of the fence and since it is around their residence or cultivation, regular maintenance is not a problem for them.

Currently there are resident people in 69.4% of elephant range in Sri Lanka (Fernando et al. 2021). Thus, HEC which is mostly due to crop raiding is a major issue. Over 4,500 km of electric fences have been erected by the government with public funds but have failed to resolve the conflict, which has been steadily increasing (Fernando et al. 2011; Prakash et al. 2020). The obstruction of elephant movement by such fences constructed on administrative boundaries of protected areas has also been very detrimental to elephants (Fernando 2020). Our results suggest that electric fences around private properties are very efficient at preventing elephant depredation and do not harm or disturb elephants. Electric fences erected by the government around protected areas, incur repeated breakdowns and have to be repaired frequently, incurring government expenditure. For the private electric fences reported herein, the government did not invest any funds, human or other resources in construction or maintenance. Therefore, facilitating individuals getting their
own electric fences could significantly reduce HEC, without burdening the government. Our results seriously question continued erection of electric fences around protected areas and instead support the proposed paradigm shift in managing HEC, in which parties who are protected by electric fences should construct and maintain them (Fernando 2015).

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Facilitate to Innovate: Lessons Learned from Virtual Strategy Workshops for Asian Elephants

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Background

Asian elephants (Elephas maximus) are endangered, with many populations facing various degrees of threats throughout their range. In Southeast Asia, their situation is even more dire, with population declines threatening local extinctions in some range countries. To reverse the trajectory for this species, moving beyond ‘business as usual’ is essential. Although there have been wide-ranging efforts to protect Asian elephants, much more is needed to reverse their current decline, particularly in Southeast Asia. Over the past several months, WWF has been driving a collaborative effort among WWF offices and partners across the elephant’s Southeast Asian range to develop a strategy that aims to do just that.

Before the COVID-19 pandemic, WWF would typically gather range-country and broader WWF Network teams together for an in-person workshop to develop a regional strategy for the species. But organising in-person gatherings has become more complex. To navigate this, WWF partnered with Impact by Design to conduct this complex process virtually. Our task was to lay the groundwork for a regional strategic plan for Asian elephants, focusing on Cambodia, Laos, Indonesia, China, Myanmar, Malaysia, Thailand, and Vietnam.

The process began with deep assessment: we engaged key individuals and groups via detailed interviews to inform our approach. Subject-matter experts who participated in the assessment provided us with baseline knowledge of what’s currently being done to conserve Asian elephants in the region, stressing the inadequate nature of current actions, as well as a lack of resources to address conservation needs. Improved cooperation across national boundaries to allow for elephant movement, and meaningful engagement of communities and other stakeholders in the management of human-elephant conflict were just some of the needs mentioned. Assessment participants identified an aspirational ‘guiding star’ in their description of what success looks like, and they surfaced key questions that should be brought into the participatory workshop space. What actions can still be taken to reverse the declining trajectory of the species? What solutions to the problem have you thought about, but perhaps have been too hesitant to share?

The assessment revealed that ‘business as usual’ is not satisfactory for the future viability of Asian elephants in Southeast Asia. In other words, innovation was key.

The innovation conundrum

Early in our work, we recognised that ‘innovation’ is a tricky term. Too often, people automatically think of technological innovation as opposed to other types of creative solutions. Of course, that type of thinking wasn’t off the table, but game-changing innovation was going to come from a new set of ideas, actions and risk-taking and the creative use of existing resources, and not necessarily a new piece of technology.

Even more importantly, the vast majority of our virtual workshop attendees spoke English as a second language. While we could have spent workshop time aligning on a shared definition of words, we feared doing so would put too many parameters on attendees’ creative think-
ing. We tasked ourselves with spurring innovative thinking without relying on the word ‘innovation’ itself. We knew participants had all of the innovative solutions they needed locked away in their brains; we had to find the most effective way of unpacking and making sense of it in a virtual setting.

**The facilitator guides the innovators**

While planning for the workshop series, we kept circling back to the same question as we debated how to set the stage for innovation - What is the role of a facilitator? While there are many descriptions of this role, the authors of this article think of a facilitator as a guide that helps people do their best thinking while working in groups. So as facilitators, we focused on providing participants with the right tools and conditions to unlock and share ideas in a productive way.

Over the course of seven sessions, we gathered over 80 professionals from WWF and beyond, providing them with specific prompts and workspaces to guide their discussions toward our set objectives that emerged from the assessment. Some approaches and practices included:

- **Adaptive management.** While it was important to give participants a clear roadmap and agenda of what to expect from the workshops, we highlighted the likelihood that the process was open to adaptation in response to their needs. Indeed, there were opportunities for participants to check in with the workshop planning team to provide feedback, and while certain conversations took longer than expected at times, these conversations gave us the opportunity to ensure the process reflected shifting needs and expectations. While this meant that certain discussions had much less time dedicated to them, the adaptations allowed room for innovative thinking. All of these changes were clearly communicated to those participating.

- **Norm to perform.** Innovative thinking meant stepping outside of comfort zones, so we suggested group norms to help create a safe space for participants, and referred back to them when needed. At the start of the workshop series, we demonstrated what it meant to encourage bold thinking and foster creativity by enabling those attending to use multiple modes of communication (raising hand, virtual sticky wall, chat box) to express their thoughts, all within a respectful setting where there was no ‘wrong’ idea. Through these and other norms, participants understood that if an idea seemed unrealistic, the group asked clarifying questions instead of shooting it down.

- **Leverage a single, powerful tool for collaboration.** These days, there are endless online tools and platforms for groups to collaborate - and using too many can detract from effective engagement. While video conferencing software was used as our primary gathering place, we developed a highly organised virtual sticky wall to focus our discussions and capture the outcomes of our decision making. The virtual sticky wall had clearly articulated instructions and questions to guide group discussion. A core organising team, representing various perspectives present in the process, reviewed and provided feedback on the format of questions and how they were organised in the virtual space to most effectively spur discussion.

- **Asking the right questions the right way.** Providing quiet thinking time after asking a question is a staple approach to effective engagement that was so important to our process. After posing a prompt or question, we never dove directly into open discussion. Instead, participants were able to both hear and see prompt questions and given time to think before going into group discussions. This allowed everyone to gather their thoughts and gain confidence in proposing ‘out of the box’ ideas. In many cases, these prompts were sent via email before workshop sessions to give everyone extra thinking time. In the workshop itself, the way in which questions were asked were meant to evoke innovative thinking. Questions were not leading in nature, but rather encouraged participants to deeply reflect on their personal experiences and feelings. For example, instead of asking, "what challenges does your country team expect to face when implementing the plan?" we asked, "What aspects of the plan would your country team like to support but may not have the cur-
rent resources to do so?" We then followed up with, "What resources would be needed to ensure your country team's support?"

• The right activities for the objectives. Choosing specific activities and exercises in facilitated spaces isn’t a random process – it’s guided by objectives and the needs of participants. We selected specific approaches, such as modifications to a ‘World Cafe’ conversation and different versions of How/Now/Wow matrices to both evoke innovative ideas and prioritise them for decision making.

The outcome and pathway forward

The hours participants spent in the facilitated space helped to build camaraderie and a sense of being part of a coordinated group driving positive change for elephants across the region - something critical for actualising the plan itself. And although participants expressed an appetite to let ‘innovative’ ideas emerge, we found that spoon-feeding the concept of innovation was not necessary. The nature and structure of the discussions themselves were more than enough. Implementing teams from range country offices had the opportunity to engage directly with WWF team members with expertise in resource allocation, messaging, and fundraising. Together, they discovered overlaps in their needs and challenged each other to ensure solutions were holistic in nature.

What was the result? The overall framework of the strategic plan emerged as a two-pronged approach: A set of programmatic strategies aimed at on-the-ground actions that will lead to direct impact for Asian elephants in Southeast Asia, and supporting strategies aimed at providing the enabling conditions for success. These efforts were designed to push the region toward a guiding vision of success for 2030. Table 1 provides deeper details.

Through well-structured discussions, it became apparent that regional coordination, capacity, and funding had waned since WWF’s AREAS (Asian Rhino and Elephant Action Strategy) Programme concluded in 2016. As such, solutions did not solely focus on key aspects such as habitat conservation and reducing human-elephant conflict – but on tapping into the power and potential of collaborating with people living in the region: Promoting partnerships and shared learning experiences to improve regional cooperation among teams; scale conservation actions beyond small, project-based approaches; co-design management actions with various stakeholders; and draw connections to

Figure 1. A sample screenshot from the Miro platform demonstrates outcomes from a facilitated, strategic discussion. The post-it notes included are meant to demonstrate examples of workshop outcomes and are not exhaustive.
message and themes to elevate the profile of the Asian elephant that would culturally resonate with broad audiences and bring in sustaining funds.

It is important to keep in mind that this regional strategic plan was designed to not be prescriptive, but rather to give participating country teams the flexibility to move actions forward in ways that reflect their national priorities. While regional-level interventions bind the countries together, country-level interventions reflect the uniqueness of each country and, indeed, the elephant populations that reside in them. This ‘no one size fits all’ approach felt critical in ensuring buy-in among participating countries.

At their core, the virtual workshop sessions were opportunities to convene unique perspectives that could tackle key questions from different angles. They did not result in a perfectly polished strategic plan – but they served as a staging ground to align around what mattered most to participating countries and the wider WWF Network. Since the workshops, we have been working on fleshing out the finer details of strategy implementation and ensuring it is ready for launch, which is slated for mid-2023.

The call to action: Invest in facilitation

In a world seemingly filled with insurmountable, wicked environmental problems – like the reality of Asian elephants in Southeast Asia – facilitation is timelier than ever. These issues require intensely debated, collaborative solutions that only emerge from well-structured conversations where tough questions are tackled by diverse groups. The past couple of years have taught teams around the world that these solutions can be achieved without sitting in a room together. Indeed, we strongly believe virtual meetings and workshops aren’t going anywhere.

Nature is bombarding us with signals that there is no time to spare, so as professionals we have a shared responsibility to make every convening count. Remember: good meetings and workshops don’t just happen – you need to facilitate to innovate. Effective facilitation takes practice, but it is a skill that can be learned and even shared with like-minded colleagues. Whether convening in person or virtually, teams and organisations around the world can benefit from investing in this skillset, which has the capacity to open pathways to better, more innovative solutions to challenges of all shapes and sizes.
Joint Elephant Health Camp in Sauraha, Nepal

Michelle Szydlowski

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Elephant health camp

The National Trust for Nature Conservation (NTNC), Nepal in conjunction with pachyderm researcher, Dr. Michelle Szydlowski, and the Katie Adamson Conservation Fund, completed an elephant health camp in the area surrounding Chitwan National Park in November of 2022. The NTNC is the primary manager of ~33% of the protected areas within Nepal, and is tasked with research, anti-poaching support and building capacity within local communities (NTNC 2019). This collaboration is part of an ongoing partnership between the NTNC and funding bodies. The organisations previously teamed up with the World Wildlife Fund, Wildlife Veterinarians International and other entities to build the first wildlife hospital within Nepal. The hospital opened in 2020.

This elephant health camp, initially planned for 2020 but delayed due to COVID lockdowns, began through the collaborative efforts of Szydlowski and the NTNC’s head veterinarian, Dr. Amir Sadaula. Through joint efforts with the NTNC in Sauraha (Dr. Babu Ram Lamichhane, project manager in charge, Biodiversity Conservation Center), and other NTNC leadership (Dr. Naresh Subedi, department head), the KACF was able to fund the camp and sent a team of seven veterinary professionals and foot care specialists to assist Dr. Sadaula and his team with the health camp.

The camp’s goals included obtaining baseline measurements on elephant health (such as body condition scoring, weights, girths, wound and foot assessments, Figs. 1 & 2), performing basic examinations (faecal and blood chemistry panels), performing foot care, checking that microchips are still readable using current equipment, and providing training for local veterinary students. The camp also offered veterinary staff from the US and Nepal the opportunity to exchange information on elephant husbandry methods, nutrition, and stabling from both countries. Farriers and specialists from the US, including foot specialist Mike McClure of McClure International Consulting, shared their professional experience and learned about the unique foot issues facing captive elephants in Nepal. They further assisted the NTNC in offering care to working elephants in the area.

Private elephants

Maintaining up to date records on captive elephants in Nepal is now easier, thanks to the supreme court, which last year rededicated efforts toward ending illegal transboundary trade in elephants. Privately owned elephants currently residing within the Sauraha area will no longer face sale to India, ensuring that their health and

Figure 1. Showing how to measure the girth at the workshop. Photo by Lori Teirney.
welfare can now be monitored over the long
term by the NTNC as well as elephant health or-
ganisations and researchers. Keeping these indi-
viduals in the area is key to supporting ongoing
research, ensuring that records can be updated
regularly, and that improvements can be under-
taken which increase their health and welfare
(Szydlowski 2021, 2022). The health of these
elephants is key to maintaining healthy wild
populations, as disease transmission at the cap-
tive-wild interface is of growing concern
(Thapa 2017).

Government elephants

Government elephant teams serve vital conser-
vation purposes. These elephants, and their ma-
houts, serve in anti-poaching efforts, wildlife
census, provide transport for researchers, and
rescue wildlife and humans during the annual
monsoons. These elephants and mahouts are
housed throughout the national park areas of
Nepal. The joint health camp will offer addi-
tional support for ongoing health care programs
which regularly occur through the NTNC and
Government of Nepal Department of National
Parks and Wildlife Conservation veterinary
staff.

The camp served over 40 elephants in 2022,
and, has the potential to become an annual event
serving both privately-owned tourism elephants
and government and NTNC owned individuals.

Dr. Lamichhane said, ‘The owners appreciated
the effort of NTNC and KACF for the health
camp. It is important to continue such health
camp at least once a year for all captive ele-
phants in Nepal to ensure their better health and
welfare.’ Information garnered from the camp
will become part of each elephant’s medical re-
cord files and will be written up as part of
Szydlowski’s ongoing health and welfare study
in Nepal. This camp and the associated research
projects were approved by the University of Ex-
eter College of Social Sciences and Interna-
tional Studies Ethics Committee.

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Figure 2. Demonstration of a foot assessment
at the workshop. Photo by Lori Teirney.
**Introduction**

Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) is an international agreement between governments which aims to ensure that international trade in specimens of wild animals and plants does not threaten their survival. It originated from a resolution adopted at the 1963 IUCN Members’ Assembly and entered into force on 1 July 1975. The 19th meeting of the Conference of the Parties (CoP19) to the CITES was held in Panama City from 14th to 25th November 2022. Delegates adopted 46 of the 52 proposals put forward to increase or decrease controls on international trade in wildlife and wildlife products, bringing many species of sharks, lizards, turtles, fish, birds, frogs, and more than a hundred tree species under CITES control to ensure the sustainability of these species in the wild while allowing their international trade. The discussions on both Asian and African elephants are briefly summarised in this report (CITES Summary Record 2022 and IISD Reporting Services 2022).

**CoP19 Proposal 4: Amend the existing annotation for the populations of African elephant (*Loxodonta africana*) in Botswana, Namibia, South Africa, and Zimbabwe**

Zimbabwe introduced CoP19 Prop.4 to amend annotation 2 pertaining to the populations of *L. africana* in Botswana, Namibia, South Africa and Zimbabwe, highlighting the relatively large elephant populations in these countries and the need to raise funds for anti-poaching and for communities living near elephants.

Botswana, the Democratic Republic of the Congo, Lesotho, Namibia, the United Republic of Tanzania and Zambia supported the proposal, emphasising the need to deliver conservation benefits to local communities.

Benin, Burkina Faso, Burundi, the Central African Republic, Eritrea, Ethiopia, the European Union and its Member States, Gabon, Kenya, Liberia, Niger, Panama, Senegal, Togo and the United Kingdom of Great Britain and Northern Ireland opposed the proposal; while several of these recognised the successful elephant conservation efforts in the four countries, many considered that the proposed amendment would undermine previous efforts to close international ivory markets and could incentivise poaching. The European Union and its member states noted that it could not support changes to the existing annotation that would impact current trade rules.

The Chair called for a vote on proposal CoP19 Prop. 4. With 15 in favour, 83 against and 17 abstentions, the proposal CoP19 Prop. 4 to amend annotation 2 pertaining to the African elephant populations of Botswana, Namibia, South Africa and Zimbabwe was rejected.

The proposal was reopened in the plenary by Zimbabwe to amend the annotation for the Appendix II listing of elephant populations (*L. africana*) to change Annotation 2.e to be allowed to trade in leather goods for commercial and non-commercial purposes along with Botswana, Namibia, South Africa and Zimbabwe. Benin, Liberia, Burkina Faso, Panama, Kenya, EU, Gabon, UK, Ethiopia Israel, Senegal, Togo, Gabon, Mali, Panama, Congo and many other Parties opposed the amended proposal on the grounds that it would reopen international trade in ivory. Eswatini, Tanzania, Botswana, Lesotho, Democratic Republic of Congo, Botswana,
Zambia, Namibia, China and South Africa supported it highlighting the relative stability of southern African elephant populations. IUCN stressed the endangered status of the African savannah elephant. Zimbabwe called for a vote on the amended proposal.

**Outcome**

With 53 votes in favour, 48 against and 32 abstaining, the proposal to amend paragraph 2e) of the annotation to include Zimbabwe in the list of Parties allowed to trade in leather products for commercial purposes was rejected.

**CoP19 Proposal 5: Transfer elephant populations of Botswana, Namibia, South Africa and Zimbabwe from Appendix II to Appendix I**

Burkina Faso introduced CoP19 Prop.5 to include all populations of African elephants (L. africana) in Appendix I through the transfer from Appendix II to Appendix I of the populations of Botswana, Namibia, South Africa, and Zimbabwe. Benin, Togo, Kenya, Niger, Senegal, Panama, Nigeria and Burundi supported the proposal, calling for the single listing of all African elephants in Appendix I. Congo, Botswana, EU, Tanzania, Eswatini, Zimbabwe, Japan, Rwanda, Zambia, Namibia, Indonesia, Eritrea, Uganda, USA and Malawi opposed the proposal arguing that it lacked robust scientific data and that the biological criteria for listing the southern African populations of the species in Appendix I were not met. Burkina Faso asked for the proposal to be put to a vote.

**Outcome**

With 44 Parties in favour, 59 against, and 13 abstentions, CoP19 Prop.5 to transfer the populations of Botswana, Namibia, South Africa and Zimbabwe of L. africana from Appendix II to Appendix I was rejected.

**Doc.66.1: Implementation of Resolution Conf.10.10 (Rev. CoP18) on trade in elephant specimens**

The Secretariat introduced the document. India, Indonesia, Malaysia, Sri Lanka, Thailand, the United Kingdom of Great Britain and Northern Island, the United States of America did not support the Secretariat’s proposed amendment to direct Asian elephant range states to report on trade as it was not just Asian elephant range states being involved in such trade. Indonesia and Thailand added that non-Asian elephant range states should also be expected to report.

The European Union and its member states and the USA supported the Secretariat to ensure that no additional resources were used to undertake work on mammoth ivory. India stated that they supported measures to close legal markets in Asian elephant products and explained that they had been taking measures to better manage captive elephants. Thailand offered to share details of the system they have in place for captive elephants and tigers.

**Outcome**

The CoP directs the Secretariat, in collaboration with range states and other relevant stakeholders to develop requirements for registering, marking, and tracing system for mammoth ivory. India stated that they supported measures to close legal markets in Asian elephant products and explained that they had been taking measures to better manage captive elephants. Thailand offered to share details of the system they have in place for captive elephants and tigers.

**Doc.66.2.1 Ivory stockpiles: Implementation of Resolution Conf.10.10 (Rev. CoP18) on trade in elephant specimens**

Burkina Faso introduced CoP19 Doc.66.2.1 on enhancing reporting and security of ivory stockpiles stating that stockpiles stimulated demand for ivory and therefore posed a serious threat to African elephants.

Benin, Equatorial Guinea, Ethiopia, Gabon, India, Liberia, Kenya, Mali, Mauritania, Senegal,
Togo and USA supported the draft decisions in document CoP19 Doc.66.2.1. However, Botswana, China, the European Union and its member states, Japan, the Lao People’s Democratic Republic, Namibia, South Africa, Thailand and the United Republic of Tanzania did not support the proposed updated declaration on ivory stocks and model inventory form. These Parties variously expressed concerns that the new model inventory form would increase the burden on Parties with ivory stockpiles and believed that existing reporting requirements were sufficient. Some of the Parties also expressed concerns about the decisions directed at Parties to destroy stockpiles, indicating that this is a domestic matter. The matter was put to a vote. Committee II rejected the amendment, with 34 in favour, 54 against, and 13 abstaining. Committee II agreed to the document without the amendment.

Outcome

The CoP directs Parties to comply with the provisions of paragraph 7 e) of Resolution Conf. 10.10 (Rev. CoP18) on trade in elephant specimens concerning reporting on stockpile inventories to ensure the required information is submitted to the Secretariat every year.

Doc.66.2.2: Establishing a fund accessible to range states upon non-commercial disposal of ivory stockpiles

Kenya introduced CoP19 Doc.66.2.2. Ethiopia, Gabon, Guinea, Guinea-Bissau, Mali, Niger, Switzerland, Togo and the United States of America supported the document to establish an intersessional working group on sustainable financing for elephant and other wildlife conservation. Botswana, Japan, South Africa, Eswatini, Namibia, Zambia, USA and Tanzania rejected the document with several elephant range states arguing that they had not been consulted in its creation. The US and Switzerland supported establishing a fund for elephant range states but opposed the Secretariat’s recommendation that the SC be directed to consider various issues and options relating to sustainable financing for conservation in the upcoming intersessional period. The UK, EU, Botswana, China, India opposed Kenya’s proposal but supported the Secretariat’s recommendation, being of the opinion that further discussions should take place for the development of alternative and innovative sustainable funding mechanisms that could support conservation initiatives in African elephant range states.

Outcome

The issue went to a vote. A motion to accept Kenya’s proposal was rejected, with 50 against, 24 for and 33 abstaining. Committee II invited Kenya to further discuss this matter with relevant Parties and present an in-session document containing revised draft decisions to the Committee.

Doc.66.3: Implementing aspects of Resolution Conf. 10.10 (Rev. CoP18) on the closure of domestic ivory markets

Burkina Faso introduced CoP19 Doc.66.3, whereby countries with a domestic ivory market would report measures taken to close them. It also requests an analysis of ivory seizures connected to Parties with legal domestic ivory markets.

On the former, Benin, Burkina Faso, Gabon, Kenya, Senegal supported the adoption of the draft decisions in document emphasising the role of domestic ivory markets in contributing to poaching and illegal trade. Botswana, Thailand, the United Arab Emirates, Zimbabwe, Japan, South Africa rejected the proposal and were of the view that domestic ivory markets...
were not within the mandate of CITES. Botswana and Japan stated that consensus on measures to be implemented by Parties relating to legal domestic ivory markets had been reached at CoP18 and that the provisions in Resolution Conf.10.10 (Rev. CoP18) are adequate to address this matter. Saudi Arabia and the United Arab Emirates emphasised the importance of addressing illegal trade in ivory. The European Union and its Member States, Thailand and Zimbabwe supported draft decision with the amendments proposed by the Secretariat.

The Chair invited delegates to indicate whether the agreement could be reached on the draft decision as amended by the Secretariat. With a vote of 39 Parties in favour, 58 opposed and 5 abstentions the amendment proposed by Secretariat was rejected. Committee II agreed to the document without the first provision, keeping the Secretariat’s proposed text on commissioning an analysis.

Outcome

The CoP directs the Secretariat to engage the MIKE and ETIS Technical Advisory Group and TRAFFIC to advise whether an analysis of ivory seizures connected to each party with a legal domestic market for commercial trade in ivory could be undertaken and, if feasible, carry out the analysis and include the results in the ETIS report to the SC at its 77th and 78th meetings, and to CoP20.

Doc.66.4.1: International trade in live African elephant specimens: Proposed revision to Resolution Conf.10.10 (Rev. CoP18) on trade in elephant specimens and Doc. 66.4.2: Clarifying the framework: Proposal of the European Union

CoP19 Doc.66.4.1 introduced by Burkina Faso and CoP19 Doc.66.4.2, introduced by the EU, were considered together. Views strongly diverged on approaches. Benin, Guinea, Kenya, Liberia, Niger, Senegal Zimbabwe, Mali, and others supported the proposal of Burkina Faso.

Senegal, Eswatini, Namibia, Japan, United Republic of Tanzania, Zambia, Zimbabwe, Botswana, US, China and the UK supported the proposal by the EU and but raised concerns of the existing language in the document and suggested for further dialogue on the matter.

Burkina Faso, supported by Senegal, Togo, Mali, Guinea Bissau, Uganda, Niger, Cote D’Ivoire, Ethiopia, and Guinea proposed an inter-sessional working group to discuss the matter. They further proposed a moratorium on live elephant trade until a consensus is reached, which was opposed by Botswana and Zimbabwe.

The Chair noted the various aspects to be considered by the Committee and proposed to consider these in a systematic manner and directed the Standing Committee to call a CITES dialogue meeting for African elephant range states to consider a harmonisation of the conditions to trade in live African elephants. It also directed the Parties on any export of live wild caught African elephant will be limited to in situ conservation programmes or secure areas in the wild, within the species’ natural and historical range in Africa, except in exceptional circumstances where, in consultation with the Animals committee, through its Chair with the support of the Secretariat, and in consultation with the IUCN African elephant specialist group, it is considered that a transfer to ex situ locations will provide demonstrable in situ conservation benefits for African elephants, or in the case of temporary transfers in emergency situations.

Outcome

The CoP directs:

• The SC to call a CITES dialogue meeting, as per Resolution Conf.14.5, for African elephant range states to consider a harmonisation of the conditions for trade in live African elephants and propose relevant changes to resolutions to CoP20 as well as relevant changes to annotation 2, including changes to streamline and simplify the annotation; and recommend other Parties, the CITES Secretariat, and technical experts to participate in the meeting in accordance with the annex to Resolution Conf.14.5 on dialogue meetings.
• The Parties to agree that while the process for the dialogue meeting is under way, any export of live wild-caught African elephants will be limited to in situ conservation programmes or secure areas in the wild, within the species’ natural and historical range in Africa, except in exceptional circumstances where, in consultation with the AC, through its Chair with the support of the Secretariat, and in consultation with the IUCN African elephant specialist group, it is considered that a transfer to ex situ locations will provide demonstrable in situ conservation benefits for African elephants, or in the case of temporary transfers in emergency situations.

**Doc.66.5: Report on monitoring the illegal killing of elephants**

The Secretariat introduced CoP19 Doc.66.5. Parties broadly supported the report. Uganda noted that the report does not analyse the impacts of COVID-19 on illegal elephant killings. Committee II noted the report.

**Doc.66.6: Report on the Elephant Trade Information System (ETIS)**

The Secretariat introduced CoP19 Doc.66.6 which contained a report on the comprehensive analysis of the ETIS data carried out by TRAFFIC. The Democratic Republic of Congo opposed the report, arguing that the data was not objective. DRC supported by Malaysia and Singapore emphasised the importance of forensic analysis to determine the source of ivory seized by Parties. Uganda expressed concern that there are a number of Parties that are not submitting data. Vietnam reported it had made great efforts to tackle the illegal ivory trade and asked the Secretariat to reassess its analysis of their enforcement efforts. Togo noted difficulties in gathering the necessary data and asked for capacity building assistance from the Secretariat. Malaysia raised concerns with the methodologies that have led to Malaysia being clustered with other source countries. USA and Kenya did not support changing the final deadline for submission of seizure data by Parties. Committee II and CoP noted the report.

**Doc.66.7: Review of the National Ivory Action Plan (NIAP) process**

Malawi introduced CoP19 Doc.66.7 noting discrepancies in reporting requirements and the need for better alignment between reporting in NIAP and other processes under CITES. The USA called for a review of the effectiveness of NIAP. The EU did not support review of the entire process. Committee II established a working group chaired by the EU (Belgium) to consider drafting terms of reference for the review of the NIAP. The Working Group included International Union of Conservation of Nature (IUCN) amongst 18 Parties and five other international agencies. Representatives from IUCN SSC AsESG and IUCN SSC AfESG participated in the discussions of the Working Group.

Belgium reported to the Committee II on the discussions of the Working Group, noting that the timing for the SC to consider recommendations could be left more flexible. The USA, supported by Senegal and the UK and opposed by Singapore and China, proposed an additional instruction in the terms of reference to consider consultations with experts to strengthen the resolution. Committee II agreed to the document as proposed, while striking out a reference to a specific meeting of the SC.

**Outcome**

The CoP directs the Secretariat to contract a consultant to conduct a review of the NIAP; and the SC77 to review the consultant’s report and determine if further evaluation of the NIAP is needed and if so, outline any elements requiring further evaluation and direct the Secretariat to undertake the additional tasks as necessary and provide a report to SC78.
AsESG side event

The third Asian elephant range states meeting in collaboration with IUCN SSC Asian Elephant Specialist Group (AsESG) in April 2022 concluded with the drafting of the “Kathmandu Declaration for Asian elephant conservation” charting out 9 key priority actions underlined and agreed upon by all range states to attempt to fulfill by 2025. Taking the way forward, IUCN SSC AsESG organised a side event at the CoP 19 of CITES on “Kathmandu Declaration and its implication for conservation of Asian elephants” on 16th November 2022 at Panama Convention Centre, Panama City. About 100 people participated at the side event.

- Mr. Vivek Menon, Chair IUCN SSC AsESG introduced the Kathmandu Declaration and the role of IUCN SSC AsESG in assisting the range countries in meeting the priorities outlined in the declaration.
- Dr. Jon Paul Rodriguez, Chair IUCN SSC highlighted the role of IUCN SSC in providing support and leadership in working with Asian elephant range states to address the conservation issues of Asian elephants and taking appropriate steps in meeting targets of the Kathmandu Declaration.
- Mr. Azzedine Downes, President IFAW called out for collaboration and synergistic efforts needed to take forward the priorities outlined in Kathmandu Declaration, role of IFAW in working in tandem with countries to conserve both Asian and African elephants and IFAW’s commitment in supporting the IUCN AsESG.
- Dr. Maheshwar Dhakal, DG, Govt. of Nepal shared the plans of Govt. of Nepal in taking forward the targets outlined in the Declaration.
- Dr. S. P. Yadav, ADG, Govt. of India committed to the involvement of Indian Govt. in working with the Asian elephant range countries for conservation of elephants and on fulfilling the targets outlined in the declaration.
- Ms. Rahmah Illias, Principal Assistant Director, Govt. of Malaysia agreed with the views of India and Nepal in conserving Asian elephants and agreed to work forward to meet the targets of the declaration.
- Ms. Tanya McGregor, MIKE Coordinator, CITES shared the role of MIKE in working in tandem with Asian elephant range countries and how MIKE can synergise its efforts with AsESG to ensure effective conservation measures to protect Asian elephants.
- Dr. Benson Okita-Ouma, Chair AfESG and Ms. Rose Mayienda, AfESG reflected on the challenges and advantages that AfESG faced in creation of African elephant database and the African Elephant Conservation Fund.

This event brought together the Asian range countries as well as other stakeholders to an agreement to establish transboundary collaboration, create pan India Asian elephant database, complete national elephant conservation plans and establish an Asian Elephant Conservation Fund.

Source


Figure 4. AsESG side event at CoP19.
Island Elephants: The Giants of Sumatra by Dr. Alexander Mossbrucker offers a rare insight into the critically endangered Sumatran elephant and the steps required to secure the future of the species in the wild. Written by an expert in the field, Island Elephants presents an in-depth, highly researched approach to the protection of the Sumatran elephant (Elephas maximus sumatranus) in its natural habitat. Despite the scientific rigour, this is not an impenetrable technical book, as it has been written for a wide audience that includes laypeople, scientists and conservationists in Indonesia, with a free version translated into Indonesian.

For those wondering about the title, Mossbrucker explains in the Preface that ‘island elephants’ has a double meaning. It refers, on the surface, to the fact that Sumatran elephants live exclusively on the island of Sumatra. It also refers to the ways in which deforestation has isolated the species into separate ‘islands’ of forest. Sumatran elephants are separated from each other by vast seas of human habitation, roads and cities. This highly sentient species, whose memories of lost forests remain, have become islands, unable to reach each other.

Separated into four sections, this detailed book is easy to navigate and read, with text generously supported by photos such as elephant feet and footprints, babies suckling, and aerial shots of herds in their habitats. The text provides insights into the science, conservation and habits of elephants, starting with a fascinating excursion into the world of elephants accompanied by rich (and sometimes unexpected) details and insights into elephants, such as the family structures of elephant ‘clans’, the importance of ‘aunties’, and the roles of bulls. This first section is a thorough introduction to Asian elephants, covering all the basics about their biology and behaviour in a compact and easy-to-understand way.

The second section focuses specifically on the elephants of Sumatra and how they’re unique in the world of elephants. It provides details about their specific origin, distribution, threats, conservation status, and conservation needs. Some of the captive Sumatran elephants who are in the care of elephant conservation centres are briefly mentioned, although the book mainly focuses on wild elephants and their conservation.

The third section presents a selection of research and monitoring approaches and methods, with a focus on those that are directly related to elephant conservation. This includes attempts being made to understand, predict and address what is known as ‘human-elephant conflict’. Mossbrucker says, “For many, human-elephant conflict is the ultimate manifestation of all the difficulties we have to deal with in elephant conservation, a constant headache for site managers and conservationists across the elephant range. To really ‘solve’ human-elephant conflict permanently is a complex and challenging task.”

Section four then focuses on some of the best practice conservation methodologies being used by Mossbrucker and the Indonesian teams he works with to ‘solve’ this complex issue. In this final chapter, the author goes into detail about all aspects of management and conservation of elephants in the unique Sumatran context, covering topics including habitat management,
meta-population management, efforts to turn conflict into coexistence, and the importance of working with local communities.

Dr. Alexander Mossbrucker is a trained biologist and forester who has spent more than a decade on the Indonesian island of Sumatra, researching the native elephants and working with international and local organisations to close knowledge gaps and support various elephant conservation programs. Not surprisingly, this beautifully illustrated book contains plenty of first-hand information and authentic insights.

According to Mossbrucker, the publication is primarily aimed at future elephant conservationists and students who are looking for a compact and reliable source of information. Regardless of this intent, the text will be of interest to a wider audience, especially those who are fascinated by elephants and concerned about their future survival. Importantly, the book is also relevant for seasoned practitioners and scientists, who will enjoy and appreciate the careful attention to detail in this book.

*Island Elephants* is the most comprehensive book on the Sumatran elephant available today, and the clear writing style makes it an enjoyable read, with the many subheadings making the information simple to navigate. It’s great to hear that the Indonesian version of the book is available for free under [https://www.elephant.org.au/islandelephants/](https://www.elephant.org.au/islandelephants/), which reduces barriers for those working at the coalface of this challenge. For readers with even a passing interest in Sumatran elephants, *Island Elephants* is a clear, accessible and detailed deep dive that will fascinate and inform, hopefully leaving you with a desire to help save this iconic and critically endangered species.

Citation

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Recent Publications on Asian Elephants

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R. Ahmed & A. Saikia
**Pandora’s box: A spatiotemporal assessment of elephant-train casualties in Assam, India**

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**Abstract.** Railways are an indispensable component of sustainable transportation systems, but also exact a toll on wildlife. Wild Asian elephants are often killed by trains in Assam, India, where we assess temporal variations in the occurrences of elephant-train collisions (ETCs) and casualties during 1990–2018. This study also assesses spatially varying relationships between elephant-train collision (ETC) rates and elephant and train densities in the adjoining 10 km$^2$ grid cells of 11 prioritized railroad segments using ordinary least squares (OLS) and geographically weighted regression (GWR) models. The temporal analysis indicated that ETCs spiked at certain hours and months. The adult and calf elephant casualties on the railroads were found to be two to fivefold high during the post monsoon season compared to other seasons. During the operation period of meter gauge railroads (1990–1997), the proportions of ETCs and casualties were only 15.6% and 8.7% respectively. However, these increased substantially to 84.4% and 91.3% respectively during the operation of broad gauge railroads (1998–2018). The OLS model indicated that both elephant and train densities explained 37% of the variance of ETC rate, while GWR model showed 83% of the variance of ETC rate. The local coefficient values of GWR indicated that both the predictor variables interplayed significantly and positively to determine ETC rates in the Mariani-Nakachari and Khatkhati-Dimapur railroad segments. However, the relationship between ETC rate and elephant density is significantly negative in the Habaiipur-Diphu railroad, implying that the elephant population along this railroad stretch is significantly af-
ected by railways through large scale ETCs. Hence, there is an urgent need to address long-term mitigation strategies so that elephants can be conserved by providing safe passages and survival resources along railway lines. © 2022 The Authors.

R. Ahmed, A. Saikia & S.M. Robeson

Tracks of death: Elephant casualties along the Habaipur-Diphu railway in Assam, India
Annals of the American Association of Geographers 112 (2022) 1553-1575

Abstract. Railway development is an important component of sustainable transportation systems but also affects wildlife habitats worldwide. Here, we assess spatiotemporal patterns of elephant–train collisions and mortalities within the state of Assam, India, and relate them to spatial and temporal land cover change (LCC) from 1988 to 2018. The results indicate that an extension of railways into forested landscapes is associated with large-scale LCC and increased elephant–train collisions and mortality. Prior to 1997, when the railway system used narrower gauge rails, elephant deaths from collisions occurred at a rate of one or two per year. After 1997, when the system was converted to larger gauge rails, elephant deaths increased starkly and now occur at a rate approaching ten per year. While the rail gauges were being converted, the landscape around the Habaipur-Diphu railway line saw a sevenfold increase in annual net loss of dense forest. The transition from forest to croplands was the most dominant process of deforestation and forest fragmentation during the postconversion period. Although elephant-train collisions are strongly associated with the land use transitions shown here, conservation and remediation measures can help to stem further declines in forest habitats and promote safe movement by elephants between resource patches. © 2022 American Association of Geographers.

Z. Amir, J.H. Moore, P.J. Negret & M.S. Luskin

Megafauna extinctions produce idiosyncratic Anthropocene assemblages
Science Advances 8 (2022) eabq2307

Abstract. The “trophic downgrading of planet Earth” refers to the systematic decline of the world’s largest vertebrates. However, our understanding of why megafauna extinction risk varies through time and the importance of site- or species-specific factors remain unclear. Here, we unravel the unexpected variability in remaining terrestrial megafauna assemblages across 10 Southeast Asian tropical forests. Consistent with global trends, every landscape experienced Holocene and/or Anthropocene megafauna extirpations, and the four most disturbed landscapes experienced 2.5 times more extirpations than the six least disturbed. However, there were no consistent size- or guild-related trends, no two tropical forests had identical assemblages, and the abundance of four species showed positive relationships with forest degradation and humans. Our results suggest that the region’s megafauna assemblages are the product of a convoluted geoclimatic legacy interacting with modern disturbances and that some megafauna may persist in degraded tropical forests near settlements with sufficient poaching controls. © 2022 The Authors,


Dynamic occupancy of wild Asian elephant: A case study based on the SMART database from the Western Forest Complex in Thailand
Environment and Natural Resources Journal 20 (2022) 310-322

Abstract. Understanding distribution patterns is essential for the long-term conservation of megafauna, particularly the Asian elephant. We investigated the dynamic occupancy of Asian elephants in the Thung Yai Naresuan West Wildlife Sanctuary in Thailand. Asian elephant occurrences were recorded during patrol activities from 2012 to 2019. We applied a single-species dynamic occupancy model to examine the environmental factors influencing habitat occupancy of Asian elephant across multiple seasons. The best-supported model, based on the Akaike information criterion (AIC), indicated that the normalized difference vegetation index and elevation positively influenced the probability of colonization. In contrast, the distance to the nearest population source sites showed a negative association. The probability of local extinction was positively correlated with the distance to the nearest villages and population.
source sites. The predictive map indicated a higher probability of colonization in a remote mountainous region of the center of the protected area. Higher extinction probability was associated with areas of dense human activity and far from population source sites connecting the Asian elephant population to the east. This is the first study to utilize a patrol database for assessing the dynamic occupancy of Asian elephants across multiple years. Our model provides insight into the dynamic distribution patterns of elephants within the wildlife sanctuary and the factors that most influence these patterns. Long-term ecological data provide crucial information for assessing biodiversity, population status, and ecological processes of focal wildlife species and are valuable for both protected area management and conservation efforts.

Changes in serum cardiac troponin I in Asian elephants (Elephas maximus) with elephant endotheliotropic herpesvirus infection J. of Zoo and Wildlife Med. 53 (2022) 249-258
Abstract. Elephant endotheliotropic herpesvirus (EEHV) is one of the most important causes of mortality in Asian elephants. The unusual tropism of EEHV for endothelial cells of capillaries can lead to catastrophic vascular dysfunction, hemorrhage, cardiac damage, and death. Cardiac troponin I (cTnI) is an intracellular protein of cardiomyocytes that is released into circulation in levels directly correlated to the severity of cardiomyocyte damage. The purpose of this study was to assess if cTnI could be used to distinguish when EEHV viremia leads to clinical disease versus subclinical infection. Thirty-seven individual Asian elephants contributed 53 blood samples that were evaluated for EEHV viremia using quantitative polymerase chain reaction and analyzed for cTnI using a high-sensitivity assay. Viremia was categorized as none (24/53), low (<20,000 vge/ml, 12/53) and high (≥20,000 vge/ml, 17/53). Seven of the nonviremic samples had detectable cTnI. Nine low-viremia samples were positive for EEHV1 (1A and 1B combined) and lacked a detectable cTnI. Fourteen high-viremia samples were positive for EEHV1 and had detectable cTnI. There was statistical significance between having viremia and having a detectable cTnI value (P = 0.0001), and animals with EEHV1 viremia were more likely to have a positive cTnI value (P = 0.04). The presence of cTnI was associated with the presence of clinical signs, with higher values of cTnI in the presence of clinical signs versus subclinical viremia (P = 0.0001). In addition, four elephants contributed multiple samples from a single viremic event and results displayed a trend of elevation in troponin values with progression of EEHV viremia. The association of EEHV viremia with cTnI suggests these markers might be used in conjunction to help predict when EEHV viremia is likely to progress to EEHV-HD for an individual. © 2022 American Association of Zoo Veterinarians.

D. Bai, X. Wan, L. Zhang, A. Campos-Arceiz, F. Wei & Z. Zhang
The recent Asian elephant range expansion in Yunnan, China, is associated with climate change and enforced protection efforts in human-dominated landscapes Frontiers in Ecology and Evolution 10 (2022) e889077
Abstract. Recently, the northward movement of Asian elephants in Yunnan, China, has attracted international attention. Climate change or human disturbances have been proposed to be the key drivers, but these hypotheses have not been rigorously tested. In this study, we quantified the relationship between climate change and human impacts on the recent range expansion of Asian elephants in southwest China. We found that the first observation probability of this species in a new place during 1959–2021 had a significant and positive association with change in air temperature and human density, resulting in a movement toward a high-latitude region with a warmer climate and higher human density; however, its association with precipitation was scale-dependent in time: positive or negative during the past 10 or 5 years, respectively. Under the enforced protection policy, human-dominated areas became preferred habitats for elephants. Our results indicate that climate change and enforced protection efforts in human-dominated landscapes in the last few decades are significant drivers of the recent range expansion of Asian elephants in Yunnan, China. It is necessary to expand the current protected areas or habitat corridors toward the north or set
up new reserves in the north and set up barriers between human settlements and elephant habitats to facilitate elephant movements and minimize human-elephant conflicts under accelerated global change. © 2022 The Authors.

S. Banerjee & A. Aiyadurai

**Everyday conservation**: A study of actors and processes in an elephant conservation project in Assam, India

*Human Dimensions of Wildlife* 27 (2022) 536-553

**Abstract.** Existing studies on community-based conservation in India, while highlighting the results and effectiveness of conservation interventions fail to engage with the underlying social processes emerging from the interactions among conservation actors. This article demonstrates conservation as a social process in which the actors interact with each other daily. We use the notion of ‘Everyday Conservation’ to highlight that actors use their resources, skills and limitations to create a space where conservation processes are negotiated and shaped on an everyday basis. Using ethnographic work carried out in Assam (India), this article analyzes an Asian elephant conservation project to understand the various actors involved in the project, such as project managers, staff, local community, funding organization and forest department and their interactions, resulting in ‘Everyday Conservation.’ The inter-actor interactions were of varying intensity, depending upon which the actors negotiated, collaborated, or came into conflict, thereby producing conservation results embedded in contextual factors. We suggest that conservation needs rethinking and the framework of ‘Everyday Conservation’ can provide a fresh perspective on community-based wildlife conservation. © 2021 Taylor & Francis Group, LLC.

A. Baotic, B. Brady, E.A. Ramos & A.S. Stoeger

**Elephants and sirenians: A comparative review across related taxa in regard to learned vocal behavior**

*Comparative Cognition and Behavior Reviews* 17 (2022) 89-108

**Abstract.** Vocal production learning is the ability to modify a vocal output in response to auditory experience. It is essential for human speech production and language acquisition. Vocal learning evolved independently several times in vertebrates, indicating evolutionary pressure in favor of this trait. This enables cross-species comparative analysis to be used to test evolutionary hypotheses. Humans share this ability with a versatile but limited group of species: songbirds, parrots and hummingbirds, bats, cetaceans, seals, and elephants. Although case studies demonstrate that African savanna and Asian elephants are capable of heterospecific imitation, including imitation of human words, our understanding of both the underlying mechanisms and the adaptive relevance within the elephant’s natural communication system is limited. Even though comparing phylogenetically distant species is intriguing, it is also worthwhile to investigate whether and to what extent learned vocal behavior is apparent in species phylogenetically close to an established vocal learner. For elephants, this entails determining whether their living relatives share their special ability for (complex) vocal learning. In this review, we address vocal learning in Elephantidae and Sirenia, sister groups within the Paenungulata. So far, no research has been done on vocal learning in Sirenians. Because of their aquatic lifestyle, vocalization structure, and evolutionary-ary relationship to elephants, we believe Sirenians are a particularly interesting group to study. This review covers the most important acoustic aspects related to vocal learning in elephants, manatees, and dugongs, as well as knowledge gaps that must be filled to fully comprehend why vocal learning evolved (or did not) in these distinctive but phylogenetically related taxa.

K. Baral, S. Bhandari, B. Adhikari, R.M. Kunwar, H.P. Sharma, A. Aryal & W. Ji

**Anthropogenic mortality of large mammals and trends of conflict over two decades in Nepal**

*Ecology and Evolution* 12 (2022) e9381

**Abstract.** Wildlife conservation in human-dominated landscapes faces increased challenges due to rising conflicts between humans and wildlife. We investigated the human and wildlife loss rates due to human-wildlife conflict between 2000 and 2020 in Nepal. We concentrated on Asian elephant, greater one-horned rhino, tiger, and leopard mortality, as well as human mortality caused by these species. Over
the 21-year period, we recorded 1139 cases of wildlife mortality and 887 cases of human mortality. Leopard mortality was the highest, followed by that of greater one-horned rhinos, tigers, and Asian elephants. Overall, the rate of wildlife mortality has been increasing over the years. Asian elephants were found to be more responsible for crop damage than greater one-horned rhinos, while leopards were found to be more responsible for livestock depredation than tigers. The generalized linear model indicated that the mortality of wildlife in the districts is best predicted by the additive effect of human mortality, the proportion of agricultural land, and the literacy rate of the districts. Retaliatory wildlife mortality was the most challenging issue for wildlife conservation, especially for the large mammals. Findings from this study are important for mitigation of human-wildlife conflicts, controlling retaliatory killing, and conserving these threatened large mammals. © 2022 The Authors.

P. Bharathy, S. Wijeyamohan, K. Suthakar & S. N. Surendran

Vulnerability of land use/cover associated with human-wildlife conflicts in Mullaitivu District, Sri Lanka
Geocarto International 37 (2022) 15378-15391

Abstract. Human-wildlife conflict has increased over the decades and is now considered one of the most severe challenges to the survival of threatened species and the livelihood of communities worldwide. In Sri Lanka, population growth, fragmentation of land, and conversion of natural wildlife habitats into settlements and agricultural areas are the leading causes of human-wildlife conflict. This study seeks to characterise the conflict pattern in the Mullaitivu District by identifying land use/cover changes and assessing the vulnerability of land use/cover. Primary data were collected through a field survey using a structured questionnaire and direct observation methods, and secondary data on land use/cover changes were obtained from remote sensing images. These data were analysed statistically and on the Geographic Information System (GIS) platform. The study reveals land use/cover vulnerability status over the 26 years. Dense forests are on the decline, and wild animals migrate into human settlements and agricultural sites, resulting in different types of human-wildlife conflict such as crop damage, livestock depredation, and loss of life and/or injuries to both people and wildlife in the Mullaitivu District. People employ various wildlife mitigation strategies. However, they cannot safeguard their crops or livestock from these animals. By implementing appropriate management measures to avoid wildlife infiltration into human settlements, the human-wildlife conflict in the Mullaitivu District can be minimised. © 2022 Informa UK Limited.

P. Bodesheim, J. Blunk, M. Körschens, C.-A. Brust, C. Käding & J. Denzler

Pre-trained models are not enough: Active and lifelong learning is important for long-term visual monitoring of mammals in biodiversity research – Individual identification and attribute prediction with image features from deep neural networks and decoupled decision models applied to elephants and great apes
Mammalian Biology 102 (2022) 875-897

Abstract. Animal re-identification based on image data, either recorded manually by photographers or automatically with camera traps, is an important task for ecological studies about biodiversity and conservation that can be highly automatized with algorithms from computer vision and machine learning. However, fixed identification models only trained with standard datasets before their application will quickly reach their limits, especially for long-term monitoring with changing environmental conditions, varying visual appearances of individuals over time that differ a lot from those in the training data, and new occurring individuals that have not been observed before. Hence, we believe that active learning with human-in-the-loop and continuous lifelong learning is important to tackle these challenges and to obtain high-performance recognition systems when dealing with huge amounts of additional data that become available during the application. Our general approach with image features from deep neural networks and decoupled decision models can be applied to many different mammalian species and is perfectly suited for continuous improvements of the recognition systems via lifelong learning. In our identification experiments, we consider four different taxa, namely two elephant species: African forest ele-
phants and Asian elephants, as well as two species of great apes: gorillas and chimpanzees. Going beyond classical re-identification, our decoupled approach can also be used for predicting attributes of individuals such as gender or age using classification or regression methods. Although applicable for small datasets of individuals as well, we argue that even better recognition performance will be achieved by improving decision models gradually via lifelong learning to exploit huge datasets and continuous recordings from long-term applications. We highlight that algorithms for deploying lifelong learning in real observational studies exist and are ready for use. Hence, lifelong learning might become a valuable concept that supports practitioners when analyzing large-scale image data during long-term monitoring of mammals. © 2022 The Authors.

Souraditya Chakraborty

Trends and patterns of elephant conservation management and human elephant conflict scenario in forests of northern West Bengal, India

Proc. of the Zoological Soc. 75 (2022) 319-332

Abstract. No permission to print abstract.


Landscape characteristics influence ranging behavior of Asian elephants at the human-wildlands interface in Myanmar

Movement Ecology 10 (2022) e6

Abstract. Asian elephant numbers are declining across much of their range driven largely by serious threats from land use change resulting in habitat loss and fragmentation. Myanmar, holding critical range for the species, is undergoing major developments due to recent sociopolitical changes. To effectively manage and conserve the remaining populations of endangered elephants in the country, it is crucial to understand their ranging behavior. Our objectives were to (1) estimate the sizes of dry, wet, and annual ranges of wild elephants in Myanmar; and quantify the relationship between dry season (the period when human-elephant interactions are the most likely to occur) range size and configurations of agriculture and natural vegetation within the range, and (2) evaluate how percent-

age of agriculture within dry core range (50% AKDE range) of elephants relates to their daily distance traveled. We used autocorrelated kernel density estimator (AKDE) based on a continuous-time movement modeling (ctmm) framework to estimate dry season (26 ranges from 22 different individuals), wet season (12 ranges from 10 different individuals), and annual range sizes (8 individuals), and reported the 95%, 50% AKDE, and 95% Minimum Convex Polygon (MCP) range sizes. We assessed how landscape characteristics influenced range size based on a broad array of 48 landscape metrics characterizing aspects of vegetation, water, and human features and their juxtaposition in the study areas. To identify the most relevant landscape metrics and simplify our candidate set of informative metrics, we relied on exploratory factor analysis and Spearman’s rank correlation coefficient. Based on this analysis we adopted a final set of metrics into our regression analysis. In a multiple regression framework, we developed candidate models to explain the variation in AKDE dry season range sizes based on the previously identified, salient metrics of landscape composition. Elephant dry season ranges were highly variable averaging 792.0 km² and 184.2 km² for the 95% and 50% AKDE home ranges, respectively. We found both the shape and spatial configuration of agriculture and natural vegetation patches within an individual elephant’s range play a significant role in determining the size of its range. We also found that elephants are moving more (larger energy expenditure) in ranges with higher percentages of agricultural area. Our results provide baseline information on elephant spatial requirements and the factors affecting them in Myanmar. This information is important for advancing future land use planning that takes into account space-use requirements for elephants. Failing to do so may further endanger already declining elephant populations in Myanmar and across the species’ range. © 2022 The Authors.


Drought may severely reduce the ability of wild Asian elephants Elephas maximus (Mammalia: Proboscidea: Elephantidae) to resist opportunistic infections
**J. of Threatened Taxa 14 (2022) 20951-20963**

**Abstract.** The present study was conducted to assess the microbial quality of water in forest waterholes in different seasons and its possible impact on wild animals, at Bandipur and Nagarahaole Tiger Reserve forests in the state of Karnataka, India, during the year 2012 which evidenced drought, and the year 2014 which witnessed normal rainfall in these forests. The forests recorded the death of 39 wild elephants during April and May of 2012. One ailing elephant was confirmed to have high fever, diarrhoea, leucocytosis, and symptoms of colic. Water samples collected from major waterholes during the peak drought showed higher numbers of coliforms and several species of opportunistic bacteria including species of Vibrio and Campylobacter. In the year 2014–15, with normal rainfall, the death of less than 10 wild elephants was documented during April to May, 2015. We collected water samples from 20 major waterholes every month from June 2014 to May 2015 and assessed the water quality. We found that the microbial water quality improved in rainy season (Jun – Sep), started deterioration in winter (Oct – Jan) and became poor in summer (Feb – May). Though, the water during the summer of 2014–15 was equally of poor microbial quality as seen during peaks of droughts, the elephant deaths were relatively lower, signifying the role of normal rainfall in forests which provides the availability of fodder and water, which determines the general body condition and ability to resist opportunistic infections. We discuss the measures suggested and implemented from this study and their utilities at ground level. © 2022 The Authors.

**C. Cheah & K. Yoganand**

**Recent estimate of Asian elephants in Borneo reveals a smaller population**

*Wildlife Biology 2022 (2022) e01024*

**Abstract.** Asian elephants occurring in northern Borneo form a geographically isolated and genetically distinct population. Of this, the subpopulation of Central Sabah holds the greatest opportunity for long-term survival, due to a relatively large population size and occurrence over a vast, contiguous and protected habitat. We surveyed this subpopulation in 2015 using advanced methods to obtain a population size estimate. We used the distance-sampling frame-work and laid out transects following a stratified random design for counting elephant dung piles; measured dung decay following the ‘retrospective’ method; and used Bayesian analysis to estimate dung decay rate and dung pile density. Thus, we estimated a posterior mean dung decay rate of 212 days (95% BCI: 133–319), an overall elephant density of 0.07 per km² (95% BCI: 0.03–0.11) and a population size of 387 elephants (95% BCI: 169–621). These estimates were far lower than the population size of 1132 individuals and density of 1.18 per km² estimated in 2008. It is unlikely that there has been a steep population decline, as there were no drastic land-use changes between 2008 and 2015, nor were there other identifiable causes for a population decline. Therefore, it appears that the methodological and analytical flaws in the previous estimate are the most plausible reason for this observed difference. Given that the new estimate suggests a much smaller population, it is prudent and precautionary to use the new estimate as the basis for all policy decisions and conservation actions for elephants in Sabah. © 2022 The Authors.


**Scanning electron microscopy of Quilonia renniei from Asian elephants revealing variation in coronal leaflet number**

*Parasitology 149 (2022) 529 - 533*

**Abstract.** Although parasitic nematodes in the genera *Murshidia* and *Quilonia* (family Strongylidae) are recognized as major gastrointestinal parasites in Asian elephants, they have been poorly studied. Recently, light micrographs of these parasites in Myanmar have been presented, almost 100 years after the original drawings. However, the number of coronal leaflets, a key taxonomic feature of *Quilonia* species, has not been precisely determined based on light microscopy. The current study aimed to determine the exact number of coronal leaflets in *Quilonia renniei* specimens from Asian elephants in Myanmar. On the basis of scanning electron micrographs, leaflet number in females (19.7) was significantly higher (P < 0.005) than that in males (18.1). This compares with 18 coronal leaflets indicated in the original species description. Specimens bearing 19 coronal leaflets were most numerous, followed...
by those with 20 leaflets. Median-joining network analysis of mitochondrial cytochrome c oxidase subunit I gene sequences with 16 haplotypes from 19 individuals revealed no clear association between parasite populations and the number of coronal leaflets. These results highlight the importance of determining the number of coronal leaflets in the taxonomy of Q. renniei and other related Quilonia species infecting Asian elephants. © 2021 The Authors.


Potential diagnostic biomarkers for pulmonary tuberculosis in humans are not elevated in Mycobacterium tuberculosis culture–positive Asian elephants (Elephas maximus)

American Journal of Veterinary Research 83 (2022) e22.01.0016

Abstract. To determine (1) if chemokine (C-X-C motif) ligand 1 (CXCL1), matrix metalloproteinase 8 (MMP8), interleukin-10 (IL–10), interferon-γ (IFN-γ), and tumor necrosis factor-α (TNF-α) can be detected in serum from Asian elephants, and (2) if their concentrations are significantly elevated in Mycobacterium tuberculosis (M. tb) culture–positive elephants compared to –negative elephants. CXCL1, MMP8, IL-10, IFN-γ, and TNF-α were recently identified as potential diagnostic biomarkers for pulmonary tuberculosis in experimental studies in animals and humans. Therefore, we hypothesized that they would be detectable and significantly elevated in M. tb culture–positive elephants compared to –negative elephants. 101 Asian elephant serum samples, including 91 samples from 6 M. tb-negative elephants and 10 samples from 5 M. tb-positive elephants (none of which exhibited clinical signs of disease). M. tb status was determined by trunk wash culture. Commercially available ELISA kits were used to determine the concentrations of each biomarker in serum samples. Biomarker concentrations were below the limit of detection for the assay in 99% samples for CXCL1, 97% samples for MMP8, 85/101 (84%) samples for IL–10, 74% samples for IFN-γ, and 45% samples for TNF-α. Multiple M. tb culture–positive elephants did not have detectable levels of any of the 5 biomarkers. CXCL1, MMP8, IL–10, IFN-γ, and TNF-α were not elevated in M. tb culture–positive elephants compared to M. tb culture–negative elephants. This may be related to disease state (ie, clinically asymptomatic). More sensitive assays are needed to better understand the role of these biomarkers in M. tb infection in Asian elephants.


Meta-proteomic analysis of two mammoth’s trunks by EVA technology and high-resolution mass spectrometry for an indirect picture of their habitat and the characterization of the collagen type I, alpha-1 and alpha-2 sequence

Amino Acids 54 (2022) 935-954

Abstract. The recent paleoproteomic studies, including paleo-metaproteomic analyses, improved our understanding of the dietary of ancient populations, the characterization of past human diseases, the reconstruction of the habitat of ancient species, but also provided new insights into the phylogenetic relationships between extant and extinct species. In this respect, the present work reports the results of the metaproteomic analysis performed on the middle part of a trunk, and on the portion of a trunk tip tissue of two different woolly mammoths some 30,000 years old. In particular, proteins were extracted by applying EVA films to the surface of these tissues belonging to two Mammuthus primigenius specimens, discovered in two regions located in the Russian Far East, and then investigated via a shotgun MS-based approach. This approach allowed to obtain two interesting results: (i) an indirect description of the habitat of these two mammoths, and (ii) an improved characterization of the collagen type I, alpha-1 and alpha-2 chains (col1a1 and col1a2). Sequence characterization of the col1a1 and col1a2 highlighted some differences between M. primigenius and other Proboscidea together with the identification of three (two for col1a1, and one for col1a2) potentially diagnostic amino acidic mutations that could be used to reliably distinguish the M. primigenius with respect to the other two genera of elephantids (Elephas and Loxodonta), and the extinct American mastodons (Mammut americanum).
The results were validated through the level of deamidation and other diagenetic chemical modifications of the sample peptides, which were used to discriminate the “original” endogenous peptides from contaminant ones. © 2022 The Authors.

Yunchuan Dai

The overlap of suitable tea plant habitat with Asian elephant (*Elephas maximus*) distribution in southwestern China and its potential impact on species conservation and local economy

*Environmental Science and Pollution Research* 29 (2022) 5960-5970

**Abstract.** No permission to print abstract.

P. Das, A. Kshettry & H.N. Kumara

Trunk picking from a truncating menu: Dry season forage selection by Asian elephant in a multi-use landscape

*PLoS ONE* 17 (2022) e0271052

**Abstract.** Elephants show a strong selection towards areas with high foraging opportunities at the landscape level making top-down decisions by first selecting patch types within landscapes and finally species within them. Understanding forage selection in a multi-use landscape is critical for prioritising patches for habitat management, ensuring availability of selected forage, helping in minimizing pressure on food crops and subsequent negative interactions with people. We assessed dry season forage selection in a multi-use landscape of West Bengal state, India. Relative forage use and relative plant species availability ratio were calculated to assess forage selection in a multi-use landscape comprising of the forest, tea estates, agricultural land, and human settlement. Forage use was assessed using the opportunistic feeding trail observation method (150 km). Stratified random sampling was used to assess plant species availability using the quadrat method (123 plots of 0.1 ha each). Among 286 plant species recorded, 132 plant species were consumed by elephants. A majority (80.21%) of plant species were consumed more than the proportional availability thereby showing selective foraging during the dry season in the study area. From forest to semi-open forest and open forest, canopy layer tree density and the total number of species decreased whereas invasive species density increased. This indicates the high impact on the forage species availability for elephants and the requirement of appropriate habitat management strategies. The presence of 32.14% of the selected forage species in human-use landscape alone demands the development of conservation interventions. This is the first study to assess forage selection by elephants in a multi-use landscape and used to prioritise conservation and management strategies at a landscape level. © 2022 The Authors.

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

Beyond consensus genotyping: A case study on the Asian elephant *Elephas maximus*

*Conservation Genetics Resources* 14 (2022) 403-411

**Abstract.** No permission to print abstract.


Sundaic elephants prefer habitats on the periphery of protected areas

*J. of Applied Ecology* 59 (2022) 2947-2958

**Abstract.** Protected areas (PAs) are a cornerstone of global conservation strategies. PAs, however, are not equally effective for all threatened taxa, and it is important to understand taxa-specific effectiveness of PAs networks. In this study, we evaluate the role of the PAs network on the protection of Asian elephants and their habitats in Southeast Asia’s Sundaic region. Since Asian elephants tend to prefer secondary forests or forest gaps, we predicted that PAs would not represent the species preferred habitats. We conducted the most comprehensive analysis of Asian elephant space and habitat use to date through home range estimations and step selection function analyses using over 600,000 Global Positioning System locations from 102 different elephants from Peninsular Malaysia and Borneo. Our results revealed important similarities in the habitat use of elephants in both regions, with both females and males in Peninsular Malaysia and Sabah preferring secondary forest, forest gaps and areas of regrowth and new plantations. Our results supported our prediction that PAs do not represent Asian elephants’ preferred habitats, since for most of the elephants, more than half of their ranges were outside PAs and the probability of
selection values for both sexes in both geographical areas were lower inside than outside the PAs. Our analysis suggests that conservation strategies need to acknowledge that the long-term survival of Asian elephants in the Sundaic region relies on our capacity to promote human-elephant coexistence at the boundaries of PAs. We advocate that Asian elephant conservation strategies should be based on the following three key points: (1) large PAs with core areas where elephants can find safety and potentially survive in the long term; (2) promoting connectivity among PAs using a system of wildlife corridors; and (3) effective human-elephant conflict management outside PAs. © 2022 The Authors.

M. De Silva, P. Kumarasinghe, K. De Zoysa & C. Keppitiyagama
Reidentifying Asian elephants from ear images using a cascade of convolutional neural networks and explaining with GradCAM
SN Computer Science 3 (2022) e192
Abstract. No permission to print abstract.

Feasibility of using convolutional neural networks for individual-identification of wild Asian elephants
Mammalian Biology 102 (2022) 931-941
Abstract. No permission to print abstract.

A. Devi, S.A. Hussain, M. Sharma, G.V. Gopi & R. Badola
Seasonal pattern of food habits of large herbivores in riverine alluvial grasslands of Brahmaputra floodplains, Assam
Scientific Reports 12 (2022) e482
Abstract. Jarman-Bell (1974) hypothesized that in the dry savanna of Africa, small-bodied herbivores tend to browse more on forage with high protein and low fibre content. This implies browsing on high nutritive forage by meso-herbivores, and grazing and mixed feeding on coarse forage by mega-herbivores. We tested this hypothesis in the riverine alluvial grasslands of the Kaziranga National Park (KNP), where seasonal flood and fire play an important role in shaping the vegetation structure. We analyzed the feeding habits and quality of major forage species consumed by three mega-herbivores, viz. greater one-horned rhino, Asian elephant, and Asiatic wild buffalo, and three meso-herbivores, viz. swamp deer, hog deer, and sambhar. We found that both mega and meso-herbivores were grazers and mixed feeders. Overall, 25 forage plants constituted more than 70% of their diet. Among monocots, family Poaceae with Saccharum spp. (contributing > 9% of the diet), and, among dicots, family Rhamnaceae with Ziziphus jujuba (>4%) fulfilled the dietary needs. In the dry season, the concentration of crude protein, neutral detergent fibre, calcium, sodium, and phosphorous varied significantly between monocots and dicots, whereas only calcium and sodium concentrations varied significantly in the wet season.Dicots were found to be more nutritious throughout the year. Compared to the dry season, the monocots., with their significantly high crude protein, were more nutritious during the wet season. Possibly due to the availability of higher quality monocots in the wet season, both mega and meso-herbivores consume it in high proportion. We concluded that the Jarman-Bell principle does not apply to riverine alluvial grasslands as body size did not explain the interspecific dietary patterns of the mega and meso-herbivores. This can be attributed to seasonal floods, habitat and forage availability, predation risk, and management practices such as controlled burning of the grasslands. The ongoing succession and invasion processes, anthropogenic pressures, and lack of grassland conservation policy are expected to affect the availability of the principal forage and suitable habitat of large herbivores in the Brahmaputra floodplains, which necessitates wet grassland-based management interventions for the continued co-existence of large herbivores in such habitats. © 2022 The Authors.

Anatomical, physiological, and behavioral mechanisms of thermoregulation in elephants
Journal of Animal Behaviour and Biometeorology 10 (2022) e2233
Abstract. Elephants use different thermoregulatory mechanisms that depend on the anatom-
ical and morphological characteristics of the species. The crevices and wrinkles of the skin enhance the water-retention capacity of the epidermis. The highly vascularized ear is another region of particular interest, as its movement and vasomotor changes promote heat dissipation. Generally, these mechanisms are modulated by the hypothalamic thermoregulatory center and by the peripheral response of animals. Nonetheless, elephants are currently exposed to alterations in their habitats, such as global warming and climatic changes, which challenge their homeothermy. This article aims to discuss the thermoregulation mechanisms of African and Asian elephants from an anatomical, physiological, and behavioral basis. The practical implications of these elements will be analyzed to implement tools, such as infrared thermography, or environmental enrichment, as strategies to promote the thermal balance of elephants.

J.J. Figel, M. Hambal, I. Krisna, R. Putra & D. Yansyah

Malignant snare traps threaten an irreplaceable megafauna community

*Tropical Conservation Science 14(2021) 17 February 2021*

**Abstract.** Tropical forests are under severe threat from over-hunting. Subsistence harvests and poaching have decimated wildlife populations to the extent that nearly 50% of Earth’s tropical forests are partially or fully devoid of large mammals. Declines are particularly acute in Southeast Asia where ongoing defaunation, largely attributable to indiscriminate snare trapping, is widespread. Using the extensively forested Aceh province in northern Sumatra as a case study, we document rampant snaring, which threatens Earth’s last sympatric population of tigers, rhinoceros, elephants, and orangutans. To prevent catastrophic hunting-induced impacts already experienced in mainland Southeast Asia, we call for more comprehensive conservation planning assessments that strengthen wildlife law enforcement, promote collaborative anti-poaching, and research species-specific snaring impacts, particularly in the context of human-wildlife conflict. We conclude with a discussion of the important linkages between poaching, wildlife trade, and zoonotic disease risk. © 2021 The Authors.

R. Ghimire, S. Regmi, R. Shrestha, A. Sadaula & J.D. Joshi

**Hematological value of captive Asian elephants *Elephas maximus* around Chitwan National Park, Sauraha, Nepal

*J. of Threatened Taxa 14 (2022) 21811-21817*

**Abstract.** Veterinary hematology serves as an important screening procedure to assess general health conditions, diagnosis, and treatment of disease. This study aims to interpret and establish a set of hematology reference ranges for Asian elephants managed by private and government facilities in Nepal. Blood samples from 50 elephants around Chitwan National Park, Sauraha were collected and hematological parameters such as total erythrocyte count and total leukocyte count were determined. The results show that the majority of hematological values were in line with the values previously published by different authors. The mean erythrocyte and leukocyte counts were reported as 3.32 ± 0.93 x 10^6 cell/µL and 10448 ± 335.49 cells/µL respectively. No sex-associated difference was observed in the case of total erythrocyte count, whereas total leukocyte counts varied significantly within sexes. Our findings revealed no significant difference in hematological parameters between government and privately owned elephants. The hematological values from our study can be used as reference for assessing the health condition of elephants in Nepal. Further research work should be conducted to evaluate the factors affecting hematological parameters. © 2022 The Authors.

S. Gupta, N. Mohan, P. Nayak, K.C. Nagaraju & M. Karanam

**Deep vision-based surveillance system to prevent train-elephant collisions**

*Soft Computing 26 (2022) 4005-4018*

**Abstract.** No permission to print abstract.

N.L. Hammond, A. Dickman & D. Biggs

**Examining attention given to threats to elephant conservation on social media**

*Conserv. Science and Practice 4 (2022) e12785*

**Abstract.** Although social media is growing rapidly as a news source, including for disseminating conservation information, studies comparing attention given to differing threats to species on social media are almost non-existent. As the amount of attention given to differing
threats can influence what people perceive to be important and impact the formation of environmental policies, it is vital that conservationists understand which issues are being discussed online. Using elephants (*Loxodonta africana*, *Loxodonta cyclotis*, and *Elephas maximus*) as test species, we conducted a content analysis of tweets about elephants posted to Twitter during 2019. According to the global conservation authority IUCN the most pressing threats to the conservation of wild elephant populations are habitat loss, human-elephant conflict, and poaching, with the magnitude of each threat differing between the three species of elephants. Our Twitter analysis revealed that these major threats were infrequently discussed, with habitat loss being the most infrequently discussed (<1% of all tweets). Instead, elephant welfare issues, such as tourist elephant rides, were the most frequently discussed topic (23%). Users from non-elephant range countries were the dominant voice on Twitter (72% of tweets with an identifiable location), with these tweets likely to discuss elephant welfare concerns and trophy hunting, which is not a threat to elephant conservation. Conversely, tweets from users from African elephant range countries (14%) were more likely to discuss human-elephant conflict, poaching, and promote elephant tourism. Similarly, users from Asian elephant range countries (13%) were likely to discuss human-elephant conflict and elephant tourism but unlikely to tweet about poaching. Given the relatively low representation of local stakeholders and the limited coverage of key conservation threats, there is a need to ensure that social media discussions do not overly influence decision-makers. © 2022 The Authors.

D.K. Hewavithana, M.R. Wijesinghe & P.V. Udagama

**Gastrointestinal parasites of six large mammals in the Wasgomuwa National Park, Sri Lanka**

*International Journal for Parasitology: Parasites and Wildlife* 17 (2022) 1-6

**Abstract.** Gastrointestinal (GI) parasites may impose detrimental consequences on wildlife populations due to their capacity to cause mortality and reduce fitness. Additionally, wild animals play an important role in the transmission of zoonoses. Despite this importance, information on GI parasites of tropical wild mammals is critically lacking. The present study aimed to document GI parasites of six wild-dwelling large mammal taxa in Sri Lanka: Asian elephant, sloth bear, civet, leopard, grey langur and buffalo. Fresh faecal samples (*n* = 56) collected from the Wasgomuwa National Park, Sri Lanka were subjected to coprological examination using faecal smears, and the brine floatation technique followed by microscopic identification; quantitative data were accrued using the formol-ether method. The survey revealed a high prevalence of GI parasites, where 86% of faecal samples screened positive for parasitic infections. Faecal samples of the civet, buffalo and leopard recorded 100% prevalence, while the lowest (40%) was recorded for the grey langur. Eight types of GI parasites were documented: protozoan cysts, platyhelminth ova (three types of digenean and a single cyclophилidean type), nematode ova (strongyle, strongyloid, ascarid, and trichiroid types) and rhabditiform larvae. The buffaloes and civets had a comparatively high number and diversity of GI parasites (buffalo: 7 types, *H*’ = 1.02; civet: 6 types, *H*’ = 1.52), whilst only a single type (digenean) was detected in the grey langur. Likewise, parasite loads were also highly variable; highest in the bear (486 per g faeces) and lowest in the monkey (10 per g faeces). The outcome of this survey is important on two accounts; i) to fill the knowledge gap on GI parasites of tropical wild mammals, and ii) the revelation of many first-time parasite-host records for some of the threatened wild-dwelling large mammals in Sri Lanka. © 2021 The Authors.

T.E. Hoornweg, V.P. Perera, R.N.S. Karunarathne, W. Schaftenaar, T.A.N. Mahakapuge, A.W. Kalupahana, V.P.M.G. Rutten & C.A.M. de Haan

**Young elephants in a large herd maintain high levels of elephant endotheliotropic herpesvirus-specific antibodies and do not succumb to fatal haemorrhagic disease**

*Transboundary and Emerging Diseases* 69 (2022) 3379-3385

**Abstract.** Elephant endotheliotropic herpesviruses (EEHVs) have co-existed with elephants for millions of years, yet may cause fatal haemorrhagic disease (EEHV-HD), typically in elephants between 1 and 10 years of age. EEHV is
omnipresent in (sub)adult elephants, and young elephants with low EEHV-specific antibody levels are at risk for EEHV-HD, suggesting that fatal disease may occur due to an insufficiently controlled primary infection. To further address this hypothesis, sera of three large elephant cohorts were subjected to a multiple EEHV species ELISA: (I) 96 Asian elephants between 0 and 57 years, including 13 EEHV-HD fatalities, from European zoo herds typically sized five to six elephants, (II) a herd of 64 orphaned elephants aged 0–15 years at the Elephant Transit Home in Sri Lanka and (III) 31 elephants aged 8–63 years, part of a large herd of 93 elephants at Pinnawala Elephant Orphanage, Sri Lanka. All Sri Lankan elephants showed high EEHV-specific antibody levels regardless of their age. While antibody levels of most European zoo elephants were comparable to those of Sri Lankan elephants, the average antibody level of the European juveniles (1–5 years of age) was significantly lower than those of age-matched Sri Lankan individuals. Moreover, European juveniles showed a gradual decrease between 1 and 4 years of age, to be attributed to waning maternal antibodies. Maintenance of high levels of antibodies in spite of waning maternal antibodies in young Sri Lankan elephants is likely due to the larger herd size that increases the likelihood of contact with EEHV-shedding elephants. Together with the observation that low levels of EEHV-specific antibodies correlate with increased numbers of EEHV-HD fatalities, these results suggest that infection in presence of high maternal antibody levels may protect calves from developing EEHV-HD, while at the same time activating an immune response protective in future encounters with this virus. 


**Monitoring IgG against Mycobacterium tuberculosis proteins in an Asian elephant cured of tuberculosis that developed from long-term latency**

*Scientific Reports* 12 (2022) e4310

**Abstract.** Tuberculosis (TB) is fatal in elephants, hence protecting elephants from TB is key not only in the conservation of this endangered animal, but also to prevent TB transmission from elephants to humans. Most human TB cases arise from long-term asymptomatic infections. Significant diagnostic challenges remain in the detection of both infection and disease development from latency in elephants due to their huge bodies. In this study, we assessed cryopreserved sera collected for over 16 years, from the first Japanese treatment case of elephant TB. Semi-quantification of IgG levels to 11 proteins showed high detection levels of 3 proteins, namely ESAT6/CFP10, MPB83 and Ag85B. The level of IgG specific to these 3 antigens was measured longitudinally, revealing high and stable ESAT6/CFP10 IgG levels regardless of onset or treatment. Ag85B-specific IgG levels were largely responsive to onset or treatment, while those of MPB83 showed intermediate responses. These results suggest that ESAT6/CFP10 is immunodominant in both asymptomatic and symptomatic phases, making it useful in the detection of infection. On the other hand, Ag85B has the potential to be a marker for the prediction of disease onset and in the evaluation of treatment effectiveness in elephants. © 2022 The Authors.

Akira Ito

**Description of eight Triplumaria species (Ciliophora, Entodiniomorphida) found in Asian elephants**

*European J. of Protistology* 84 (2022) e125881

**Abstract.** Five new *Triplumaria* species were described from Asian elephants (*T. avis*, *T. cryptopteron*, *T. takakoae*, *T. soichii*, *T. cataphracta*) as well as three species described by Timoshenko and Imai (1995), namely *T. asiatica*, *T. nucleocaudata*, and *T. ovina*. The new species have distinct skeletal plate structures: *T. avis* and *T. cryptopteron* have the ventral wing, grooves lined with lobes, and posterior fin; *T. takakoae*, the dorsal oar-shaped stick; *T. soichii*, the ventral spine and dorsal turn back fringed with lobes; *T. cataphracta*, two rows of bollard-shaped lobes and two folds composed of a smooth edge and lobes. These eight *Triplumaria* species have various buccal infra-ciliary bands. *T. avis*, *T. cryptopteron*, *T. asiatica*, and *T. nucleocaudata* have the perivestibular polybrachykinety connected only to the right end of adoral polybrachykinety. *T. takakoae*
and T. soichii have the perivestibular polybrachykinety that connects to both ends of adoral polybrachykinety and has a loop along the vestibular left slit. T. cataphracta and T. ovina have the vestibular polybrachykinety connected to the right end of the twisted adoral polybrachykinety. Triplumaria species are highly differentiated ciliates in elephants; 23 of the 28 species described so far have been found in Asian elephants. © 2022 Reprinted with permission from Elsevier.


**Novel diagnostic and therapeutic approaches to elephant endotheliotropic herpesvirus 1A hemorrhagic disease in a captive juvenile Asian elephant (Elephas maximus)**


**Abstract.** Novel diagnostic and therapeutic methods were utilized in the successful management of severe elephant endotheliotropic herpesvirus hemorrhagic disease (EEHV-HD) in a 1.9-yr-old captive Asian elephant. High levels of EEHV1A viremia were detected for 12 d. In addition to established EEHV treatments, therapies included famciclovir-fortified elephant whole blood and plasma, mesenchymal stem cells harvested from elephant umbilical tissue, and aminocaproic acid. Testing conducted to examine the effects of EEHV infection on hemostasis suggested marked intravascular coagulation with decreased plasminogen activity and increased D-dimer concentrations. Thromboelastography was used to assess the efficacy of aminocaproic acid and demonstrated hypo-fibrinolysis on samples taken after drug administration, as compared with samples from healthy adult elephants. A serological assay for a novel EEHV1A-specific antibody marker (E52) was developed due to lack of seroconversion to a previously established EEHV1A-specific antibody marker (ORFQ) and showed a sustained increase after EEHV-HD illness. © 2022 American Assoc. of Zoo Veterinarians.

S.L. Jacobson, A. Puitiza, R.J. Snyder, A. Sheppard & J.M. Plotnik

**Persistence is key: Investigating innovative problem solving by Asian elephants using a novel multi-access box**

*Animal Cognition* 25 (2022) 657-669

**Abstract.** No permission to print abstract.

G. Li, Y. Jiang, Q. Li, D. An, M. Bao, L. Lang, L. Han, X. Huang & C. Jiang

**Comparative and functional analyses of fecal microbiome in Asian elephants**

*Antonie van Leeuwenhoek* 115 (2022) 1187-1202

**Abstract.** No permission to print abstract.

S. Kajaria, N. Sekar & S. Sharma

**Charisma failure: Understanding differences in support for conservation of Asian elephants compared to tigers and African elephants**

*Biological Conservation* 276 (2022) e109745

**Abstract.** The disproportionately high support for conservation of charismatic species is well-documented. However, available data demonstrate substantial discrepancies in funding for conservation even among charismatic species, and these differences are poorly understood. We use two survey experiments to explore explanations for differences in demand for conservation between charismatic species by comparing Asian elephants with tigers in India and with African elephants globally. Through social media, we collect data from conservation enthusiasts to measure (a) relative demand for conservation, (b) awareness about conservation status, (c) relative favourability, and (d) perception of which species faces greater conservation challenges (“risk perception”). Overall, respondents allocated significantly more funds to the species/taxon they perceive to be more at risk and 41–54% more to the species/taxon they say they like more (though about 70% of respondents claimed to like both species/taxa presented equally). On average, respondents in India allocated 5.6 % more for tigers than Asian elephants, a far smaller discrepancy than found in public data from key real-life funders. Internationally, respondents allocated 14% more funds for African than Asian elephants (despite there being fewer Asian elephants) and generally overestimated how endangered African elephants are compared to Asian elephants. Our study suggests (i) conservation enthusiasts wish
to donate more to more endangered charismatic species but are sometimes misinformed about the level of endangerment of even very well-known species, and (ii) discrepancies in actual funding levels across charismatic species appear to be greater than conservation enthusiasts believe they should be. © 2022 Reprinted with permission from Elsevier.

Human-wildlife conflicts in Paschim Kusaha village of Koshi Tappu Wildlife Reserve, Sunsari District, Nepal
Journal of Resources and Ecology 13 (2022) 1022-1029
Abstract. Human-wildlife conflict has been one of the most trouble-causing issues in many areas of Nepal including Eastern Nepal. This study assessed the human-wildlife conflict status in Paschim Kusaha Village of Koshi Tappu Wildlife Reserve (KTWR), Sunsari District, Nepal. Data were collected from 47 respondents of different households through questionnaire surveys and formal and informal interviews. Results revealed that the most destructive wild animals were wild elephants, wild boar, and wild water buffalo and the most raided crops were paddy (63.83 %), maize (19.15%), and potato (17.02%). Most of the encounters between humans and wildlife were recorded at night (after dusk and before dawn) (78.72%). Local people were suffering from damage of physical properties, human harassment or nuisance, and depredation of cropland due to wild animals. A total of 70% of respondents had a positive attitude towards conservation despite disturbing human mortality records (22 deaths in the last five years) from the reserve area and surrounding. Awareness of wildlife behavior together with conservation and easy access to compensation schemes were suggested to minimize conflicts in the area.

G. Katlam, S. Prasad, A. Pande & N. Ramchary
Plastic ingestion in Asian elephants in the forested landscapes of Uttarakhand, India
J. for Nature Conservation 68 (2022) e126196
Abstract. Ecological impacts of plastic contamination on marine environment have been documented extensively, however its spread and impacts on terrestrial and freshwater fauna are still poorly understood. In the present study, we investigated diet of Asian elephant for plastic ingestion around forested habitats of Uttarakhand state in India. We quantified plastic particles and other anthropogenic waste from elephant dung samples collected from edges and interiors of forest areas, confirming plastic ingestion by this endangered mammal species. Each human-derived item was identified, measured, and sub-categorized into plastic or other anthropogenic waste. About one-third (32%) of the elephant dung samples showed presence of anthropogenic waste. Plastic particles ranging from size 1–355 mm, comprised of 85% of the waste recovered from elephant dung samples (47.08 ± 12.85 particles per sample). We found twice as many plastic particles (85.27 ± 33.7/100 g) in samples collected from inside forest as compared to forest edge (35.34 ± 11.14 plastic particles/100 g). A higher count (34.79 ± 28.41 items/100 g sample) of non-biodegradable anthropogenic waste (glass, metal, rubber bands, clay pottery and tile pieces) was obtained from samples collected inside the forest area samples as compared to forest edge samples (9.44 ± 1.91 items/100 g). There were higher proportion of macroplastic (>5 mm) retrieved than microplastic (1–5 mm) in the elephant dung. The present study is the first systematic documentation of non-biodegradable waste ingestion by Asian elephants. High plastic presence in elephant dung highlights its widespread use near protected habitats and lack of waste segregation practices underlining the vulnerability of wild animals to plastic ingestion risk. We provide recommendations for developing a comprehensive solid waste management strategy to mitigate the threat of plastic pollution around critical elephant habitats in India. © 2022 Reprinted with permission from Elsevier.

K.T. Kavitha, C. Sreekumar & B.R. Latha
Case report of hook worm Grammocephalus hybridatus and stomach bot Cobboldia elephantis infections in a free-ranging Asian elephant Elephas maximus in Tamil Nadu, India
J. of Threatened Taxa 14 (2022) 20915-20920
Abstract. Elephants in the wild are susceptible to many gastrointestinal parasites. In the present study, necropsy was conducted on a free-ranging Asian elephant female aged about 15 years which died at Coimbatore forest range,
Tamil Nadu state, India. The necropsy revealed that the liver was infected with round worms and the stomach was heavily infested with dipteran larvae. These round worms and larvae were collected and processed by dehydrating in ascending grades of alcohol and then cleared in carbolic acid. The cleared samples were mounted and examined under light microscopy for species identification. Faecal samples collected from the rectum were analysed by sedimentation for the presence of helminth eggs. On microscopic examination, the head end of the round worms showed a buccal capsule which possessed a pair of semilunar ventral cutting plates. Male worms showed well-developed bursa at the posterior end. The anterior end of the dipteran larvae showed two powerful oral hooks with cephalopharyngeal skeleton. Anterior spiracle appeared as a short club-shaped tube with 12 lobes. The abdominal segments of the larvae had a row of belt-like triangular spines. The posterior spiracles of the larvae had three longitudinal parallel slits in each spiracle with closed peritreme. Based on the above morphological characters, the round worms and larvae were identified as *G. hybridatus* and *C. elephantis*, respectively. Strongyle eggs were identified in the faecal sample based on the morphology of thin shell and segmented yolk. This appears to be the first report of *G. hybridatus* infection in a free-ranging elephant in Tamil Nadu state, India. © 2022 The Authors.

N. Kitratporn & W. Takeuchi
**Human-elephant conflict risk assessment under coupled climatic and anthropogenic changes in Thailand**
*Science of the Total Env.* 834 (2022) e155174

Abstract. As natural resources decrease, competition between humans and large endangered wildlife increases, hindering the sustainability of animal conservation and human development. Despite the multi-dimensional nature of such interactions, proactive assessments that consider both the biosphere and anthroposphere remain limited. In this study, we proposed a human elephant conflict risk assessment framework and analyzed the spatial distribution of risk at the baseline (2000–2019) and in the near future (2025–2044) for Thailand, so that it may address the multifaceted characteristics and impending effects of climate change. Future scenarios were based on the combination of RCP45/SSP2 or RCP85/SSP5 and spatial policy, with or without elephant buffer zones. The composite risk index, comprised of hazard, exposure, and vulnerability, was constructed using the geometric mean, and validation was performed with the area under the curve (AUC). Our results projected a shift with increasing future risk.
toward higher latitudes and altitudes. Increasing future risk (average +1.7% to +7.4%) in the four forest complexes (FCs) in northwestern regions was a result of higher hazard and vulnerability from more favorable habitat conditions and increasing drought probability, respectively. Reduction in future risk (average −3.1% to −57.9%) in other FCs in lower regions was mainly due to decreasing hazard because of decreasing habitat suitability. Our results also highlight geographically explicit strategies to support long-term planning of conservation resources. Areas with increasing future risk are currently facing low conflict; hence it is recommended that future strategies should enhance adaptive capacity and coexistence awareness. Conversely, areas with lowering future risk from a decrease in habitat quality are recommended to identify buffer strategies around protected areas to support existing large elephant populations. © 2022 Reprinted with permission from Elsevier.

C.A. LaDue, K.E. Hunt, M.G.S.M. Samara-weera, R.P.G. Vandercone, W.K. Kiso & E.W. Freeman

**Physical and behavioral indicators associated with hormonal changes during musth in zoo-housed and free-ranging Asian elephants (Elephas maximus)**

*Theriogenology Wild 1 (2022) e100011*

**Abstract.** In-situ and ex-situ Asian elephant populations are threatened with extinction, and male elephants pose unique challenges to long-term sustainability. The heightened sexual state of “musth” is accompanied by a suite of physical, behavioral and physiological changes. Furthermore, musth is unique to male elephants and requires special consideration when developing short- and long-term management strategies for elephants in the wild and in human care. The purpose of this study was to identify associations between fecal hormone metabolites [fecal androgen metabolites, FAM; fecal glucocorticoid metabolites, FGM; and fecal triiodothyronine (T3) metabolites, FT3] and visible musth indicators [temporal gland secretions (TGS) and urine dribbling (UD)], and behavioral changes around musth. From fecal samples collected non-invasively from wild elephants in Wasgamuwa National Park, Sri Lanka, and zoo-housed elephants in the United States, we hypothesized that (1) TGS and/or UD would be associated with changes in FAM, FGM, and/or FT3 concentrations; (2) variation in fecal hormone metabolites would be associated with increased locomotion and chemosensory behavior, and decreased foraging; and (3) relationships we identified would be similar between wild and zoo-housed elephants. We found that FAM concentrations changed significantly with TGS and UD activity in both wild and zoo elephants. Further while FGM concentrations were higher with increased TGS and UD in zoo elephants, the opposite pattern occurred in wild elephants. We did not identify substantial change in FT3 concentrations with TGS/UD activity. Behavioral changes in zoo elephants were significantly associated with FAM concentration as predicted, but these relationships were more difficult to identify in wild elephants due to lower sample availability. Further, FGM concentration was directly related to time spent locomoting in zoo elephants, but no other apparent association existed between FGM concentration with other behaviors in zoo elephants, or in any behaviors in wild elephants. Likewise, we did not report associations between FT3 and any behaviors we measured. This study contributes to our understanding of the complex response patterns that male Asian elephants exhibit around musth, and it provides another example of complementary in-situ–ex-situ research that can be directly applied to improve the well-being of elephants and other wildlife. © 2022 The Authors.

C.A. LaDue, B.A. Schulte, W.K. Kiso & E.W. Freeman

**Musth and sexual selection in elephants: A review of signalling properties and potential fitness consequences**

*Behaviour 159 (2022) 207-242*

**Abstract.** Sexual selection mediated by multimodal signals is common among polygynous species, including seasonally breeding mammals. Indirect benefit models provide plausible explanations for how and why mate selection can occur in the absence of direct benefits. Musth – an asynchronous reproductive state in male elephants – facilitates both inter- and intrasexual selection via indirect benefits, and it is further communicated through a multimodal signal. In this review, we synthesise existing ev-
idence that supports the hypothesis that musth is a multimodal signal subject to sexual selection and that male elephants increase their direct fitness by propagating this signal while females accrue indirect benefits. Musth is characterised by a suite of physiological and behavioural changes, serving to facilitate copulation between the sexes, and via multisensory modalities musth conveys honest information about the condition of a male. Female elephants mate preferentially with musth males, increasing their own fitness in the absence of direct benefits. In addition, musth resolves dynamic dominance hierarchies among male elephants and often eliminates the need for costly physical combat. Future work in this field should investigate potential postcopulatory selection mechanisms in elephants, including sperm competition and cryptic female choice. These topics join other fundamental questions related to sexual selection, signalling, and indirect benefits that are still unanswered in elephants. © 2022 The Authors.

C.A. LaDue, R.P.G. Vandercone, W.K. Kiso & E.W. Freeman

Behavioral characterization of musth in Asian elephants (Elephas maximus): Defining progressive stages of male sexual behavior in in-situ and ex-situ populations

Applied Animal Behaviour Science 251 (2022) e105639

Abstract. Complementary studies of wild and zoo-housed animals offer insight into behavioral variation across a range of conditions including the context under which various behaviors evolved in natural settings. This information can be used to improve the sustainability of in-situ and ex-situ populations and enhance the well-being of individuals. Managed ex-situ populations are critical to the long-term existence of Asian elephants, yet relatively little is known about male reproductive behavior compared to females. Male elephants undergo a unique sexual state called “musth” that further complicates in-situ and ex-situ management strategies. The ability to manage musth males to enhance breeding success and overall wellness of elephants is dependent upon better understanding how intrinsic and extrinsic factors influence male behavioral variation around musth. Here, we observed 62 free-ranging male Asian elephants in Sri Lanka and compared their behavior to observations from 26 elephants managed in facilities around the US. We hypothesized that musth is associated with significant behavioral changes that can be used to define distinct stages in the progression of musth. During observations, we quantified environmental variables and recorded musth status of each focal elephant using visual indicators (temporal gland secretions and urine dribbling). We showed that musth’s behavioral correlates (including changes in locomotion, foraging, alertness, and chemosensory behavior) were remarkably similar in wild and zoo-housed elephants. We also found that behavioral variation around musth was also associated with intrinsic (e.g., musth stage, age) and extrinsic factors (e.g., space availability, temperature) in zoo-housed, but not wild, elephants, indicating that musth is potentially plastic in changing environments. As musth progressed, we noted distinct behavioral signatures that define four stages of sexual activity in male elephants: non-musth, early musth, full musth, and post-musth. Finally, although we did not observe significant changes in overall social behavior (including aggression) during musth, we found that elephants increased the frequency with which they displayed certain behaviors associated with communication (e.g., alertness, chemosensory behavior, ear-flapping) in both populations. Together, these results indicate the significant behavioral changes that occur during musth in wild and zoo-housed elephants, and that musth progresses in distinct behavioral stages that can be easily distinguished by visual indicators. Studies like these serve to provide wildlife managers with information about a species’ unique, evolved behavioral strategies and how these seemingly fixed behaviors may be influenced by intrinsic and extrinsic factors in predictable ways. © 2022 Reprinted with permission from Elsevier.

G. Li, Y. Jiang, Q. Li, D. An, M. Bao, L. Lang, L. Han, X. Huang & C. Jiang

Comparative and functional analyses of fecal microbiome in Asian elephants

Antonie van Leeuwenhoek 115 (2022) 1187-1202

Abstract. No permission to print abstract.
L.-L. Li, R. He, R. Pansini & R.-C. Quan

Prolonged proximity to humans ensures better performance of semi-captive Asian elephants at discriminating between human individuals by voice

Frontiers in Ecology and Evolution 10 (2022) e963052

Abstract. To avoid risks, organisms must recognize threatening heterospecies from non-threatening ones via acoustic cues from a distance. With land-use change, humans have encroached considerably into natural areas. Therefore, it is beneficial to animals to use acoustic cues to discriminate between different levels of threats posed by humans. Our study aims at testing this discriminatory ability in Asian elephants, animals that have been for long history subjected to human interaction. We tested whether eighteen semi-captive elephants could discriminate between voices of their own mahouts (i.e., who take care of the elephants exclusively) and of other mahouts (unfamiliar individuals). The results showed that elephants responded successfully to the commands from their own mahouts, with an average response rate as high as 78.8%. The more years the mahouts had been as their caretakers, the more the elephant showed active responses toward the commands. Female elephants responded to the commands more frequently and faster than males. Also younger elephants responded more frequently and faster than older elephants. We argue that Asian elephants can discriminate between familiar and unfamiliar humans by acoustic cues alone. Proximity with humans may be a factor, as fundamental as domestication, for animals to develop heterospecies discriminatory ability. © 2022 The Authors.

I. Lueders & C. Stremme

Construction of a full mouth speculum facilitating oral examinations, bronchoscopy and gastric tubing in elephants

Tierärztliche Praxis Ausgabe G: Grosstiere / Nutztiere 50 (2022) 86-90

Abstract. Here we tested the application of a full mouth speculum to sedated elephants in human care to gain access to the oral cavity, the trachea (bronchi) and esophagus (stomach) and therefore improve diagnostic and therapeutic options in elephant medicine. The construction of this oral speculum for elephants and the procedure are described. The oral speculum is a steel construction consisting of 2 bite plates attached between 2 threaded guiding poles. Through crank handles, the metal plates are dispersed once placed between the elephant’s jaws in front of the molars. The oral speculum was applied in 26 elephants (6,16 Asian elephants, and 1,3 African elephants) during standing sedation. All sedated elephants tolerated the positioning of the mouth opener and subsequent manipulations well. The mouth opener was applied for the following procedures: inspection of the oral cavity (n = 2), placing a stomach tube (n = 16), and/or performing endoscopic examinations such as bronchoscopy (n = 20) and/or gastroscopy (n = 8). This method provides a new possibility to open the jaws to gain access to the molars, larynx and pharynx in captive elephants without full immobilization. Valuable samples for diagnostics may be obtained or animals medicated via stomach tube with this application. The mouth opener provides veterinarians with a new option to perform necessary diagnostic and therapeutic procedures around the oral cavity, airways and stomach in captive elephants during standing sedation with no need for a full anaesthesia. © 2021 Thieme.


Eighteen years (2001–2018) of forest habitat loss across the Asian elephant’s range and its drivers

Science Bulletin 67 (2022) 1513-1516

Abstract. none.


Investigating associations between nematode infection and three measures of sociality in Asian elephants

Behavioral Ecology and Sociobiology 76 (2022) e87

Abstract. Frequent social interactions, proximity to conspecifics, and group density are main drivers of infections and parasite transmissions. However, recent theoretical and empirical studies suggest that the health benefits of sociality and group living can outweigh the costs of infection and help social individuals fight infec-
tions or increase their infection-related tolerance level. Here, we combine the advantage of studying artificially created social work groups with different demographic compositions with free-range feeding and social behaviours in semi-captive Asian elephants, employed in timber logging in Myanmar. We examine the link between gastro-intestinal nematode load (strongyles and *Strongyloides* spp.), estimated by faecal egg counts, and three different aspects of an elephant’s social world: individual solitary behaviour, work group size, and work group sex ratio. Controlling for sex, age, origin, time since last deworming treatment, year, human sampler bias, and individual identity, we found that infection by nematodes ranged from 0 to 2720 eggs/g between and within 26 male and 45 female elephants over the 4-year study period. However, such variation was not linked to any investigated measures of sociality in either males or females. Our findings highlight the need for finer-scale studies, establishing how sociality is limited by, mitigates, or protects against infection in different ecological contexts, to fully understand the mechanisms underlying these pathways. © The Authors 2022.


**Strategies of protected area use by Asian elephants in relation to motivational state and social affiliations**

*Scientific Reports* 12 (2022) e18490

**Abstract.** Animals’ space requirements may vary according to life-history and social considerations. We observed 516 wild adult Asian elephants from both sexes, over 9 years, to investigate how life-history traits and social behavior influence protected-area (PA) use at Udawalawe National Park, Sri Lanka. Male PA-use, quantified in terms of average between-sightings-interval (BSI), was significantly influenced by the interaction of age class and motivational state (i.e. reproduction vs. foraging). Musth lengthened with age, with a median of 24.5 days for ages 21–30, 32.5 days for ages 31–40, and 45 days for those > 40. A minority (11%) used it exclusively during musth, while others used it exclusively for foraging (44%) or both (45%). Males using it in both states and older musth-only males were more likely to be seen across years. There were 16 social communities containing between 2–22 adult females. Females’ BSI was significantly influenced by social ties, but this relationship was weak, because members of social communities do not necessarily disperse together, resulting in high individual variation in space-use. Inter-annual variability in sightings among individuals of both sexes indicates that around ¾ of the population is likely non-residential across years, challenging the prevailing fortress-conservation paradigm of wildlife management. © 2022 The Authors.

Rajib Majumder

**Human-elephant conflict in West Bengal, India: Present status and mitigation measures**

*European J. of Wildlife Research* 68 (2022) e33

**Abstract.** No permission to print abstract.

R.N. Makecha, S. Phalke & Y. Nakai

**Assessing the effects of a cognition-based education program on attitudes of villagers toward Asian elephants (Elephas maximus) in conflict-prone areas**

*Journal of Applied Animal Welfare Science* 25 (2022) 368-381

**Abstract.** A vital role in mitigating human-elephant conflict (HEC) involves conservation education programs in local communities. It is therefore important to assess the types of information that make conservation education programs effective. Given the public’s fascination with animal minds, the elephant being a cognitively complex species, and the high occurrence of HEC surrounding Asian elephants, the current research assessed whether using information on elephant cognition in a conservation education program increased positive attitudes toward elephants/elephant conservation in Bannerghatta National Park (BNP). BNP, located in Karnataka, India, is an area reporting high HEC. Results indicated no significant difference in adult male villagers’ attitudes toward elephants/elephant conservation when exposed to one of two educational programs, one of which included information on elephant cognition. However, a significant difference in attitudes between the two programs and a control group was discovered, suggesting the importance of an educational intervention in the communities surrounding BNP. © 2021 Informa UK Limited.
R. Manuel, P.M. Deepa, R.U. Ashok, Rajeshkumar, K. Vijayakumar, K. Karthiayini & A. Janus

**Galactosylgalactosylxylosylprotein 3-beta-glucuronosyltransferase – A potent biomarker for the diagnosis of tuberculosis in elephants**

*European Journal of Wildlife Research* 68 (2022) e49

**Abstract.** No permission to print abstract.

A. Mohanarangan, S. Chinnaiyan, S. Kaliyaperumal, S. Shanmugavelu & A.A. Desai

**Age-specific differences in Asian elephant defecation, dung decay, detection and their implication for dung count**

*Ecol. Solutions and Evidence* 3 (2022) e12145

**Abstract.** In vertebrate population estimation, converting faecal density into animal density requires information on the faecal production rate, decay rate and faecal density. Differences in the above factors for long-lived species across age classes were not evaluated. We have evaluated these factors associated with the dung count of Asian elephants in the tropical forest of southern India. The defecation rate of elephants was determined in semi-wild elephants at the Mudumalai elephant camp. The relationship between dung bolus diameter and age was determined to estimate the age of the elephant. The total and age-specific elephant density based on dung bolus diameter was estimated. A total of 24 transect lines of 2–4 km (125 km) were sampled in the study area. An experiment was conducted to assess the detection probability across the age classes of dung piles. The dung decay rates across age classes and seasons were determined by marking fresh dung piles (n = 1551). The dung-based age structure assessment and its limitations were evaluated. The mean defecation rate was 13.51 ± 0.51 per day. The defecation rate was significantly lower for the younger age class and increased with the age of elephants. Defecation rates were significantly lower in the wet season than in the dry. The dung bolus diameter positively increased with the age of elephants, and the growth curve can be used to predict the age and age structure of elephant populations. The disparity in the dung production rate results in the lower availability of younger age class (juvenile and calf) dung in the transect for counting, which results in lower dung abundance. The detection probability of dung piles of younger age classes was low (0.58). The survival rates of dung piles of younger age classes were lower and increased with the age of elephants in the wet season. Hence, the demographic assessment of the population based on dung needs to consider age-specific differences in dung production, decay and detection probability. Although the demographic assessment using dung provides insight into population age structure, it has limitations in predicting age structure for young elephants. © 2022 The Authors.

R.A. Montgomery, J. Raupp, M. Mukhwana, A. Greenleaf, T. Mudumba & P. Muruthi

**The efficacy of interventions to protect crops from raiding elephants**

*Ambio* 51 (2022) 716-727

**Abstract.** Both African elephants and the Asian elephant across their range come into conflict with people because of their crop-raiding behavior, which presents profound impediments to farmer livelihoods. In response, a series of interventions, designed to reduce elephant crop raiding have been applied. Based on an extensive review of elephant crop-raiding studies published over a 31-year period, we identified four primary categories of interventions including: (i) detection efforts; (ii) preemptive measures; (iii) fencing and trenches; and (iv) deterrent techniques. The interventions reported to be most effective involved chili peppers (i.e., fences, spray, and briquettes) and crop guarding coupled with deterrents. The extent to which these interventions can be applied more widely is unclear as only two studies examined efficacy across sites in more than one country. Thus, future inquiry should evaluate the ability of effective interventions, or indeed a combination of interventions, to be applied across the range of elephants to reduce crop raiding at scale. © 2021 The Authors.

A.D. Moudgil & L.D. Singla

**Haemato-biochemical responses in Trypanosoma evansi infected Indian elephants (Elephas maximus indicus)**

*Biologia* 77 (2022) 1089-1094

**Abstract.** No permission to print abstract.
D. Neupane, S. Baral, T.S. Risch & A. Campos-Arceiz

Broad scale functional connectivity for Asian elephants in the Nepal-India transboundary region

Journal of Environmental Management 321 (2022) e115921

Abstract. The Nepal-India transboundary region hosts one of Asia’s most complex large mammal assemblages, including a small (but growing) population of Asian elephants. These elephants occur in four widespread and geographically disjunct subpopulations, and some of them undergo seasonal transboundary movements. We conducted a broad-scale evaluation of the amount and quality of elephant habitat available in the region and of functional landscape connectivity between and within subpopulations using Maxent, circuit theory, and least-cost path analysis. Habitat suitability was highly influenced by abiotic geographical factors (altitude and precipitation) and less by ecological factors (habitat heterogeneity, plant productivity) and human disturbance (distance to settlements). The region had a relatively small amount of high and optimal suitability habitat (12.6% out of 93,700 km²) but all subpopulations seem to be far from carrying capacity, suggesting ample potential for further population growth. Landscape connectivity was higher between and within the west and far-west subpopulations, which should be considered a single subpopulation. The central and east subpopulations, however, had low to very low between-subpopulation connectivity. Conservation priorities include maintaining the current connectivity in the west subpopulation and across the border in the east, and protecting high-quality habitats in eastern Nepal. Restoring connectivity between the central and other subpopulations is possible if the number of elephants continues growing, and it should be a long-term conservation aspiration. Maintaining and enhancing landscape connectivity in this region requires transboundary cooperation and coordination between Nepali and Indian authorities. If successful, it will bring considerable benefits for the conservation of elephants and other wildlife. © 2022 Reprinted with permission from Elsevier.

V.V. Nguyen, T.T.T. Phan & L. Chun-Hung

Integrating multiple aspects of human-elephant conflict management in Dong Nai Biosphere Reserve, Vietnam

Global Ecology and Conservation 39 (2022) e02285

Abstract. Human-elephant conflict (HEC) is a multifaceted complex phenomenon, and managing it requires multiple strategies. However, HEC remains prevalent in tropical areas due to a lack of “synergy of options”. Establishing synergistic HEC management strategies is thus crucial. We applied a choice experiment to capture the preference heterogeneity of the human population in Dong Nai Biosphere Reserve, Vietnam, regarding synergistic HEC management strategies and evaluate their marginal willingness to participate (MWTP) under multiple scenarios of HEC management. The following characteristics were found to affect this human population’s preferences regarding a HEC management program: 1) their attitude toward elephant conservation, 2) education and income level, and 3) employment status. Three promising guide scenarios were suggested based on the positive-preference attributes regarding HEC management. Among these, the scenario of a human-elephant coexistence program generated the highest MWTP compared to the scenarios of ‘building HEC prevention and mitigation’ and ‘protecting elephants and forest’. These outcomes can help managers adopt sustainable policies for mitigating HEC and facilitating human-elephant coexistence. © 2022 The Authors.

W. Nokkaew, A. Intarapuk, A. Sakulthai, W. Wajjwalku & N. Thongtip

Study of fecal glucocorticoid metabolites in captive Asian elephants in Kanchanaburi Province, Thailand

Veterinary World 15 (2022) 647-654

Abstract. Over the past two decades, the number of elephant camps in Thailand has increased considerably, and captive elephants have become more popular within the tourism industry. Tourist activities involving elephant exhibitions and trekking potentially affect animal health and welfare. This study aimed to investigate the relationships between a novel stress biomarker, fecal glucocorticoid metabolites (fGCM), and various factors (sex, age, weather season, tourist
season, and elephant usage patterns), monitoring the fGCM concentration during and after trekking activities ceased. Fecal samples of 20 captive Asian elephants from two camps in Kanchanaburi Province were collected monthly for 1 year. The fGCM concentrations were measured using enzyme immunoassay and evaluated relative to individual demography, season, and tourist trekking activity. The mean differences of fGCM concentrations were compared by analysis of variance and t-test statistics according to data types with p<0.5. Significant differences in mean fGCM concentrations were found between age categories, trekking and non-trekking animals, and during and after trekking. The mean fGCM concentration of elephants aged 0–44 years was significantly higher than for animals over 44 years old, and the elephant trekking group was significantly higher than the other group. Within the trekking group, the mean fGCM concentrations gradually declined to 129.13 ng/g within 8 months of trekking cessation. Elephant's ages and activities co-influenced the variance of fGCM concentrations. In addition, permanent tourist activity, especially trekking, can increase elephant stress. This study's findings can be applied to the health status monitoring of captive elephants and result in improved animal welfare. © 2022 The Authors.


**Current surveillance practices for shedding of elephant endotheliotropic herpesviruses in breeding and bachelor Asian elephant Elephas maximus herds in Europe**

*Journal of Zoo and Aquarium Research* 10 (2022) 183-187

**Abstract.** Elephant endotheliotropic herpesvirus-haemorrhagic disease (EEHV-HD) is the most common cause of death in juvenile captive Asian elephants. Currently, weekly whole blood screening is recommended for the detection of viraemia, which occurs prior to the development of clinical disease, but there are no recommendations for monitoring viral shedding into the environment. The aims of this study were to evaluate current EEHV shedding surveillance protocols in Asian elephant herds in Europe, as well as to collate and describe existing EEHV shedding data from these herds. Results from a European Association of Zoos and Aquaria Taxon Advisory Group-approved survey revealed that as of January 2021, 42% of breeding institutions had a protocol for screening for EEHV viraemia, while 30% monitored viral shedding. Shedding data were available from 12 institutions, where a total of 2,863 samples had been collected for polymerase chain reaction (PCR) analysis. Overall, 13.9% of all tested samples were positive for EEHV and 48.9% of elephants tested positive for EEHV. EEHV-1 was both the most common genotype detected and the most commonly tested for. Evidence of the presence of EEHV was reported in 12/12 (100%) of breeding herds. Routine monitoring of EEHV shedding is recommended to enable better understanding of the dynamics of EEHV infection and disease.

J.M Plotnik & S.L Jacobson

**A “thinking animal” in conflict: Studying wild elephant cognition in the shadow of anthropogenic change**

*Current Opinion in Behavioral Sciences* 46 (2022) e101148

**Abstract.** While researchers interested in the evolution of human intelligence have traditionally focused on the psychology of other primates, a growing field aims to understand how similar cognitive abilities emerge in evolutionarily distant taxa. Here, we briefly review what we know, and why we do not know more, about the ‘mind’ of one such animal — the elephant — as well as its relevance to understanding convergent cognitive evolution across species. We also discuss the importance of studying animals such as elephants in the wild to better identify expressions of cognitive flexibility in human-impacted environments. Finally, as researchers invested in the study of an endangered species, we emphasize the need to contribute to the management of conservation-related problems from novel, cognitive perspectives. © 2022 Reprinted with permission from Elsevier.

S.S. Pokharel, N. Sharma & R. Sukumar

**Viewing the rare through public lenses: Insights into dead calf carrying and other thanatological responses in Asian elephants using YouTube videos**

*Royal Society Open Science* 9 (2022) e211740
Abstract. Documenting the behavioural repertoire of an animal species is important for understanding that species' natural history. Many behaviours such as mating, parturition and death may be observed only rarely in the wild due to the low frequency of occurrence, short duration and the species' elusiveness. Opportunistic documentation of rare behaviours is therefore valuable for deciphering the behavioural complexity in a species. In this context, digital platforms may serve as useful data sources for studying rare behaviours in animals. Using videos uploaded on YouTube, we document and construct a tentative repertoire of thanatological responses (death-related behaviours) in Asian elephants. The most frequently observed thanatological responses included postural changes, guarding/keeping vigil, touching, investigating the carcass, epimeletic behaviours and vocalizations. We also describe some infrequently observed behaviours, including carrying dead calves by adult females, re-assurance-like behaviours and attempts to support dying or dead conspecifics, some of which were only known anecdotally in Asian elephants. Our observations indicate the significance of open-source video data for gaining insights into rarely observed behaviours and support the accumulating evidence for higher cognitive abilities of Asian elephants in the context of comparative thanatology. © 2022 The Authors.

S. Preethee, K. Saminathan, M. Chandran & P. Kathireswari

Valorization of phyto-biomass with tertiary combination of animal dung for enriched vermicompost production

Environmental Research 215 (2022) e114365

Abstract. A study was conducted for 90 days in two cycles on 45th day (Cycle I), and 90th day (Cycle II) in 144 vermicbins with precomposted cow dung (T1), elephant dung (T2), cow dung + elephant dung (T3) in combination with leaf substrates of Ficus religiosa, Azadirachta indica, Terminalia catappa, Carica papaya, Vitex negundo, Acalypha indica and Borassus flabellifer to generate nutrient-enriched vermicompost. Different verminib feedstock materials were retained as experimental setup in other substrates with earthworm (vermicompost) and without earthworm (compost). This method was employed in the current study to decompose environmental leaf debris into the earthworm's mass production and transform it into high-value manure for long-term soil fertility control. The majority of the substrates exhibit pH and electrical conductivity in vermicomposts showed an increment while the total organic carbon and carbon to nitrogen ratio were significantly lowered. A prominent percentage increment of total NPK contents (P < 0.05) in vermicompost over initial values (N: 7.09–164.03; P: 4.39–101.09; K: 0.45–84.10). Among the vermibed substrates, Ficus religiosa leaf litter mixed with T3 showed stabilized cocoons and juveniles in Cycle I (45 days), while sub-adults and adults growth was favored in Cycle II (90 days). The higher reproductive potential of earthworms could be due to the composition and palatability of the substrate combination. This study provides a platform for utilizing leaf wastes in combination with animal wastes amended to reproduce earthworms, nutrient enrichment which could benefit soil fertility improvement. © 2022 Reprinted with permission from Elsevier.

H.H.T. Prins, Y. Liefting & J. F. de Jong

Marginal farmers carry the burden of damage caused by Asian elephants Elephas maximus in Bardiya National Park, Nepal

Oryx 56 (2022) 73-81

Abstract. In areas where farmland borders protected areas, wildlife may be attracted to crops and cause substantial financial damage for farmers. Elephants, in particular, can destroy a year's harvest in a single night, and can also cause damage to buildings and other farm structures. Few studies have examined whether damage caused by wild elephants increases social inequalities in farmer communities. We interviewed settlement leaders and subsistence rice farmers living in the buffer zone of Bardiya National Park, Nepal, to examine (1) the variation and spatial distribution of wealth within the farmer community, (2) the severity and spatio-temporal distribution of damage inflicted by Asian elephants, and (3) the willingness to insure against such damage. We investigated whether particular societal strata are disproportionately affected by negative interactions with elephants. We found that farmers near the boundary between agricultural and wilderness areas were significantly poorer and had smaller
landholdings than those further into the cultivated lands. Concomitantly, damage to crops and houses was more frequent nearer the wilderness-agriculture boundary than further away from it. Hence, in the buffer zone of Bardiya National Park, farmers near the wilderness-cultivation boundary, with small landholdings, had a relatively higher cost of elephant damage, yet were less willing to pay for an insurance scheme. We infer that in areas where both social inequality and damage caused by wildlife are spatially structured, conservation success may cause economic hardship for the local community, particularly for the poorer class. We discuss causes of the current lack of communal mitigation measures against the damage caused by elephants in the Park, and potential solutions. © 2021 The Authors.


Trigeminal ganglion and sensory nerves suggest tactile specialization of elephants

Current Biology 32 (2022) 904-910

Abstract. Sensory nerves are information bottlenecks giving rise to distinct sensory worlds across animal species. Here, we investigate trigeminal ganglion and sensory nerves of elephants. The elephant trigeminal ganglion is very large. Its maxillary branch, which gives rise to the infraorbital nerve innervating the trunk, has a larger diameter than the animal’s spinal cord, i.e., trunk innervation is more substantive than connections of the brain to the rest of the body. Hundreds of satellite cells surround each trigeminal neuron, an indication of exceptional glial support to these large projection neurons. Fiber counts of Asian elephant infraorbital nerves of averaged 4,000,000 axons. The infraorbital nerve consists of axons that are ~10 μm thick and it has a large diameter of 17 mm, roughly 3 times as thick as the optic and 6 times as thick as the vestibulocochlear nerve. In most mammals (including tactile specialists) optic nerve fibers greatly outnumber infraorbital nerve fibers, but in elephants the infraorbital nerve fiber count is only slightly lower than the optic nerve fiber count. Trunk innervation (nerves and ganglia) weighs ~1.5 kg in elephant cows. Our findings characterize the elephant trigeminal ganglion as one of the largest known primary sensory structures and point to a high degree of tactile specialization in elephants. © 2022 The Authors.


Understanding Mycobacterium tuberculosis complex in elephants through a One Health approach: A systematic review

BMC Veterinary Research 18 (2022) e262

Abstract Mycobacterium tuberculosis complex (MTC) that causes the chronic infectious disease- tuberculosis (TB), often presents with a complicated epidemiological pattern where the transmission chain may include humans, domestic animals and wildlife, including elephants. TB has been reported globally in both captive and wild elephants. The One Health approach might be the most effective way of understanding the shared MTC infection dynamics in captive and wild animals like Asian elephants. This systematic review accumulates evidence on occurrence, transmission pathways, and preventive measures of TB in elephants from a One Health perspective. The prevalence of TB reported in elephant populations ranges from 0 to 23.33% and high prevalence’s are reported for elephants that are in close proximity to infected humans. The risk of elephant to human infection transmission increased significantly with exposure duration and contact with infected elephants. Some studies described the plausible TB transmission to captive elephants from other animals (wild and domestic), suggesting inter- and intra-species transmission. The results of this systematic review based on 27 relevant published works, suggest three overarching interrelated transmission pathways for M. tuberculosis infections in Asian elephants- i) humans and elephants, ii) other animals (wild or domestic) and elephants and iii) unclear sources of infection. The progress made with new TB diagnostic tools provides multiple methods to choose from. However, lack of harmonization of TB testing in elephants and their human contacts remains a challenge to prevent TB in those animals. Routine TB screening among elephants and caretakers by setting up an occupational health program for early diagnosis
of infection through combined efforts of public health, veterinary medicine, and occupational health experts is suggested. This implies the need for a One Health approach to elephant TB control. This review reveals the need for more research on M. tuberculosis complex transmission pathways at the human-animal interface. © 2022 The Authors.


**Drivers of human-megaherbivore interactions in the Eastern and Western Ghats of southern India**

*Journal of Environmental Management 316 (2022) e115315*

**Abstract.** The global effort to protect megaherbivore populations is largely dependent on how human-wildlife conflict is identified, prioritized, and remedied. We examined the socio-ecological and landscape-scale factors determining spatial patterns of human-megaherbivore (Asian elephant and gaur) interactions across sixteen Forest Divisions in Tamil Nadu, India. Using a systematic grid-based design, we conducted questionnaire-based surveys of 1460 households at the human-wildlife interface adjacent to protected areas, Reserve Forest and fringe areas. We specifically collected information on elephant and gaur conflict incidents (e.g., human death/injuries, property damage, and crop-raiding), cropland type, extent of crop area and area lost to crop-raiding, from each household. We found that human-elephant conflict increased with percentage of crop cover, diversity of major and minor crops grown, proximity to water source, flat terrain, and lower rates of precipitation. Human-gaur conflict was greatest with a high diversity of major crops, proximity to water source, moderate precipitation, and more undulating terrain. We identified ca. 7900 km² hotspot area of contiguous high-intensity elephant conflict. For gaur, we identified high-frequency conflict hotspot areas covering ca. 625 km², which were patchily distributed, highly localised, and attributed mostly to the recent changing land-use patterns. Our findings will help policymakers and park managers in developing landscape-scale human-wildlife conflict mitigation plans in the identified conflict hotspots. © 2022 Reprinted with permission from Elsevier.


C.W.M. Rathnayake, S. Jones, M. Soto-Berlov & L. Wallace

**Human-elephant conflict and land cover change in Sri Lanka**

*Applied Geography 143 (2022) e102685*

**Abstract.** Human-elephant conflict (HEC) is a key environmental issue in number of Asian countries, including Sri Lanka. Incidents of HEC have significantly increased in Sri Lanka between 1991 and 2018, with 1734 human deaths reported in this period (281% increase), 4837 elephant deaths (1172% increase), 1053 human injuries (140% increase) and more than 23,000 property damage reports (1406% increase). In this study we present a Sri Lanka wide analysis to explore the role of land use and land cover change (LULCC) in relation to HEC, using official government data and a land cover change dataset (1993–2018) recently developed by the authors using satellite imagery from the Landsat archive. We investigated rates of HEC over time and compared these to rates of LULCC over the same period. We also present spatial analytics of HEC and LULCC, as well as determining hotspots of HEC and LULCC using a kernel density estimator. Annual HEC incidents were found to broadly increase in line with land use change events (r = 0.43, p < 0.05). Human deaths, elephant deaths, human injuries and property damage hotspots show distinct spatial patterns: human deaths and injuries being more concentrated in the Northwest, Polonnaruwa and Ampara, wildlife regions; while elephant deaths are spread throughout the HEC region and property damage is high in the Central, Polonnaruwa Anuradhapura, Northwest, and Southern wildlife regions. We found a strong negative correlation between HEC location and distance to LULCC events. In total, 98% HEC occurred within 1 km of an area that experienced recent LULCC Since 2017, the primary HEC hotspots have shifted to the south and east of the country in concert with LULCC. These countrywide perspectives could help inform HEC mitigation strategies in Sri Lanka and other countries facing similar human-wildlife challenges. © 2022 Reprinted with permission from Elsevier.
Age related variation of health markers in Asian elephants
Experimental Gerontology 157 (2022) e111629

Abstract. Although senescence is often observed in the wild, its underlying mechanistic causes can rarely be studied alongside its consequences, because data on health, molecular and physiological measures of senescence are rare. Documenting how different age-related changes in health accelerate ageing at a mechanistic level is key if we are to better understand the ageing process. Nevertheless, very few studies, particularly on natural populations of long-lived animals, have investigated age-related variation in biological markers of health and sex differences therein. Using blood samples collected from semi-captive Asian elephants, we show that pronounced differences in haematology, blood chemistry, immune, and liver functions among age classes are also evident under natural conditions in this extremely long-lived mammal. We provide strong support that overall health declined with age, with progressive declines in immune and liver functions similarly in both males and females. These changes parallel those mainly observed to-date in humans and laboratory mammals, and suggest a certain ubiquity in the ageing patterns. © 2021 The Authors.

Jessica Bell Rizzolo

Nonhuman animal nations: Transforming conservation into wildlife self-determination
Society & Animals 29 (2021) 393-413

Abstract. Neuroscientists have recently asserted that human and nonhuman animals share comparable brain structures and processes that govern cognition, emotion, and consciousness. This unitary, species-common model of transspecies neuropsychology compels a transformation from the current model of wildlife conservation to wildlife self-determination. Self-determination supports wildlife agency and resilience at the individual and population levels and is based on principles of positive assistance and supportive intervention, parallel sovereignty, and fair terms of cooperation in wildlife-human interactions. The case of Asian elephants in Thailand illustrates how wildlife capture and domination-based captivity, even when intended to conserve animals, can impede self-determination by producing psychophysiologic ally traumatized wildlife. This article integrates concepts germane to individual animals (agency and trauma recovery) with characteristics of wildlife populations and species (self-determination). It contends that psychosocial data on the mental, emotional, and social functioning of wildlife societies and their members should be included in wildlife assessments and policies. © 2019 Koninklijke Brill NV, Leiden.

A. Roy, S.K. Dash & S. Sathyakumar
A combination of cultural values and economic benefits promote tolerance towards large mammals in a hotspot of human-wildlife conflicts in eastern India
Human Ecology 50 (2022) 321-329

Abstract. No permission to print abstract.

Elephantoloemus indicus Austen, 1930 (Diptera: Calliphoridae) as the cause of cutaneous myiasis in captive Indian elephants from Assam, India
Veterinary Parasitology: Regional Studies and Reports 32 (2022) e100734

Abstract. Elephantoloemus indicus Austen, 1930, a dipteran calliphorid fly is known to cause by its larval stage obligatory cutaneous myiasis in Indian subspecies of Asian elephants in Myanmar and Thailand. The present study was undertaken on morphological identification of some specimens of fly larvae which were recovered from the warbles detected on the skin of captive Indian elephants at the Nameri National Park and Kaziranga National Park both situated in the state of Assam, India. The larval specimens were whitish to creamy white in colour and body conformation varied from cylindrical to barrel shaped depending on their measured size (Av 6.12 ± 0.28 × 2.35 ± 0.12 mm). Microscopic examination of processed larvae revealed presence of numerous single pointed spines uniformly distributed on entire body surface, well developed mouth hooks and cephalopharyngeal skeleton at the anterior end and posterior spiracles each with lightly sclerotized peritreme enclosing three short and straight respiratory slits. Based on geographical distribution of the fly, host relation, larval parasitism and morphological characters, the larvae were determined as of the genus Elephantoloemus.
which is represented by *E. indicus* as the only species described so far. This finding seems to be the first record in India after its report from Myanmar and Thailand. © 2022 Reprinted with permission from Elsevier.

M.W. Seltmann, J. Jackson, E. Lynch, J.L. Brown, W. Htut, M. Lahdenperä & V. Lummama

Sex-specific links between the social landscape and faecal glucocorticoid metabolites in semi-captive Asian elephants

*General and Comparative Endocrinology* 319 (2022) e113990

**Abstract.** Although social behaviour is common in group-living mammals, our understanding of its mechanisms in long-lived animals is largely based on studies in human and non-human primates. There are health and fitness benefits associated with strong social ties, including increased life span, reproductive success, and lower disease risk, which are attributed to the proximate effects of lowered circulating glucocorticoid hormones. However, to deepen our understanding of health-social dynamics, we must explore species beyond the primate order. Here, using Asian elephants as a model species, we combine social data generated from semi-captive timber elephants in Myanmar with measurements of faecal glucocorticoid metabolite (FGM) concentrations. These data enable a “natural experiment” because individuals live in work groups with different demographic compositions. We examine sex-specific FGM concentrations for four different aspects of an individuals’ social world: general sociality, work group size, sex ratio and the presence of immatures (<5 years) within the work group. Males experienced lower FGM concentrations when engaged in more social behaviours and residing in female-biased work groups. Surprisingly, females only exhibited lower FGM concentrations when residing with calves. Together, our findings highlight the importance of sociality on individual physiological function among elephants, which may have broad implications for the benefits of social interactions among mammals. © 2022 The Authors.

Z.M. Thant, R. May & E. Røskaft

Human-elephant coexistence challenges in Myanmar: An analysis of fatal elephant attacks on humans and elephant mortality

*J. for Nature Conservation* 69 (2022) e126260

**Abstract.** Understanding the underlying causes behind human-elephant conflict (HEC)-driven mortality of humans and elephants will help improve both parties’ wellbeing. The objective of this study was to examine the temporal and spatial mortality patterns of humans and elephants and the influence of local attitudes, conflict factors and habitat factors on elephant poaching. We used the Myanmar Forest Department data from 2001 to 2020 for humans and 2011 to 2020 for elephants together with explanatory data on human attitudes, habitat, and conflict factors. Approximately seven persons were...
killed annually in elephant attacks, with a bias towards men. The annual mortality of elephants during the study period was on average 16 individuals, and most elephants were killed by humans. There was a significant relationship between the number of killed humans and human-killed elephants around HEC villages. Villages with more property damage exhibited a higher rate of human mortality, which also correlated with negative feelings of local people towards elephants. Elephant poaching was higher in villages with less suitable habitat available for elephant use. Human encroachment is an important cause of HEC, leading to human loss and forming the main threat to the survival of wild elephants. We suggest local involvement to ensure good governance in conflict resolution and mitigation strategies and to strengthen law enforcement. © 2022 The Authors.


Semen characteristics and second successful artificial insemination of Asian elephant (Elephas maximus) in Thailand

Veterinary World 15 (2022) 1246-1255

Abstract. As the number of wild Asian elephants continues to decline, maintaining healthy populations under human care is vital. Male fertility assessment is essential for understanding the reproductive status, which can help to uncover underlying problems and improve the rate of pregnancy success. The objectives of this study in Asian elephants were as follows: (1) To investigate the semen characteristics; (2) to compare the relative seminal vesicle size and semen characteristics; (3) to compare the semen characteristics between good-motile (>60% progressive motility) and poor-motile (<60% progressive motility) ejaculates; and (4) to investigate the pregnancy success rate after artificial insemination (AI) with combined chilled and frozen semen. From 153 ejaculates, the mean ± standard error values of progressive motility, semen volume, sperm concentration, pH, and viability were 40.18%±2.28%, 40.94±3.86 ml, 1,205.58±62.26×10⁶ sperm/ml, 7.50±0.10, and 56.17%±1.96%, respectively. Comparing ampulla size and semen characteristics revealed that the bulls with ampullae of ≥7 cm² yielded significantly larger volume ejaculates. However, there were no significant differences in sperm motility and concentration. The comparison of semen characteristics between good- and poor-motile ejaculates revealed that the former had significantly higher pH, viability, normal acrosomes, intact membranes, and normal head and tail morphology but often had a significantly lower volume and sperm concentration. From seven AI attempts in four females, one female had a confirmed pregnancy (14.3% pregnancy rate), and delivered a healthy live female baby weighing 128 kg at 21 months and 12 days of gestation. The baby is now 3 years old and in a healthy condition, with normally developing growth and behavior. The semen characteristics of Asian elephants can be used as the baseline reference for further applications. The ampullae size indicates semen quantity but not quality. Our success in producing an elephant calf from AI using frozen and chilled semen demonstrated that AI can be used as an alternative approach for the breeding management of Asian elephants. However, the semen of Asian elephants is of poor quality, especially in terms of membrane integrity; thus, the improvement in semen quality through intensive and careful management of elephant health and fertility remains a challenge for the future. Furthermore, a sperm bank should be established to develop sperm cryopreservation, which will be invaluable for improving the genetic diversity of the Asian elephant.

Lucy Vigne & Vincent Nijman

Elephant ivory, rhino horn, pangolin and helmeted hornbill products for sale at the Myanmar-Thailand-China border

Environmental Conserv. 49 (2022) 187-194

Abstract. While many species are affected by trafficking in their products, some take centre stage, including elephants, rhinos, pangolins and helmeted hornbills, and we report an open
trade that continued in these items in eastern Myanmar between 2015 and 2020. We surveyed Myanmar’s border towns of Tachilek and Mong La, recording volumes, prices, origins and trade routes. We observed c. 16,500 ivory items, 8 helmeted hornbill casques and 264 beads, over 100 African rhino horn items and over 250 pangolins (mainly skins and scales). In 2020, asking prices in Mong La for rhino horn tips were US$ 10,770, rhino horn bracelets US$ 5385, helmeted hornbill casques US$ 2424 and big ivory bangles c. US$ 800, with prices being stable overall since 2017. We estimate the combined monetary values at US$ 0.25–0.30 million for Tachilek and US$ 0.75–2.00 million for Mong La. Mong La’s market today far surpasses Tachilek’s, being on the border of mainland China. Mobile phones and online trading allow customers to order items without bothering to cross the borders. Commitment to address the illegal wildlife trade across Myanmar’s borders requires a greater degree of cooperation and coordination amongst the relevant authorities in Myanmar, China and Thailand. © 2022 The Authors.

Y. Wang, J. Qu, Y. Han, L. Du, M. Wang, Y. Yang, G. Cao, S. Tao & Y. Kong

Impacts of linear transport infrastructure on terrestrial vertebrate species and conservation in China

Global Ecology and Conservation 38 (2022) e02207

Abstract. Two strategic documents issued by the Chinese Central Government projected that, by the mid-21st century, the linear transport infrastructure (LTI) network of China will rank at the forefront of ecological and sustainable transport networks globally. With this goal, it is urgent to summarize existing research, benchmark international research levels, and propose development directions and strategies for terrestrial vertebrate species protection around LTI in China. In this study, we searched for peer-reviewed papers before 2020 in both Chinese and international databases. A total of 170 academic articles were collected. Most focused on roads, but some focused on railways, of which the Qinghai-Tibet Railway occupied half. The most researched taxa were mammals, including the Tibetan antelope, Siberian tiger, and Asian elephant, the number of bird research papers was less than half that of mammal research papers, and fewer amphibian and reptile studies. The impact of LTI on wildlife was classified to habitat effects, roadkill, behavioral influences, and barrier effects. Wildlife preservation efforts included wildlife and habitat surveys, route selection, subgrade and pavement design, and the design and monitoring of wildlife crossing structures. Studies were concentrated in five zoogeographical regions, i.e., the Qinghai-Tibet, South China, Central China, Northeast China, and Southwest China regions. Conservation suggestions, knowledge gaps, and future research directions for China were identified through comparisons with the state of international research. These focal priorities will help guide the development of road ecology in China. Multi-disciplinary, cross-departmental, and national level research is necessary. Based on this review, a national data integration platform should be established and efforts to cooperate with international research teams to mitigate the adverse effects of LTI should be made. © 2022 The Authors.

S. Yasui & G. Idani

Characteristics of social relationships in a group of captive Asian elephants (Elephas maximus) in the elephant village in Thailand

Animal Behavior and Cognition 9 (2022) 89-105

Abstract. Wild Asian elephants (Elephas maximus) form complex fission–fusion societies centered on matrilineal groups. In captivity, unrelated females remain in the same group and create social relationships. To better understand well-being in captivity, it is important to investigate the social relationships between females. However, to date, little information is available on this topic. The goal of this study was to clarify the social relationships between captive female Asian elephants using social network analysis. Our subjects were 13 captive Asian elephants at the Elephant Study Center in Surin Province, Thailand. We investigated variations in the frequencies of affiliative behaviors between dyads. Individuals that stayed in the group longer tended to play a more central role in terms of group member connections. We found that two individuals played an important role in strengthening connections, and that their removal influenced group cohesion. Our results
revealed that individuals that stayed in the group long-term and that had existing relationships with others in the group tended to build better social connections, regardless of their age. In addition, the existence of some young individuals that show frequent affiliative behaviors may be important for bond strength and therefore, overall group cohesion.


CT anatomy of cervical vertebrae of Asian elephant (Elephas maximus)
Veterinary Medicine and Science 8 (2022) 1750-1768

Abstract. Elephants are currently the largest mammals on earth. A comprehensive examination of the anatomy of this animal to diagnose various disorders is required. In addition, due to the heavy head of these animals, adaptations have been made in the anatomical structure of the neck that is worth studying. This study aimed to investigate a standard morphologic and morphometric description of the elephant cervical spine. Another aim of this study was to compare the changes in the cervical skeleton of elephants with horses and cattle. For this study, the cervical vertebrae of the Asian elephant, cattle and horse were examined. CT Images were obtained. Two dorsal tubercles and a groove between them were observed on the dorsal arch of the atlas vertebra of the Asian elephant. In elephant samples, the variation of vertebral body height, spinous process height, transverse process width, vertebral body length and vertebral foramen volume indices were statistically significant. The volume of the vertebral foramen in the elephant decreases in the second vertebra compared to the first vertebra, decreases in the third vertebra, decreases in the fourth, increases in the fifth, decreases in the sixth and increases in the seventh. In this study, the structure of the cervical vertebrae of the Asian elephant was examined, and certain features were observed. One of the main features was the reduction of the length of the vertebral column, which leads to the decrease of the ratio of neck length to the size of the body. This condition can be due to the high weight of the head in the elephant. To maintain this weight, it is necessary to reduce the length of the neck and confer less mobility. © 2022 The Authors.


Point-of-care and standard laboratory reference intervals for coagulation values in Asian elephants (Elephas maximus): Variation by age class, sex and time to centrifugation
Journal of Zoo and Wildlife Medicine 53 (2022) 291-301

Abstract. In Asian elephants, elephant endotheliotropic herpesvirus causes significant calf mortality. Coagulation testing may aid veterinarians in early identification and management of hemostatic disorders. This study sought to establish reference intervals for select coagulation and platelet values. Blood was collected from clinically healthy Asian elephants (n = 63) in juvenile (≤15 yr old, n = 9), adult (>15 to ≤50 yr old, n = 41), and geriatric (>50 yr old, n = 13) age classes at seven institutions in Kanchanaburi Province, Thailand. Activated clotting time (ACT) was immediately assessed with a handheld analyzer, whereas remaining blood was stored at 5°C in sodium citrate and potassium EDTA collection tubes and transported to a central laboratory. Coagulation values were assessed on an automated blood coagulation analyzer, and platelet values were assessed on a hematology analyzer. Reference intervals were established for ACT, prothrombin time, activated partial thromboplastin time, thrombin time, fibrinogen, platelet count, mean platelet volume, platelet distribution width, and plateletcrit according to the American Society for Veterinary Clinical Pathology guidelines. No significant differences were observed for any value when comparing sex and time to centrifugation. Plasma fibrinogen (P = 0.002) and platelets (P = 0.003) varied significantly by age class, with adults displaying the highest fibrinogen concentrations and geriatric individuals displaying the lowest platelet counts. The ACT kaolin cartridges resulted in high success rates (84.3% feasibility) compared with celite cartridges (4.8% feasibility). Further studies are warranted to stratify reference intervals in accordance with age class trends. © 2022 American Association of Zoo Veterinarians.
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May 2023
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Manuscripts should be submitted by e-mail to the editor <jenny@aim.uzh.ch>. 
## Contents

### Editorial

*Jennifer Pastorini*

1

### Notes from the Chair IUCN SSC Asian Elephant Specialist Group

*Vivek Menon*

2-3

### Research Articles

1. **Road for elephants: Elephant use of the Karadikkal-Madeshwara Corridor, southern India**
   *Avinash Krishnan, Nicholas Warren, Upasana Ganguly, Ekadh Ranganathan & Dilip Kumar*
   4-9

2. **Villagers’ experiences, perceptions of human-elephant conflict and attitudes towards elephant conservation in south-eastern Bangladesh**
   *Shorfu A. Chowdhury, Karl W. Larsen & Robert Hood*
   10-16

3. **Captive breeding of Asian elephants at the Pinnawala Elephant Orphanage, Sri Lanka**
   *Mihiran Medawala, Shashi Madhushanka & Kithsiri B. Ranawana*
   17-22

4. **One stable’s novel approach to mitigating human-elephant conflict near Chitwan National Park, Nepal**
   *Michelle Szydlowski*
   23-29

5. **A simple approach to monitor faecal particle size in the Asian elephant – A proof of concept study**
   *Christian Schiffmann, Linda Schiffmann, Javier Bonillo, Ineta Bulkeviciute, Elisa Gozalbes Aparicio, Jorge Paniagua, Gloria Ribera, Maria Ruiz, Mario Torró & Marcus Clauss*
   30-35

### Short Communication

**Private electric fences: A novel and effective approach to preventing elephant depredation**
*G. D. Kurukula Samaranayake, H. M. Heshanthi Herath, T. S. Kumara Piyadasa & Ashoka Dangolla*
36-39

### News and Briefs

1. **Facilitate to Innovate: Lessons learned from virtual strategy workshops for Asian elephants**
   *Benjamin Christ & Nilanga Jayasinghe*
   40-43

2. **Joint elephant health camp in Sauraha, Nepal**
   *Michelle Szydlowski*
   44-45

3. **Elephant topics discussed at the 19th Meeting of the CITES Conference of the Parties (CoP19)**
   *Prajna P. Panda & Vivek Menon*
   46-51

   *Vicki Renner*
   52-53

5. **Recent publications on Asian elephants**
   54-84

6. **List of members of the IUCN SSC Asian Elephant Specialist Group**
   85-86