GAJAH

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Journal of the Asian Elephant Specialist Group



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The journal is intended as a medium of communication on issues that concern the management and conservation of Asian elephants both in the wild and in captivity. 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 research results, experiences, ideas and perceptions freely, so that the conservation of Asian elephants can benefit. 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.

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Editorial Note

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Cover

Elephants in the Minneriya National Park, Sri Lanka,
during the famous "elephant gathering"
Photo by Jennifer Pastorini
(See article on page 16)

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Editorial

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This second issue of *Gajah* for 2021 contains four research articles and five short communications about Asian elephants. Five studies are on elephants from India, two from Sri Lanka, one from Vietnam and one paper is about a captive elephant in Europe. In News and Briefs there is a report on the IUCN World Conservation Congress, an obituary and a book review.

The first **Research Article** by Nguyen X. Dang and co-authors describes the issues faced by a poor Vietnamese community from elephants occasionally venturing out of the neighbouring National Park and causing conflict. Nimain C. Palei *et al*. analysed elephant mortality data spanning 18 years for Odisha. They found that annual deaths are increasing and infants and mature-adult elephants have the highest mortalities. M.D.S.I. Karunatilaka and co-authors collected data on monthly elephant numbers over two years and assessed its correlation with the trends of water and food availability around the Minneriya reservoir in Sri Lanka. Schiffmann ***et al.*** describe how they found a simple solution to help a captive geriatric elephant to lie down again to sleep.

In **Short Communications** Ekadh Ranganathan and Avinash Krishnan analysed human and elephant mortality in southern India caused by human-elephant conflict in the last 40 years. Most casualties happened early morning and early night and from September and December. Mrinmay Mandal and Nilanjana Das Chatterjee studied human-elephant conflict in West Bengal. Over eight years most mortalities happened in the dry season. Nirupama Mohanty and Malaya R. Mahananda describe the habitat of a new elephant corridor in Odisha. The Tal-Kholgarh corridor consists of two sections linking four forest fragments and is used by about 20 elephants. Nikitasha Bora and co-authors describe treatment of a captive elephant in India that suffered from diarrhoea caused by a worm infection. K.G. Sachintha Udayanga *et al*. used *E. coli* to assess phagocytosis by leucocytes in four captive elephants in Sri Lanka.

In **News and Briefs** Sandeep K. Tiwari gives us a summary on the happenings at the 7th World IUCN Conservation Congress held in France earlier this year. Vivek Menon wrote an obituary for the AsESG member Kalayansundaram Ramkumar who sadly passed away in June. Hemanth Kumar presents a book review for Sanjeev Kumar Chadha's new book titled "Jumbos on the edge: The future of elephant conservation in India". This *Gajah* also contains a collection of abstracts of research articles about Asian elephants published recently.

As usual, Vivek Menon, the Chair of the AsESG, briefs us on recent activities of the AsESG. With the IUCN World Conservation Congress, a new quadrennium has started for the group and Vivek explains the changes in structure and membership of the group. He also gives us an update on the progress made by the different Working Groups.

I would like to thank the authors who shared the results of their studies with the readers of *Gajah*. Again the Editorial Board Members put in many hours, editing manuscripts to help the authors to shape up their articles. Mandai Nature generously paid for printing this *Gajah* and mailing it to readers across the globe.



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Notes from the Chair IUCN SSC Asian Elephant Specialist Group

Vivek Menon

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

Dear Members

Hope you are safe, keeping well and that most of you have been vaccinated against Covid-19. While we have all been working remotely over most part of 2020 and early 2021, I believe with SARS-CoV-2 cases coming down globally, you have been able to resume your travel and normal work. However, the threat still persists and we should maintain Covid protocols while we resume our work.

Covid has stolen many good friends, colleagues, scientists and conservationists from us. As we were still trying to overcome the shock and grief from the death of Mr. Ajay Desai late last year, we lost Dr. K. Ramkumar, a talented and committed scientist and a member of the AsESG this year. It is tragic to lose a loved one before their time and his loss to the field of elephant conservation in India will be long felt. An obituary to his memory is also published in this issue.

One of the main responsibilities of the AsESG Secretariat in the last few months after I was reconfirmed as Chair of AsESG for the coming quadrennium, was to review the contribution of the members in last quadrennium along with the Membership Advisory Committee (MAC) and decide the membership for the new quadrennium (2021–2025). I am happy to inform that we have been able to confirm 106 members (98 from the last quadrennium and eight new members) from 22 countries (including members from all the 13 range states) for this quadrennium (Fig. 1). The new team brings in regional representation and gender parity and is a good balance of youth, experience and skills. The expertise of the current membership covers 13 broad skill sets with a large proportion of them working on elephant ecology and population, human-elephant conflict (HEC) mitigation, habitats and corridors, wild elephant management, captive elephants and elephant health and reproduction. The current male to female ratio is 2.4:1, which is an improvement from the 3.3:1 when I took the responsibility of the group in 2015. The average age of the group today is 52.5 years with 13.2% of the members between 30–40 years and 32.1% in the 41–50 years age group (Fig. 2). Please see an analysis of our member's diversity index presented graphically. We have not renewed the normal membership of Dr. Jacob Cheeran and Mr. Richard Lair due to their old age but we have offered them an AsESG Emeritus Membership to gain from their experience.

I am happy to inform you that I have also reconstituted the AsESG Leadership Team for this quadrennium. Ms. Heidi Riddle has been deputed as the Vice-Chair of the group and will be helping me with leading the range state meetings, captive elephant conservation and welfare issues, and international fundraising for the group. Dr. Wong Ee Phin will serve as Deputy Chair of the group, responsible for ensuring members from South-East Asian states join the AsESG, mentoring young professionals (YP) and also forging scientific collaboration between members for joint publications. Dr. A. Christy Williams will continue to serve as the AsESG's Red List Coordinator. Dr. Jennifer Pastorini has also agreed to continue serving as

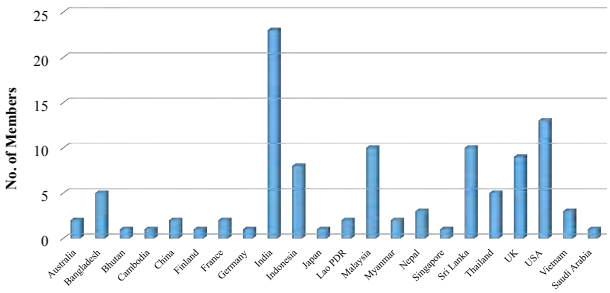


Figure 1. Countries of AsESG members (October 2021).

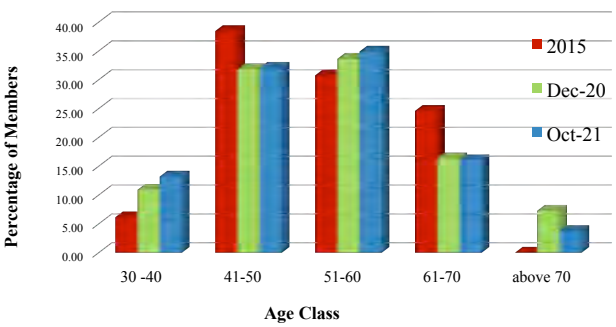


Figure 2. Age composition of the AsESG membership in 2015, 2020 and 2021.

the Editor of the journal Gajah. I hope you will join me in wishing the new Leadership Team the very best for the quadrennium 2021–2025.

Unfortunately for the AsESG, but happily for him, Dr. Sandeep Kr Tiwari has accepted new leadership roles in his parent organisation Wildlife Trust of India (WTI) and will be leaving his Program Manager role in March 2022. I would like to thank him for the excellent work done during his tenure for the last quadrennium and wish him well for his future. We will put out a vacancy advertisement for an amended role soon on the website and please do circulate for us to get a good candidate for this.

In the last quadrennium, 14 Working Groups were formed of which 7 Working Group documents have been finalised including the Red List reassessment of Asian Elephant that has been published. Three Working Groups have also submitted their draft documents and are being reviewed. The finalised documents will soon be uploaded on the website. Of the remaining 4 Working Groups, the Sumatra NECAP is pending approval from the Government. The other three Working Groups who have not been able to finalise their documents include mapping the distribution of elephants across range states, guidelines for best practices in addressing and mitigation human elephant conflict, and managing the elephant habitat affected by Rohingya in Cox Bazar, Bangladesh.

The two Working Groups formed in 2020 are also working on their mandate. The Sabah Working Group formed to decide on the taxonomy of Borneo elephants had a meeting on 2nd June 2021 and looked at both the cytogenetic studies and morphological features to confirm on the taxonomy of the population. The group also discussed on the need of Red Listing of the subspecies and are collecting all relevant information including historic distribution and population data to undertake the assessment. The AsESG and its members are also assisting the drafting of the National Elephant Conservation Action Plans (NECAP) for range countries. Peninsular Malaysia has constituted a core team (with AsESG member) that through a series of meetings reviewed the achievement of the last plan and has prepared the first draft of the NECAP, which is being further reviewed. The AsESG, in collaboration with WCPA CCSG Transport Working Group, has developed the draft report on best practices for linear infrastructures passing through elephant habitats in Asia and is being reviewed.

The World Conservation Congress (WCC) was held from 3rd to 11th September 2021 in Marseille, France where Government and members from across the world came together with the goal of conserving the environment and harnessing the solutions that nature offers to global challenges and to also elects the new IUCN council. The congress also marks the beginning of the new quadrennium (2021–2025) and I was happy to be part of the congress. As informed to you earlier, I have been elected to the new IUCN governing Council for 2021–2025 as IUCN Councillor from South and East Asia Region and will be happy to take up regional conservation issues, including ones on elephants, at the IUCN council. A separate report is included in this issue.

I think as a team, the AsESG has been able to contribute significantly for the conservation of the species and I would like to thank you all for your active contribution and look forward to taking forward the momentum in the new quadrennium. I would also like to thank the Gajah editorial board, our institutional partners, range state officials and SSC Chair Office for all their support and assistance.

Vivek Menon
Chair IUCN SSC AsESG

Research Article *Gajah 54 (2021) 4-10*

Human-Elephant Conflict Around Pu Mat National Park, Vietnam

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Abstract. The elephants living in Pu Mat National Park and Anh Son Watershed Forest, often move out to adjacent areas and cause severe human-elephant conflict (HEC). The main reasons for the HEC are, reduction and degradation of natural forest, human disturbance of elephant habitat, not taking elephants into account in land-use planning and poor HEC management. Local communities are very poor and have little experience in HEC prevention. HEC significantly impacts their livelihoods, threatens their lives and induces significant psychological stress, resulting in decreased support for elephant conservation.

Introduction

The Asian elephant (*Elephas maximus*) is threatened by illegal hunting, trade, habitat loss/degradation and ever-increasing human-elephant conflict (HEC) (AsESG 2017). In many countries, HEC causes significant economic damage and psychological impacts on communities. Consequently, killing of elephants has been increasing. Thus, resolution of HEC is a major concern and a high priority for conservation of elephants (Fernando *et al*. 2008; Desai & Riddle 2015). In Vietnam, the Asian elephant population in the wild has decreased from about 1500–2000 individuals in 1990 to only 100–130 in 2013 (Nguyen 2015; Vietnam Forestry Department 2018). Currently they live in small isolated groups, mostly below 5 individuals (Nguyen 2015). Threats to their survival are widespread. In order to save the existing Asian elephants in Vietnam, the Government has designated 3 priority areas for elephant conservation, consisting of the Pu Mat National Park region, Cat Tien National Park – Dong Nai Cultutral & Nature Reserve Region, and Yok Don National Park – Ea Sup District Region.

The elephant population in the Pu Mat NP region consists of 3 groups with a total of 13–14 individuals (Nguyen *et al*. 2020a, b). The group in Con Cuong District was thought to consist of 7–8 individuals. However recent observations found only a single adult female. They do not cause much HEC. The group in Tuong Duong District has 4–5 individuals. They occupy an area next to the Laos border and also cause little HEC. The third group is located in Anh Son District and consists of 8–9 individuals. As this is the largest group, it is the most important for elephant conservation in the Pu Mat NP region. However, the elephants cause severe HEC including economic damage, human deaths and injuries. In 2011 an adult male was killed in retaliation. The aim of this study was to assess HEC in Pu Mat NP region and develop strategies for its management.

Methods

Study area

The Pu Mat NP region is situated in the Southwest of Nghe An Province (18º46' - 19º12' N; 104º24' - 104º56'E), on the border with Laos. It covers the administrative territories of Anh Son, Con Cuong, Tuong Duong and Thanh Chuong districts (Fig. 1). The Pu Mat NP has a core zone of 94,715 ha and a buffer zone of 86,000 ha. The region is intersected by mountains with steep slopes and narrow valleys, with the elevation ranging from 100 to 1841 m a.s.l. About 90% of the area is below 1000 m. Level areas

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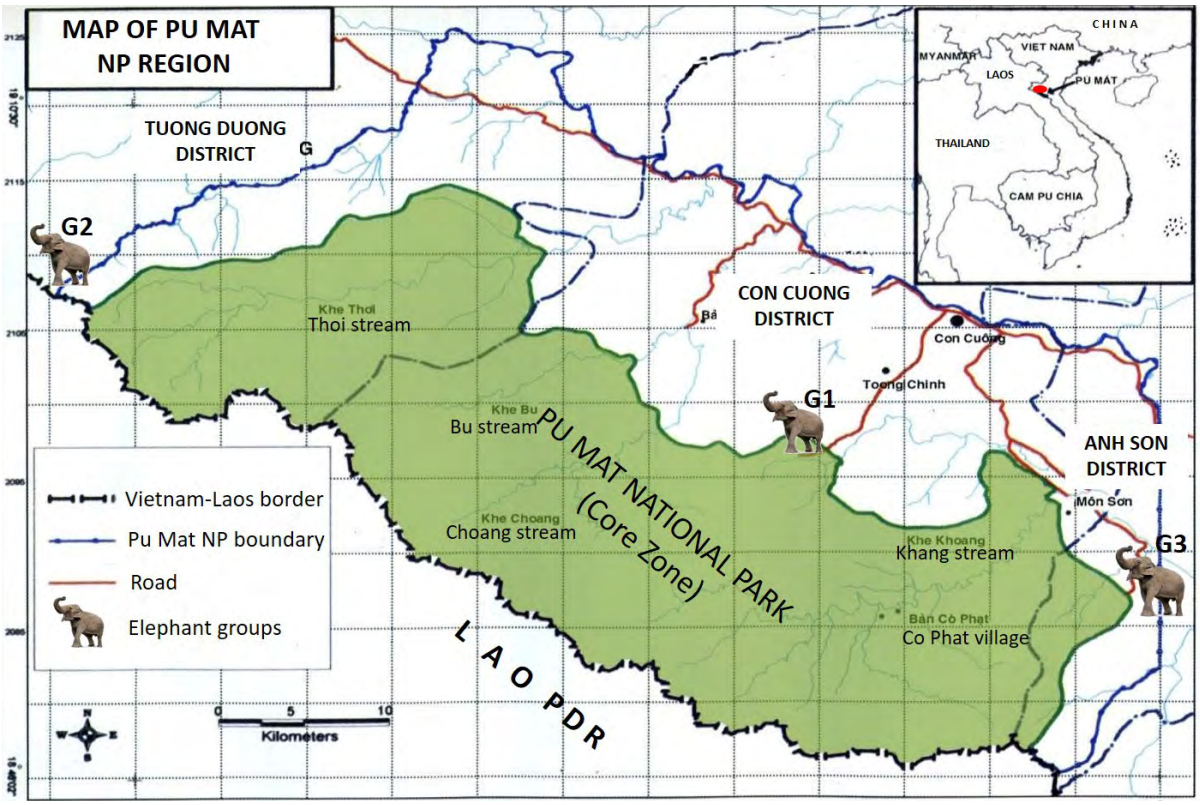


Figure 1. Location of Pu Mat NP region and elephant groups (G1 = Con Cuong elephant group, G2 = Tuong Duong elephant group, G3 = Anh Son elephant group).

are limited and are mostly occupied by settlements and agriculture. About 92,790 ha (97.8%) of the core zone is forested, with the vegetation comprising mostly of montane broad-leaf evergreen forests with bamboo forests occurring in lowland valleys. The buffer zone consists of secondary broad-leaf evergreen forests, restored forests, bamboo forests, commercial tree plantations, croplands and human settlements.

Data collection

The study was conducted in 2019–2020. Semi-structured interviews were used to collect information on HEC status, impacts and prevention/mitigation measures used. The interviews were conducted in different parts of the study area including the Pu Mat NP, the Anh Son and the Thanh Chuong watershed forests, local state rubber plantations and settlement centres. Field investigation was undertaken when information of recent HEC incidents were available (Fig. 2). In order to assess the attitude of local communities towards elephants and forest conservation, 300 questionnaires were sent to local households in Phuc Son and Thanh Duc communes, of which 254 were completed and returned. Direct semi-structured interviews of 226 local households representing 40.2% of total households in the HEC area, were also conducted. One person from each household, aged 20 years or older was interviewed, usually the male head of the household. In each village, surveyors moved from house to house for interviews. The Human-Wildlife Conflict Rapid Safety Assessment System (Brooks 2015) was used to as-



Figure 2. Survey team interviews local village on elephant damage happening last night.

sess HEC mitigation. Consultations were held with representatives of villages, commune authorities, the Pu Mat NP management board, watershed forest management boards and state rubber farms. The level of safety in each component of the system, consisting of safety for people, safety for property, safety for elephants, safety for habitat, and monitoring effectiveness of management was determined and the strengths and weaknesses in the management of HEC by each group were identified.

Results and discussion

HEC area

The home range of the Anh Son elephant group was about 18,000 ha (Fig. 3). It comprised of the Cao Veu sector of Pu Mat NP, Anh Son watershed forest, Thanh Chuong watershed forest, state rubber farms and agricultural lands of Phuoc Son, Thanh Duc and Thanh Son communes in Anh Son and Thanh Chuong districts.

The elephants mainly stayed in the Anh Son watershed forest. They moved out during January to March and November to December when young bamboo shoots and crops were abundant outside. During these periods they often went back and forth spending 2–3 weeks at a time in each habitat. The elephants stayed in the Anh Son watershed forest probably because the terrain was better with comparatively low earth mountains of about 200–600 m height and steepness of 20–35°. In contrast in the Cao Veu sector, the terrain consisted of limestone mountains, soil mountains and deep narrow valleys with elevations reaching above 1400 m and steepness over 45°. The Anh Son watershed forest also had high surface water availability

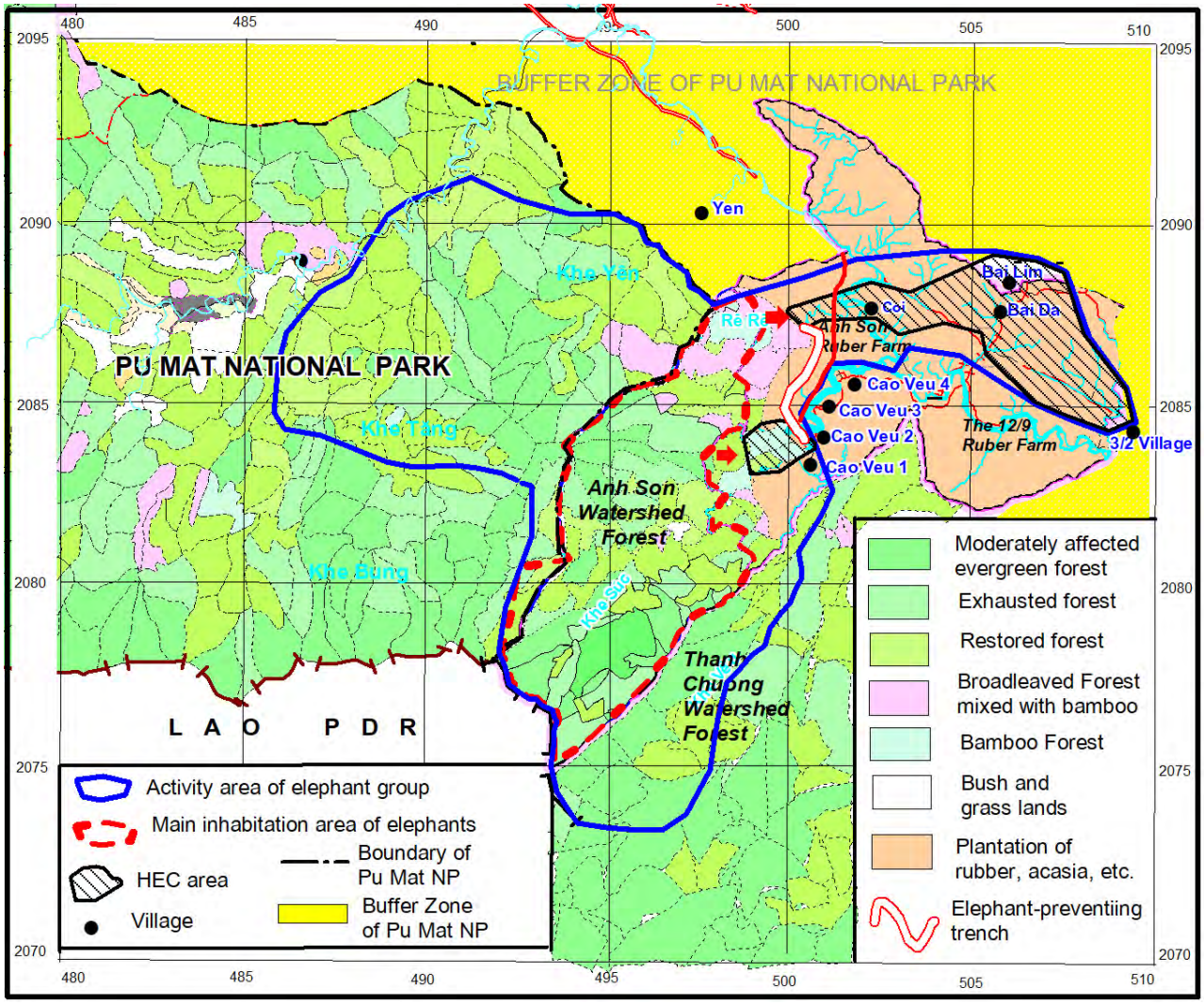


Figure 3. Activity area of the Anh Son elephant group and HEC area.

Table 1. Cultivated plant species affected by elephants and the type of damage caused.

No.	English name	Scientific name	Type of damage
1	Maize	*Zea mays*	Consumption, trampling
2	Manioc	*Manihot esculenta*	Eating, trampling
3	Rice	*Oriza sativa*	Eating, trampling
4	Banana	*Musa* spp.	Eating, breaking
5	Bamboo	Bamboo spp.	Eating young shoots, breaking
6	Small bamboo	*Schizostachyum dulloua*	Eating young shoots, breaking
7	Met bamboo	*Dendrocalamus barbatus*	Eating young shoots, breaking
8	Acacia	*Acacia auriculaeformes*	Breaking
9	Acacia	*Acacia magnum*	Breaking
10	Pagoda tree	*Styrax tonkinensis*	Breaking
11	Tea	*Camellia sinensis*	Trampling
12	Cow grass	*Penisetum purpuseum*	Eating, trampling
13	Sugar cane	*Saccharum officinarum*	Eating, trampling
14	Rubber	*Hevea brasiliensis*	Breaking
15	Mandarin	*Citrus* spp.	Breaking
16	Pommel	*Citrus maxima*	Breaking
17	Jackfruit	*Artocarpus heterophyllus*	Breaking

due to abundant streams, and high food availability from secondary forests, bamboo forests, natural banana stands and grasslands.

From Anh Son watershed forest, the elephants sometimes came to the Yen village of Luc Da commune where they occasionally damaged cultivations, but did not cause severe HEC. In the northern direction, the elephants crossed the Re Re stream in the Anh Son watershed forest and moved to the Anh Son State Rubber Plantation, Cao Veu 4, Bai Lim, Bai Da and Kim Tien villages of Phuc Son commune in Anh Son district. Then, they moved further to the 12/9 State Rubber Plantation, the Third-February village (Thanh Duc commune) and the Dai Son village (Thanh Son commune) in Thanh Chuong district. In these areas, the elephants caused severe HEC. The elephants also crossed the Khe Suc stream and the Khe Da Mai stream and entered the Cao Veu 1 village where they caused some HEC, damaging crops and houses.

Impact of HEC

HEC has occurred in the Phuc Son area since 2004. However, it was not severe at first as there were only few crop damages and no human death and injuries. HEC increased, particularly after 2009 with more crop damages and the occurrence of human deaths and injuries, and elephant deaths.

Out of about 40 crop species cultivated in the area, 17 were damaged by elephants. The most commonly damaged crops were met bamboo, bamboo, rubber, Acacia, sugar cane, banana and maize (Table 1).

In 2014, damage to a sugar cane plantation in the Cao Veu 1 village (Phuc Son Commune) was over 200,000,000 VND (22,000 US$). In 2018, damage to crops in Bai Da village (Phuc Son commune) was around 786,000,000 VND (40,000 US$). During 2018–2019, elephants damaged approximately 2000 rubber trees of the 12/9 Rubber Farm and destroyed two field houses, and the damages were estimated to be about 2 billion VND (220,000 US$). They also damaged about 400 rubber trees of the Anh Son Rubber Farm, valued at about 600,000,000 VND (330,000 US$). Total economic loss in 2019 and 2020 was estimated to be about 200,000 USD. Therefore the economic loss caused by elephants in the Anh Son area was very high and significantly impacted the livelihood of local communities, which were already very poor as their annual income was about 400 US$ per person.

Indirect impacts caused by the elephants included the fear of elephants, restriction of people's movements to and fro from their fields and villages, reduced school attendance and interference with the collection of fuel wood, thatch grass, wild fruits and other non-timber forest products, which supplemented household income.

When elephants came to their lands, farmers and their families had to guard crops and property, leading to loss of sleep and employment opportunities, increased exposure to vector borne diseases such as malaria and dengue, and psychological stress. In Bai Da and Bai Lim villages, when elephants approached the village, 30–40 men were mobilized to guard crop fields and houses. They had to be awake the whole night, keeping watch and chasing elephants. This guarding lasted 3–10 days until the elephants moved away.

In Boc Chau Tam settlement of Cao Veu 4 village (Phuc Son commune), there were 13 families who did not have land for crop cultivation and they earned their living by collecting non-timber forest products (young bamboo shoots, vegetable, fruits, medicinal plants, etc.) from forests close to the village and working as wage-workers. In high HEC seasons, they could not enter the forests because of the fear of elephants and thus lost their income.

The survey found that 110 of 226 households suffered economic loss from HEC in Phuc Son and Thanh Duc communes. In response to the question regarding meeting elephants, 29.2% expressed 'high', 14.2% 'medium' and 56.6% 'low' levels of fear. Of 110 households suffering economic loss by HEC, the number expressing a high level of fear was 72.7% and a medium level was expressed by 6.3%. The findings indicate a high indirect negative impact of HEC in the Anh Son area.

Measures for HEC prevention and mitigation

The main method used was to chase away raiding elephants. Households in Cao Veu 1 village turned on electric lamps hung around the houses, to discourage elephants from coming close. When the elephants approached houses, the people tried to chase them away by shouting, burning tires, making loud noises by beating on metal and lighting bamboo stems to create explosions. These attempts had low success because the elephants got used to it after 3-4 times of being chased using these methods.

In 2015, Pu Mat NP constructed a 5-km long concrete lined trench along the hill slope in Phuc Son commune (Figs. 3 & 4). The trench has been effective in preventing elephants entering populated areas of Cao Veu 1, Cao Veu 2, Cao Veu 3 and Cao Veu 4 villages, but has not eliminated HEC. The elephants used new routes to enter Cao Veu 1 and they also enter Bai Lim, Bai Da and Kim Tien villages (Phuc Son commune) and the Third-February village (Thanh Duc commune) where they continue to cause severe HEC.

In 2018, two HEC Response Teams, each consisting of 10 residents, was established by Pu Mat NP to help local communities in HEC prevention and mitigation. The teams were not full time employees and became activated only when elephants came. They had no monthly salary but received an allowance for subsistence when working in the forest. They were provided training on chasing away elephants by simple techniques and received very limited funds for the operation of the team (about 1,000 US$ per month for two teams). The support that could be provided to the local communities by the two teams was inadequate to address HEC effectively.



Figure 4. Elephant-preventive concrete trench in Anh Son District (Pu Mat NP).

Reasons for HEC

Habitat loss and degradation

Elephant habitat in the area has been significantly reduced and degraded due to conversion of natural forests into tree plantations and cultivated lands. Before 2009, almost the entire area (about 45,000 ha) of the Anh Son and the 12/9 Rubber Farms was covered by natural forest and served as habitat for elephants. In 2009, the natural forests in the area were converted to rubber plantations and other tree plantations such as *Acacia* spp., met bamboo (*Dendrocalamus barbatus*) and bo de (*Styrax tonkinensis*), and agricultural fields such as sugar cane and bananas. According to Pu Mat NP Management Board, before 2010, Phuc Son commune had about 43,000 ha of natural forests but from 2010 to 2018, about 12,000 ha of forests was converted into rubber plantations. The elephants are now confined to an area of about 18,000 ha, of which only 11,300 ha is natural forest. The loss of habitat may have led to decrease of food resources and movement paths for elephants.

Human disturbance

Current elephant habitat in Anh Son is much disturbed by local residents through cultivation activities in the forest, harvesting non-timber forest products such as fuel wood, bamboo, rattan, medicinal plants and bee honey and fishing and hunting/trapping wild animals. These activities may disturb the elephants and make them more aggressive towards people.

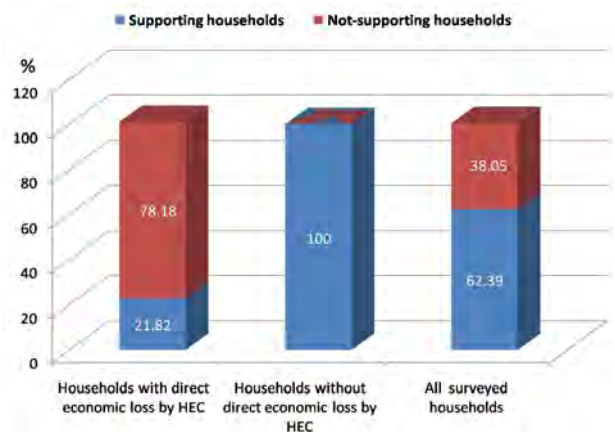


Figure 5. Support for elephant conservation.

Lack of proper land-use planning

The presence of elephants has not been taken into account in setting up settlements and cultivations. Villagers constructed houses and grew crops very close to or even within the forest. As a result, seasonal movement routes of elephants outside the forest were obstructed. In addition, most crops in the area such as rice, manioc, maize, sugar cane, banana, papaya, bamboo and fruit trees, were very attractive to elephants.

Poor HEC management

Local communities had little knowledge of HEC prevention and mitigation measures and lacked the financial capacity to implement such measures. The current governmental HEC management system merely consists of a 5-km trench, a few awareness programs on wildlife conservation and poorly-operational HEC Response Teams. There are no HEC prevention/mitigation interventions such elephant monitoring for warning local communities of elephant encroachment. Financial support is lacking for local communities to apply HEC preventive/mitigation measures such as watchtowers, elephant-preventive trenches, bee-hive fences, etc. and for elephant-friendly livelihood development schemes.

People's attitude towards elephant conservation

Out of 110 households with direct economic loss by HEC, only 24 had a positive attitude to elephant conservation (Fig. 5). In contrast, all 116 households without direct economic loss by HEC had a positive attitude. This clearly indicates that HEC caused significant decrease of local community support to elephant conservation. Local communities are very poor and the HEC significantly impacted their livelihood, threatened their lives and induced significant psychological stress on them, leading to the observed decrease in support for elephant conservation.

When households supportive of elephant conservation were questioned about their reasons, all stated that it was because elephants were an endangered species and were protected by gov-

ernment laws. In addition, 46.8% expressed support because elephants were a government asset, 23.4% because elephants had lived there for a long time as close friends of the people and 1.4% because elephants can help local economic development. The percentage of people supporting elephant conservation because they cared for elephants was lower than we expected. Possibly, this is because conservation education has focused too much on laws, neglecting the socio-cultural aspects of elephant conservation, and because of the negative impacts of HEC in the area. The fact that very few saw an economic value in elephants, reflects the lack of livelihood development measures associated with elephant conservation.

Acknowledgements

This study was funded by the International Elephant Foundation (IEF) through a grant titled "Community-based human elephant conflict mitigation in Pu Mat National Park, Vietnam". The authors would like to express sincere thanks to Management boards of Pu Mat NP, the Anh Son watershed forest, the Thanh Chuong watershed forest and local authorities for the kind support of our study.

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Research Article *Gajah 54 (2021) 11-15*

Mortality Patterns of Asian Elephants in Odisha, Eastern India

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Abstract. We examined data on elephant mortality from the year 2001 to 2018. Elephant deaths greatly increased over the last eight years. From 2001–2018, 1061 elephants died in 943 incidents with an average of 58.94% deaths per year. Elephant deaths peaked in winter and mostly occurred outside protected areas in human dominated landscapes. Disease was the major cause of death, followed by accidents and unknown reasons. The highest mortality was in the age class 21–40 years while 58.15% of deaths were of individuals less than 20 years.

Introduction

Human-elephant conflict, ivory poaching, habitat loss and fragmentation of natural habitats are the major threats to elephants in India (Baskaran *et al*. 2011). Human-induced mortality is a major factor affecting many threatened species. Mortality caused by poaching, poisoning, accidents, disease, electrocution etc. can seriously affect elephant populations, because elephants have low reproductive rates, low densities and limited distribution (Sukumar 2006). Each year, nearly 400 people and 100 elephants are killed in conflict related incidents in India (Rangarajan *et al*. 2010).

Asian elephants (*Elephas maximus*) are categorised as endangered (IUCN 2021), listed on Appendix I of CITES and in Schedule I of the Indian Wildlife (Protection) Act, 1972. The state of Odisha supports a relatively stable population of elephants (Sar & Varma 2004). As per the elephant census of 2017, there were 1976 wild elephants consisting of 344 tuskers (males), 1092 females, 38 whose sex could not be determined due to poor visibility and 502 calves, in the state (Palei & Rath 2017). The elephant population of Odisha represents about 72% of the population in eastern India and 7% of the Indian population (Palei 2017).

The intent of this study was to document the elephant deaths and causes of death in Odisha.

Methods

Study area

Odisha is situated in south-eastern India between 17º 47' to 22º 34' N latitude and 81º 22' to 87º 29' E longitude (Fig. 1). It has a geographic area of 155,707 km^2, with a forest cover of 51,345 km^2, which constitutes 28.78 % of the state. The state of Odisha consists of 30 districts and 52 forest divisions. The human density of the state is 269 per km^2 (Anon. 2011). Three seasons could be differentiated, summer (March to June), monsoon (July to October) and winter (November to February). Most of the precipitation occurs during the monsoon season, and the annual average rainfall is 1451 mm. The temperature varies between 2ºC in winter to 45ºC in summer. The majority of the people are farmers. The principal crop is rice, which is mainly cultivated in the monsoon season.

Data collection

Data on elephant deaths were obtained from Odisha Forest Department records from 2001 to 2018 and reports from office of the Principal Chief Conservator of Forest (Wildlife) & Chief Wildlife Warden, Government of Odisha, Bhubaneswar. Field visits were carried out from July 2016 to July 2018 in 28 districts, to verify data by conducting informal interviews with

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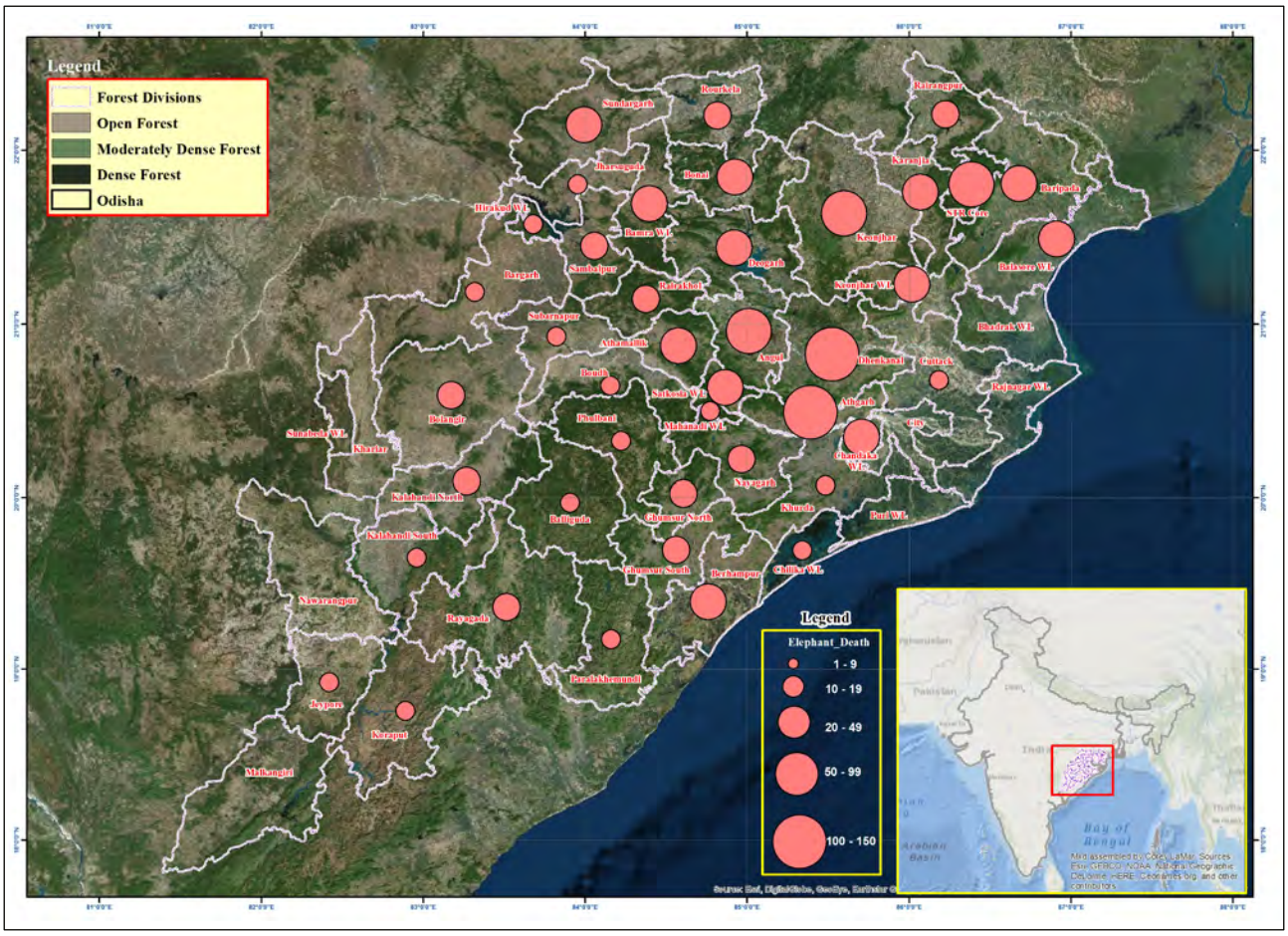


Figure 1. Map showing elephant deaths from 2001–2018 by Forest Divisions of Odisha.

government officials, local people and community leaders.

Classification of elephant mortality

Disease: Diseases such as tuberculosis, haemorrhagic septicaemia, foot and mouth disease and anthrax.

Natural death: Death on account of old age.

Poaching: Elephant death by shooting with guns or bows and arrows for ivory trade.

Electrocution: Electrocution can be accidental or intentional. Accidental incidents were caused by elephants coming into contact with energy transmission lines passing through forest areas. Deliberate electrocution of elephants was due to connecting main grid power to fences around crop fields.

Poisoning: Elephant death due to accidental consumption of insecticides or due to people poisoning vegetables, water holes and saltlicks targeting elephants.

Accident: Road and train accidents, falling from hilltop, falling into wells etc. and being struck by lightning.

Unknown reason: Decomposed/undetermined due to late detection.

Results

From 2001 through 2018, 1061 elephant deaths were recorded. The average number of deaths per year was 58.9 ± 19.0, range 20–85. The highest number of deaths occurred in 2016 (Fig. 2). The average number of annual elephant deaths from 2001–2009 was 46.00 ± 15.64 and from 2010–2018 it was 71.88 ± 12.17 ($P = 0.0015$).

In 75.8% of incidents the number of elephants dying was one, while the deaths of two (18.7%) and three (5.4%) elephants were also recorded.

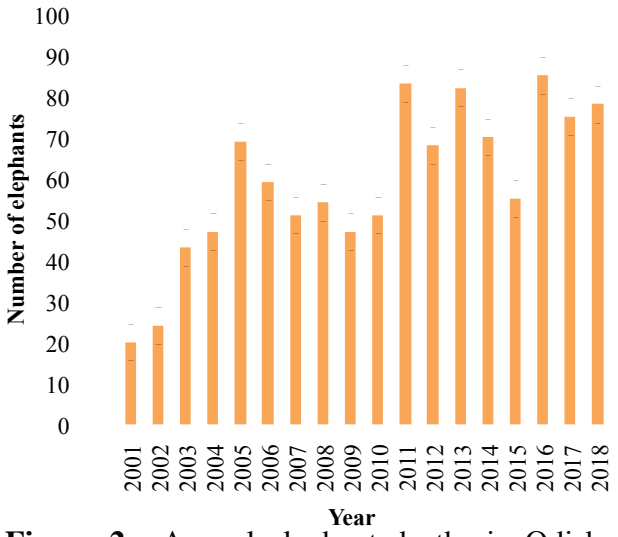


Figure 2. Annual elephant deaths in Odisha from 2001 to 2018.

The majority of deaths occurred while elephants were raiding crops in agricultural areas (35.2%), followed by sanctuaries (23.2%), village areas (18.5%), reserve forest (15.5%), and close to highways (5.4%) and railway lines (2.3%).

A total of 397 (37.4%) deaths were recorded in winter. The month with the highest deaths was December (n = 120, 11.3%, P = 0.00051).

During last eighteen years 246 (24%) elephant deaths were reported in 11 out of 19 protected areas in Odisha. Similipal had the highest number with 82 elephant deaths, while Satkosia Wildlife Sanctuary had 39 deaths, Kuldiha Wildlife Sanctuary 29 deaths, Khalasuni and Badrama Wildlife Sanctuary 26 deaths, Chandaka Wildlife Sanctuary 25 deaths, Hadgarh Wildlife Sanctuary 24 deaths, Kotgarh Wildlife Sanctuary 8 deaths, Karlapat Wildlife Sanctuary 4 deaths, Lakhari Valley Wildlife Sanctuary 4 deaths, Baisipalli Wildlife Sanctuary 4 deaths and Debrigarh Wildlife Sanctuary 1 death.

Division wise the highest was 134 deaths in the Dhenkanal Forest Division followed by Athgarh Forest Division with 119 and Keonjhar Forest Division with 91 deaths.

Disease was the commonest cause of death (n = 277, 26.1%), followed by accidents (n = 169, 15.9%), unknown (n = 167, 15.7%), electrocution (n= 160, 15.1%), natural (n = 143, 13.5%), poaching (n = 128, 12.1%) and poisoning (n = 17, 1.6%) (Fig. 3).

Electrocution

The 160 electrocution deaths occurred in 118 incidents, out of which 34 (21.0%) were deliberate killing by poachers for tusks. Elephant mortality due to electrocution varied seasonally and was highest in winter, with 51.9%, followed by monsoon 28.1% and summer 20.0% ($F_{2,51}$ = 1.455, P = 0.243). The mean annual mortality due to electrocution was 8.8 ± 4.11 elephants, with the highest number of 18 recorded in 2011.

Train accidents

A total of 20 elephant deaths (2% of total deaths) were due to train accidents and they occurred in 14 incidents. The dead elephants comprised of 4 adult males, 12 adult females, 3 male calves and 1 female calf. Of these, 11 deaths occurred in 2012.

Age and sex specific mortality

Of the dead elephants, infants comprised 20.75%, juveniles 10.00%, sub-adults 12.72%, young-adults 14.70%, mature-adults 29.96%, post prime age 6.32%, old age 3.68% and very old age 1.89%.

Age specific elephant deaths are given in Table 1.

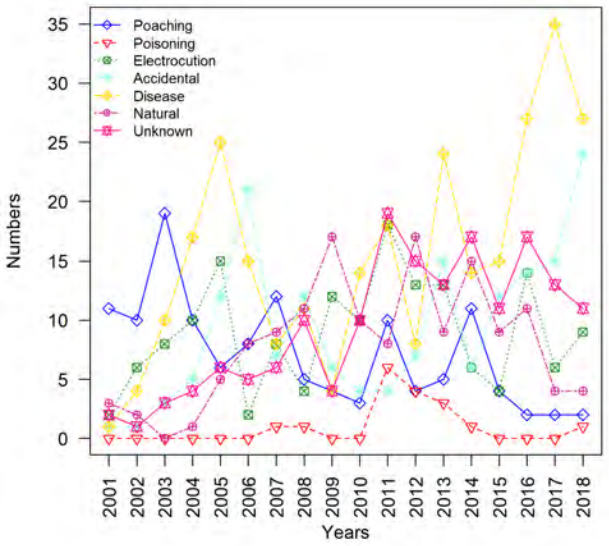


Figure 3. Elephant deaths by cause in Odisha from 2001 to 2018.

Table 1. Age specific mortality of elephants in Odisha from 2001 to 2018.

Age class	Age (in years)	Males		Females		Total	
		n	%	n	%	n	%
Infant	0–4	108	22.27	112	19.44	220	20.75
Juvenile	5–9	52	10.72	54	9.38	106	10.00
Sub-adult	10–15	59	12.16	76	13.19	135	12.72
Young-adult	16–20	71	14.64	85	14.76	156	14.70
Mature-adult	21–40	139	28.66	179	31.08	318	29.96
Post prime	41–50	33	6.80	34	5.90	67	6.32
Old	51–60	12	2.47	27	4.69	39	3.68
Very old	61–80	11	2.27	9	1.56	20	1.89
Total		485	100	576	100	1061	100

Discussion

We found that the number of annual elephant deaths in Odisha increased over the study period with the rate increasing by more than 50% between the first half of the study period and the second half. Possible contributory factors are the increase in human population in Odisha from 3.67 million in 2001 to 4.19 million in 2011 (Anon. 2011), with an associated increase in habitat fragmentation, loss and degradation due to development and encroachment. Comparable increase in elephant deaths has also been reported from Tamil Nadu (Davidar *et al*. 2015). The increase in deaths over time has been higher in Sri Lanka, with a death rate of 61 from 1951–1969 (Santiapillai 1994) and 263 from 2010–2019 (Prakash *et al*. 2020).

The present study found an annual death rate of 59 from 2001–2018 in Odisha. Annual death rates reported in some of the other states of India include, Arunachal Pradesh 4 (in 2010), Assam 6 (1993–2010), Meghalaya 6 (1994–2011), Karnartaka 87 (1990–2010), Uttarakhand 16 (1990–2011), West Bengal 22 (2000–2011), Kerala 32 (1990–2010) and Tamil Nadu 71 (2001–2011) (Arora 2015). Annual elephant death rate in Nilgiri from 1979–2011 was 9 (Davidar *et al*. 2015).

A total of 61.1% of elephant deaths in Odisha from the year 2001–2018 occurred outside forest areas during crop harvesting season. This was mainly because there were extensive agriculture areas adjacent to the forest areas.

The majority of elephant deaths took place during the winter season (37.4%) with a peak in the month of December, which is the winter crop harvesting period. Similarly, in higher mortality was recorded during harvesting time in Sri Lanka (Haturusinghe & Weerakoon 2012).

Elephant deaths due to poaching in Odisha were for ivory. Poaching for meat or hide has not been recorded. Therefore all elephants killed by poachers were males. Ivory poaching is wide spread where substantial proportions of male elephants are tuskers and has been very high in southern India (Sukumar 1989).

Palei *et al*. (2014) reported that an average of 9.8 elephant deaths occurred annually due to electrocution in Odisha. Arivazhagan & Ramakrishnan (2010) reported that in Tamil Nadu more than 50% of elephants died due to electrocution and all such elephants were in the age category of 15–25 years and were males.

The very old age group of elephants (61–80) accounted for 1.9% of deaths during the study period. Of the 20 elephants in this age group, 11 were males and 9 were females. Therefore only 2.3% of the males and 1.6% of the females had lived their full lives. Singh & Arora (2004) reported that in Kaziranga National Park, average elephant survival age in males was 41.3 years and for females was 38.7 years.

While there is a lack of information as well as proven methods for reducing elephant mortality, minimising habitat destruction, increasing

public awareness and strong law enforcement may reduce elephant deaths and ensure their long-term survival.

Acknowledgements

We are thankful to the Principal Chief Conservator of Forests (Wildlife) and Chief Wildlife Warden, Odisha Forest Department for facilitating this study. We extend our sincere thanks to Assistant Conservator of Forests (Wildlife) for his valuable support to carry out this research. We thank all Divisional Forest Officers and field staff for their kind co-operation.

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Research Article *Gajah 54 (2021) 16-23*

The World-Renowned Annual Elephant Gathering in Minneriya, Sri Lanka – Will It Endure?

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Abstract. The reservoir-bed grasslands of the Minneriya reservoir, Sri Lanka, support a large gathering of Asian elephants in the dry season. We conducted observations on elephant numbers over 12 months in 2019/2020 but did not observe as high numbers of elephants as previously. Monthly elephant numbers at the reservoir were linked to the availability of grassland. Changes in water-related parameters of the reservoir owing to the water supply from the Moragahakanda reservoir may account for the observed differences in elephant numbers. Water regulation to mimic the seasonal patterns is necessary for the endurance of the elephant gathering at Minneriya.

Introduction

Minneriya is located in the dry zone of Sri Lanka, which covers two-thirds of the country. The management of water resources in the dry zone for irrigation was the basis of Sri Lanka's ancient hydraulic civilization, which lasted from 200 BC till 1200 AD (Dharmasena 2010). With the collapse of the civilization after 1200 AD the water reservoirs fell into disuse (Fernando 2002). In the 20th century, with the increase in human population, many of the abandoned reservoirs were restored. Re-settlement schemes, restoration of reservoirs, and expansion of agriculture led to a sharp drop in the extents of forest and other wilderness areas in the dry zone, adversely impacting wildlife including elephants.

The availability of fodder is a major factor influencing the presence of elephants (Harris *et al*. 2008). The Asian elephant (*Elephas maximus*) is a mega-herbivore, with a daily food requirement of about 4% of its body weight, whereas lactating females have a higher requirement of about 6% (Sukumar 2003). Hence, elephants are not specialized feeders and consume a wide range of plant species (Vancuylenberg 1977; Sukumar 1990; Samansiri & Weerakoon 2007). However, they demonstrate a preference for grass, which shows dense growth, and is easy to gather (Sukumar 1990; Fernando 2015; Alahakoon *et al*. 2017). Grass also contains low amounts of secondary compounds and is more digestible than browse (Kos *et al*. 2012). Vancuylenberg (1977) reported that about 50% of the diet of Sri Lankan elephants consists of grass. Reservoir-bed grasslands become available to elephants in the dry season as water is discharged for irrigation and power generation, exposing parts of the reservoir bed where grass sprouts afresh (Ishwaran 2001).

The gathering of elephants at the grasslands of the Minneriya reservoir has been acclaimed as the largest gathering of Asian elephants at a single site (Yapa & Ratnavira 2013). Up to an estimated 400 elephants are thought to gather at the Minneriya and Kaudulla reservoirs (Fernando *et al*. 2011). The Minneriya reservoir receives water from several minor rivers and rain, and it discharges water to downstream reservoirs. Prior to 2018, it also received water from the Mahaweli irrigation scheme, although this decreased during the dry season. With the commissioning of the Moragahakanda reservoir in 2018, the Minneriya reservoir is assured of a year-round supply of water. Release of water from Moragahakanda to Minneriya in the dry season may prevent the exposure of the reservoir bed and the emergence of fresh grass or if

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it happens later in the dry season, submerge the grass cover.

We studied how water inflow from Moragahakanda may impact the gathering of elephants in Minneriya, by assessing (i) the number of elephants at the Minneriya reservoir (ii) elephant behaviour with particular reference to feeding on the reservoir bed grassland, (iii) the relationship between monthly elephant numbers and changes in water-related and fodder-related parameters of the reservoir, (iv) the monthly water-related parameters of the Minneriya reservoir in 2019/2020 and 2016/2017, and (v) possible links to the human-elephant conflict (HEC).

Methods

Study site

The Minneriya reservoir is located between latitudes 7°5' – 8°5' North and longitudes 80°5' – 81°0' East, in the Polonnaruwa District in the North Central Province of Sri Lanka (Fig. 1). The area covered by water at spill level is 2550 ha. The reservoir lies within the Minneriya National Park, which, together with the Minneriya-Giritale Sanctuary, covers an area of 9411 ha (DWC 2008).

Prior to the construction of the Moragahakanda reservoir (commissioned in 2018), the Minneriya reservoir received water via the Elehara-Minneriya-Yodha Ela, from the Bovetenna Scheme, but water was in short supply during the dry season. After 2018, the Minneriya reservoir received water from the Moragahakanda reservoir also via the Elehara-Minneriya-Yodha Ela. The Minneriya reservoir continues to receive water seasonally from several minor rivers – Batu Oya, Erige Oya, Talkote Ara Oya, Kiri Oya and Madyamala Oya.

The reservoir area receives rain mainly from the north-east monsoon from October to January. As elsewhere in the dry zone, there is a prolonged dry season extending from February to September, preceding the main rainy season (October to January) (DWC 2008).

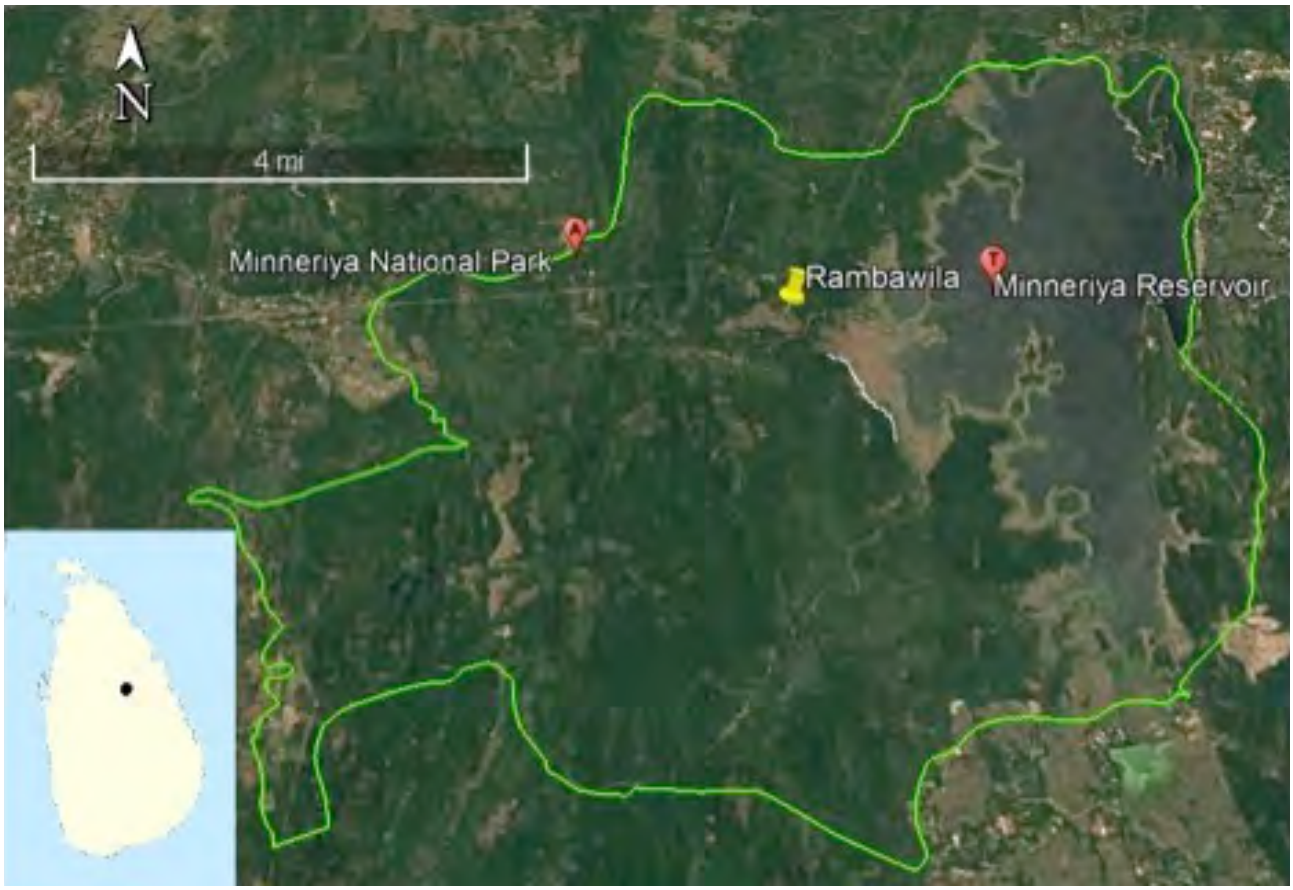


Figure 1. Location of the Minneriya reservoir within the Minneriya National Park and the observation point Rambawila. The tree-line at Rambawila is indicated by the white line.

The Minneriya reservoir releases water to Kaudulla and Kantale reservoirs.

The natural vegetation in Minneriya National Park and the surrounding areas mainly comprises of dry mixed evergreen forest, scrub and riverine forest. Grasslands arise in the exposed reservoir bed during the dry season.

Enumerating elephants

Observations were made on 24 days from February 2019 to January 2020. Counts of elephants were taken on each of two consecutive days within the first ten days of each month. Counts were made from Rambawila, a popular elephant viewing point, which provided wide coverage of the reservoir (Fig. 1). Counts were taken between 14:00 to 17:00 hours. This time frame was selected since elephants usually gather at the reservoir in the afternoon/evening hours. A binocular (Nikon 8×40) was used for observing the elephants.

Recording elephant behaviour

One to three herds within an observable range (estimated at less than 100 m) were selected each month for behavioural observations. A herd was considered to be a group of animals of any age or sex moving together in a coordinated manner (Laws 1970). Herds were selected on arrival, and observations commenced 10 min after all the individuals of that herd were deemed to have arrived. 'Grazing' and 'drinking-and-bathing' were recorded as two separate activities and all other activities were grouped as 'other'. Recordings were made through scan sampling where the activity of each individual in the selected herd was noted at 10-min intervals for up to one hour. For each herd we calculated the percentage frequency of the three activities.

Water-related parameters of the reservoir

We obtained monthly data on mean regulated inflow, mean water volume, mean water depth and rainfall at the Minneriya reservoir, from February to January 2016/2017 and 2019/2020, from the Irrigation Department. As elephants are known to use seismic and acoustic stimuli for navigation (O'Connell-Rodwell 2007), we assessed data on water inflow on the day preceding the elephant counts, assuming that inflow would create cues that elephants respond to.

Assessing fodder availability

We estimated fodder availability monthly by measuring the distance from the tree line at Rambawila (Fig. 1) to the waterline, and estimating the biomass of grass. The distance to water was used as a proxy for the extent of grassland.

For estimating grass biomass, we harvested the above ground portion of grass in 25 cm × 25 cm plots in the reservoir-bed grassland and in similar plots at the forest edge (up to 30 m into the forest from the tree line), both at Rambawila. A total of five plots, each separated by a distance of 25 m, were sampled per month in the reservoir bed grasslands and in the forest, with a total of 120 plots being sampled during the study (5 plots x 12 months x 2 habitats). For recording dry weight, the collected grass was dried to a constant weight in an oven at 70ºC (Levett *et al*. 1985).

Human-elephant conflict

HEC incidents (property/crop damage and human injury) from 2015 to 2019 recorded at the Minneriya National Park office were obtained from the Department of Wildlife Conservation.

Statistical analysis

One-way Anova was used to examine for significant differences in the proportions of different behaviour (log transformed) across months. The Pearson's correlation test was used to examine associations between water-related and fodder-related parameters and the mean number of elephants at the reservoir and the chi-square test to examine significant differences in the number of reported crop raids/property damage and human injury in the Minneriya area across years.

Results

Elephant counts and behaviour

The total number of elephants observed on a single day at the Minneriya reservoir during the period February 2019 to January 2020 ranged between zero (in August, December and January) and 160 (day 1 in April) (Fig. 2). There was no seasonal trend in the number of elephants at the reservoir. With the exception of February and June, elephants on the reservoir-bed grasslands were feeding for over 70% of time (Table 1). In February it was possible to observe only a single herd and only one scan sample was recorded for each individual as the herd moved out of the reservoir area within a short time.

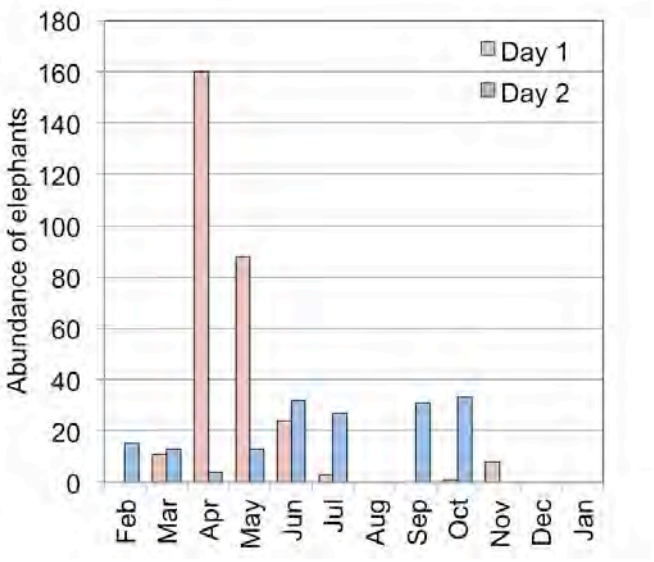


Figure 2. Counts of elephants on two consecutive days each month (solid and empty bars) at the Minneriya reservoir in 2019/2020.

Water-related parameters

In 2016/2017 the inflow from June to August was much lower and the water volume and depth from February to June were higher than in 2019/2020 (Fig. 3). In the months following May (i.e. the dry season), the water volume and depth decreased sharply in 2016/2017 but not in 2019/2020. Thus, with respect to water volume and depth, seasonality was seen in 2016/2017 but not in 2019/2020. The rainfall patterns with respect to the monsoon (November to January) and the dry months June to August were broadly similar in 2016/2017 and 2019/2020 (Fig. 3D).

Fodder related parameters

Grass biomass in the exposed reservoir-bed was greater than at the edge of the forest during the months June to December (Fig. 4).

Association between water and fodder related factors and elephant numbers

There was no association between the mean monthly inflow and elephant numbers (mean inflow r = -0.38, P = 0.22, Fig. 5A). Negative associations were present between the other three

Table 1. Monthly frequencies (mean ± standard deviation) of observed behaviours in herds.

Month	# Herds	# Individuals	# Scans	Frequency [%] Feeding	Drinking & bathing	Other
February	1	12	12	50.00	0.00	50.00
March	2	20	319	77.02 ± 1.07	0.56 ± 0.79	22.43 ± 1.86
April	2	40	641	83.50 ± 4.17	4.75 ± 5.07	11.75 ± 0.91
May	2	41	450	75.59 ± 1.79	4.68 ± 2.79	19.73 ± 4.58
June	2	55	140	64.72 ± 11.59	5.84 ± 0.58	29.44 ± 12.17
July	3	20	131	70.42 ± 8.55	0.00 ± 0.00	29.58 ± 8.55
August	0	0	0	NA	NA	NA
September	3	82	337	78.59 ± 0.98	8.45±7.38	12.95 ± 7.62
October	2	33	202	72.85 ± 12.69	1.05±1.48	26.11 ± 11.21
November	1	17	119	75.63	0.84	23.53
December	0	0	0	NA	NA	NA
January	0	0	0	NA	NA	NA
F-value				2.80	2.11	2.68
P-value				0.07	0.25	0.08

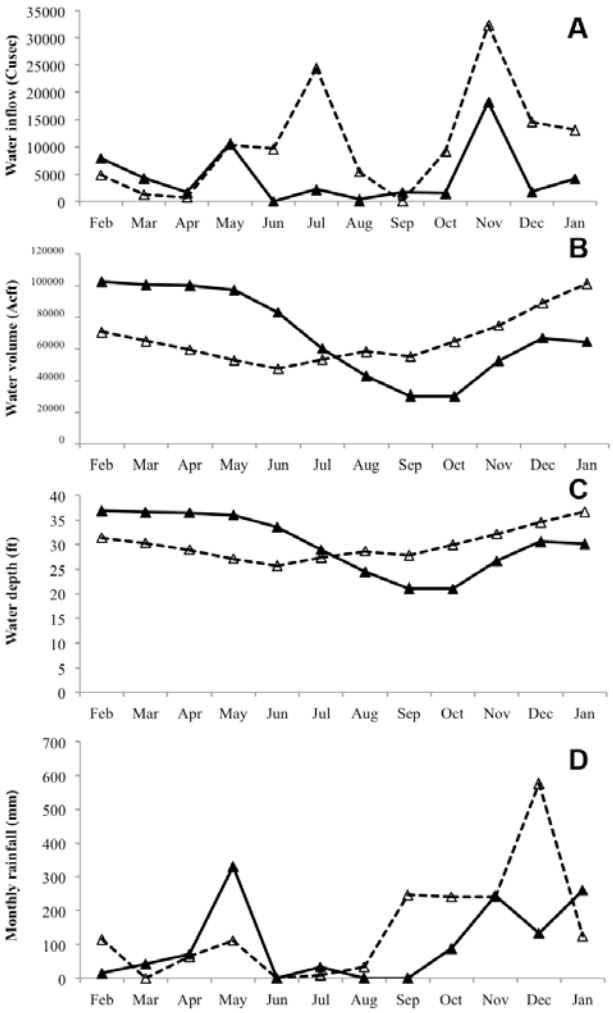


Figure 3. Monthly mean regulated inflow (A), mean water volume (B), mean depth (C) and rainfall (D) for the Minneriya reservoir in 2016/2017 (solid line) and 2019/2020 (dashed line).

water-related parameters and the numbers of elephants (mean water volume r = -0.51, P < 0.09, Fig. 5B; mean water depth r = -0.51, P = 0.09, Fig. 5C; inflow preceding elephant counts r = -0.51, P = 0.08, Fig. 5D).

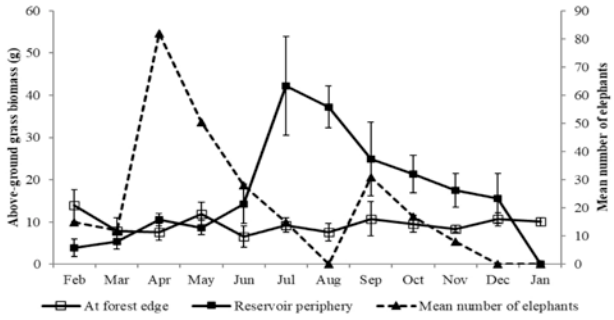


Figure 4. Mean above-ground dry grass biomass at the forest edge and in the reservoir periphery in 2019/2020.

There was a positive association between the numbers of elephants and distance from the forest edge to the water line (r = 0.52, P = 0.08, Fig. 6) but no association with grass biomass at the forest edge or in the reservoir area (forest edge r = -0.08; P = 0.82; reservoir area r = -0.18; P = 0.58) (Fig. 4).

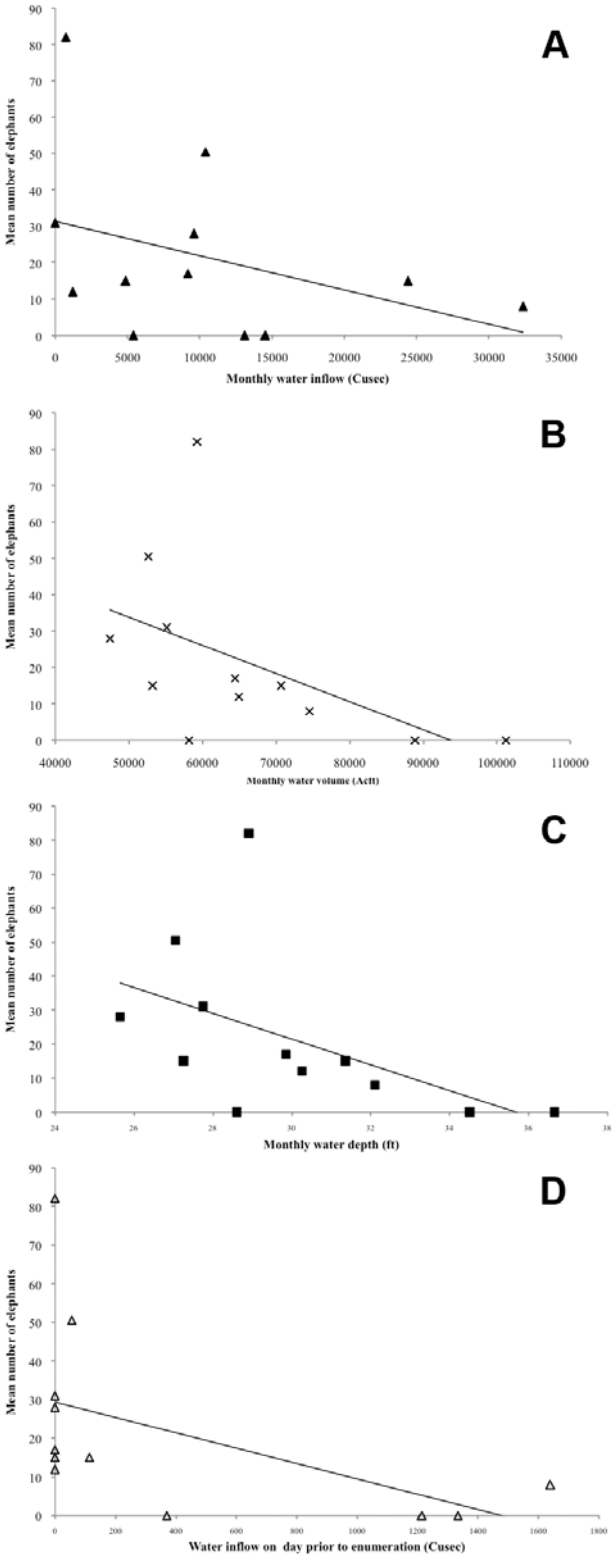


Figure 5. Association between four water-related parameters of the Minneriya reservoir and the mean number of elephants in 2019/2020.

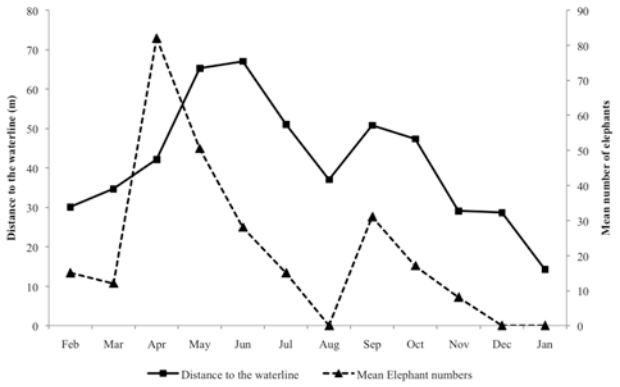


Figure 6. Distance from the forest edge to the waterline in 2019/2020.

Trends in the human-elephant conflict

The number of HEC entries around the Minneriya National Park showed a significant difference across years from 2015 to 2019 (X^2 = 52.17, P < 0.001) (Fig. 7). There was around a four-fold increase in the number of reported incidents in 2018 and 2019 compared to the previous years.

Discussion

The largest gathering of elephants enumerated at the Minneriya reservoir by us was 160 and no seasonal trend in numbers was evident. The only other study on elephant numbers in Minneriya found a gradual build-up in the dry season with a maximum of 319 elephants towards the end of the dry season in 2000/2001 (Santiapillai *et al*. 2003). The survey by Santiapillai *et al*. (2003) was based on observations conducted while driving 14 km traversing forest and grassland. Although the disparity in the numbers of elephants recorded in the two studies might be attributed to the different methods, comparison with respect to seasonality of the gathering would be valid.

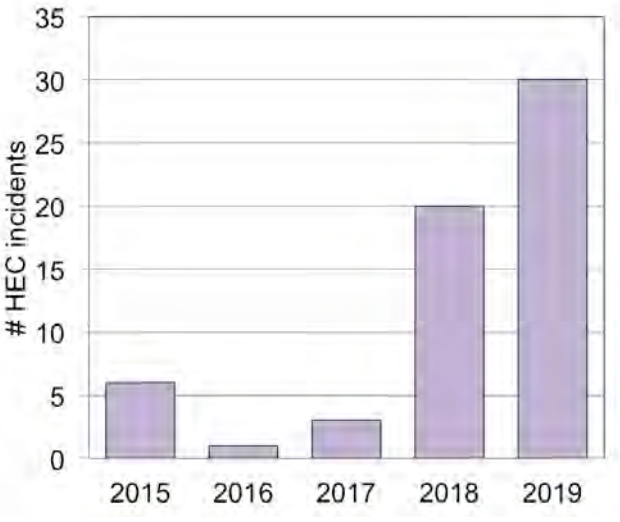


Figure 7. Recorded number of incidents arising from HEC around Minneriya.

With respect to the impact of water from Moragahakanda, comparison of water-related parameters between 2016/2017 and 2019/2020 showed that water levels were lower during the dry season in 2016/2017. In contrast, there was no seasonal difference in 2019/2020. Differences in rainfall in the two periods may have also contributed to this disparity. There was a negative association between elephant numbers and the mean monthly water volume, depth and inflow on the day prior to enumeration. The link with the inflow maybe due to elephants using seismic and acoustic stimuli to assess the environmental conditions and navigate accordingly (O'Connell-Rodwell 2007). Such a cue might alert the elephants of the possibility of the inundation of the grasslands prompting them to refrain from visiting the reservoir.

We also found that the number of elephants was positively related to the extent of exposed reservoir bed. This is explained by the observation that the elephants gather at the grasslands primarily for feeding. Several studies have shown that grass is a preferred food of Asian elephants (Ishwaran 1981; Katugaha *et al*. 1999; Alahakoon *et al*. 2017). We found that when elephants were on the reservoir bed, over 70% of the time was spent feeding on grass. Although elephants spend only a limited time of the day at the reservoir, this foraging site assumes significance in the dry season when food in other parts of the forest is likely to be scarce. Our study also showed that the grass biomass in the reservoir bed was greater than that at the forest edge, from June to December.

The present study shows that the water levels and pattern of fluctuation in the Minneriya reservoir were different to that before receiving water from Moragahakanda reservoir. Prior to 2018 they were dependent on seasonal inputs, but after 2018 inflow from Moragahakanda dis-

rupted the seasonality. While it is not possible to regulate seasonal inflows, the input from Moragahakanda could be manipulated. Based on the elephant numbers observed by us in comparison to that by Santiapillai *et al*. (2003), we conclude that seasonal fluctuation in water is critical for the endurance of the elephant gathering. Hence, an effort must be made to mimic the pre-2018 seasonal pattern of inundation and exposure of the reservoir-bed. In the wet season when the Minneriya reservoir bed is seldom used by the elephants the reservoir could be maintained at full capacity, and in the dry season the water could be drawn down so exposing the grazing grounds. A common weed *Xanthium indicum* (commonly called agada) invades the exposed beds and is a matter of concern with regard to the Minneriya reservoir (FEOSL 2020). Recharging in the wet season destroys these weeds, allowing for the unhampered resurgence of fresh grass as the water level recedes in the following dry season. Thus, inundation followed by draw down maintains optimal fodder availability for elephants.

Decrease of the grassland in Minneriya reservoir might also have other negative implications. The number of incidents of property and crop damage and injury to humans in the Minneriya area increased sharply in 2018 and 2019 compared with the previous years. While aggravation of the human- elephant conflict in the Minneriya area cannot be entirely attributed to the reduction in grasslands in Minneirya reservoir, it might be one of the contributory factors.

The large gathering of Asian elephants seen at the Minneriya reservoir has been acclaimed as one of the world's wildlife wonders (Lonely Planet 2012). Non-endurance of this elephant gathering would have a profound adverse impact on the tourist industry (Miththapala 2016). Therefore a determined effort needs to be made to maintain an appropriate water regime in the reservoir, while also meeting the demand for irrigation water.

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Research Article *Gajah 54 (2021) 24-29*

Successfully Assisting a Geriatric Elephant in Resuming Lying Rest – A Case Report

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Abstract. The provision of a sufficient amount of satisfying rest is considered a critical welfare aspect in zoo animal care. According to our current knowledge, elephants require regular bouts of lying rest in order to have restorative sleep. This case report demonstrates how a geriatric and severely handicapped Asian elephant was supported successfully to resume lying rest. Through the provision of an appropriate slope to lie on, her bouts of lying rest became shorter, more frequent and more laterally balanced. At the same time her total daily duration of lying rest increased and the days without having any lying rest at all decreased.

Introduction

Although our knowledge of resting behaviour in free-ranging Asian elephants (*Elephas maximus*) remains sparse due to challenges in observing them in their natural habitat, several reports have documented their resting behaviour under human care (Tobler 1992; Ibler & Pankow 2012; Williams *et al*. 2015; Walsh 2017; Kalirathinam *et al*. 2019; Evison *et al*. 2020). Reviewing these data led to the hypothesis that lying rest is critical for elephants, because they may not have satisfying sleep in a standing position (Schiffmann *et al*. 2018a).

Whether leaning rest may function as a substitute for lying rest is debatable (Schiffmann *et al*. 2018a). In particular geriatric and/or physically handicapped elephants may struggle with the movement sequence of lying down and getting up again. Therefore, it is not surprising that such individuals express reluctance to lay down and at one point may completely stop having lying rest (reviewed in Schiffmann *et al*. 2018a).

Under the assumption that this behavioural alteration will prevent them from having satisfying sleep, it is evident that every effort should be taken in order to facilitate elephants in human care to have lying rest and thus ensure their welfare (Schiffmann *et al*. 2018a; Williams *et al*. 2018).

Here, we report how this challenging task was solved successfully in a geriatric female Asian elephant suffering from severe physical ailments.

The individual elephant and her history

The female Asian elephant "Laksmi" was wild-born around 1969 in Myanmar. After importation to England in 1973, she lived a life on the road in circuses until October 2018. At that time, she was moved to a private elephant-keeping facility to join a female housed alone. The main reason for transferring Laksmi was a number of serious physical ailments (Tab. 1), which made it impossible to perform in the circus any longer and made travelling increasingly challenging.

After the transfer, she settled in very well at the new facility and gradually bonded with the resident younger female. This development was continuously facilitated and closely monitored by a dedicated keeper team. With respect to the multiple health issues, Laksmi underwent

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Table 1. Chronic health issues of the female Asian elephant Laksmi (compiled from examination reports on 11.06.2016 and 27.04.2019).

Ailment	First occurrence/ diagnosis	Prognosis	Consequence
Lens was removed in left eye due to cataract. Subsequent infection of both eyes and a lens prolapse in the right eye	Operation 19.10.2007 in Lyon	Incurable	Blindness
Stiffness of right front leg with muscular atrophy due to fused elbow joint (likely first dislocated and subsequently fused) with rotational deformity	Around 1980	Incurable	Significant lameness due to reduced range of motion, swaying leg forward without bending of any joint
Recto-vestibular fistula	Around 1990	Incurable	Feces enter the vestibulum continuously and lead to bacterial contamination with subsequent chronic cystitis, vaginitis and endometritis/ pyometra
Rectal paralysis	Around 1990	Incurable	Active defecation is impossible; manual rectal evacuation by handler required every 8 h
Uterine pathologies (polyps, leiomyoma, suspicion of pyometra)	11.06.2016 and 27.04.2019	Symptomatic treatment with antibiotics	May cause recurrent hematuria and carries a constant risk of septicemia

monthly veterinary checks and was under continuous treatment with an analgesic – 2 g Phenylbutazone (Equipalazone®, Dechra Pharmaceuticals), administered orally once a day, and a variety of supporting herbal drugs.

Observations of Laksmi's resting behaviour

Our study covers observational data on Laksmi's lying rest from 1.09.2019 until 7.06.2021. Bouts of lying down were observed directly or by camera observation and recorded accurately to a resolution of 5 minutes in the 'keeper diary'. In order to compare Laksmi's lying data, we calculated descriptive statistics, categorizing them into phase 1 (1.09.2019 – 28.02.2020) covering the baseline before the period of reluctance to have any lying rest at all, and phase 2 (16.08.2020 – 7.06.2021) covering the time after resumption of lying rest in the mid of August 2020 (Table 2).

Table 2. Side specific lying rest data of Laksmi.

	Phase 1	Phase 2
N lying bouts	174	557
N lying bouts on the left side	174	342
N lying bouts on the right side	0	215
% of lying bouts on the left side	100	61.4
% of lying bouts on the right side	0	38.6
Mean duration of lying bouts on the left side [hours ± SD]	2.17 ± 0.04	1.17 ± 0.03
Mean duration of lying bouts on the right side [hours ± SD]	0	0.75 ± 0.02
N days	181	296
N days without lying rest	42	32
% of days without lying rest	23.2	10.8

Since arrival at the new facility, Laksmi showed lateral lying rest exclusively on the left side. This is likely due to the stiffness in the right front leg. On average, she spent around 1.6 h a day resting in a recumbent position. At the end of February 2020, she suddenly stopped lying down at all. Although the keeper team did a continuous and accurate monitoring of the elephant's resting behaviour, they were not able to determine any reason for the abrupt reluctance of having lying rest.

Assuming a painful condition as the underlying cause, the dose of Phenylbutazone was increased to 5 g per day. This did not show any effect, and Phenylbutazone was discontinued at the end of May 2020. Until the end of July, Laksmi had lying rest only on one single day (two lying bouts of 5 and 35 minutes duration) on her left side. Data on the amount of her leaning rest were not available. Therefore, it is not possible to investigate whether Laksmi tried to compensate for her lack of lying rest by increasing leaning rest.

On the 1st of August 2020, the keeper team created a steep sand bank with a slope of around 45° in the elephant barn against the wall. The following night, the elephant made use of this slope to have 15 min of lying rest on her right side. Two weeks later she spontaneously lay down on a steep loamy bank (at a slope of approximately 55°) during a walk in the forest and rested there in a leaning-lying position for 30 min on the right side (Fig. 1A). During the following weeks, the caregivers walked with Laksmi to the bank in the forest on a daily basis, which allowed her to have lying rest there (Fig. 1).

At the same time, they reconstructed a sand bank in the elephant house with a slope similar to the steep bank in the forest. The steepness of this slope reached only around 45° due to the structure of the sand (Fig. 2). It took another six weeks for Laksmi to adapt to this new feature when having lying rest on the sand slope became a regular observation. From the beginning, Laksmi showed lying rest on the sand



Figure 1. Laksmi having right lateral lying rest on the steep bank in the forest (A) from where she is able to get up easily (B). In the same location the elephant laid down on the left body side (C and D). Note how interaction takes place with the malleable substrate and in doing so, the female shaped the ground to the needs for comfortable lying rest (C). Also note the ditch at the bottom of the slope allowing Laksmi to have all legs fully stretched and holding the body position perfectly (A–C).



Figure 2. Laksmi having right lateral lying rest on the sand pile built in the indoor enclosure to mimic the steep bank in the forest.

slope with both sides of the body, with a slight preference for the left lateral position. Her mean daily duration of lying rest increased to nearly 2 h between mid of August 2020 and June 2021 (Fig. 3). Interestingly, once Laksmi began laying down on the sand bank, the number of daily resting bouts was far above her baseline, with a simultaneous decrease in the mean duration of lying bouts (Fig. 4 and Table 2).

Outcome and conclusions

From what we know in healthy elephants, absence of side preference for lying rest is considered the normal situation. Several reports have shown individuals to have a strong side preference either in correlation with physical ailments or unilateral discomfort (e.g. due to asymmetric tusks) (Schiffmann *et al*. 2018a, 2019). Although extended duration of lying bouts in zoo elephants compared to free-ranging individuals might be interpreted as an indicator of increased welfare (in particular, safety from predation), they may also be caused by physical handicaps in certain individuals (Schiffmann *et al*. 2018b). Therefore, we consider the obvious change in Laksmi's resting behaviour with a shift to the bilateral lying pattern and shorter, but more frequent lying bouts (Fig. 5) as a significant indicator of improved welfare. This is corroborated by the finding of fewer days without any lying rest since mid August 2020 (Fig. 3 and Table 2). With respect to her chronic and severe health issues, such a development in the direction towards a normal resting behaviour with a nearly balanced laterality cannot be expected at all.

We can only speculate what caused Laksmi's temporary reluctance of lying rest. The confirmed pathologies in her uterus might have led to discomfort when lying on her lateral body

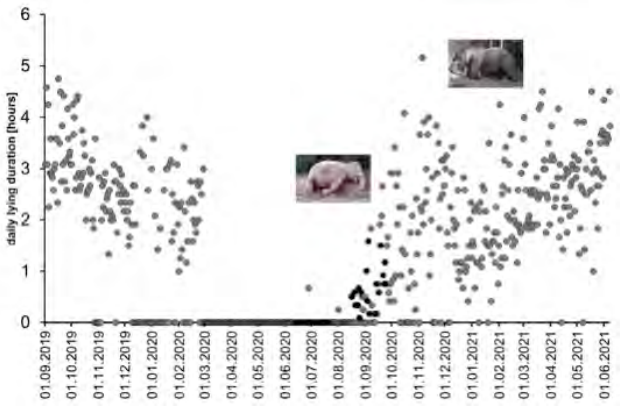


Figure 3. Total daily lying duration from 1.09.2019 until 7.06.2021. Black dots indicate days on which Laksmi had at least one lying bout on the bank in the forest.

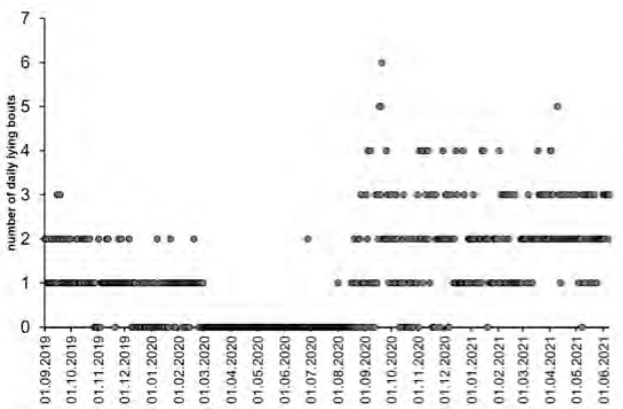


Figure 4. Number of daily lying bouts over the study period. Note the increased number of lying bouts after Laksmi's resumption of lying rest in August 2020.

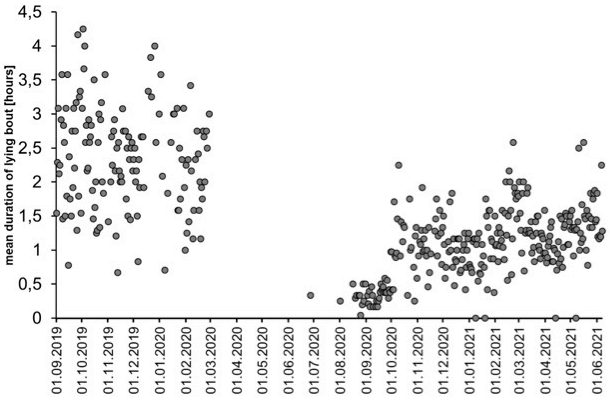


Figure 5. Mean duration of lying bouts over the study period. Note the different pattern before and after the period of cessation of lying rest. Whereas the duration of lying bouts did not decrease before the cessation of lying down, there was an apparent increase in bout length after resumption.

wall through pressure or tension on these organs. But also a musculoskeletal disorder in her left back leg (although not diagnosed) might have led to the reluctance of lying on the left side. Keeping in mind that she had been lying down exclusively in the left lateral position, this is a likely explanation for the sudden stop. Subsequently, it might have taken time to become used to lying down in the right lateral position, as she would have had to learn how to work around the stiffness of her front right elbow joint.

The keepers introduced physiotherapy as recommended by the consultant vet. These included having a ditch and logs in the middle of the barn as an obstacle that Laksmi would have to stretch to climb over and as such regularly extending and stretching muscles and joints that she may otherwise be reluctant to use. The keepers also introduced exercises for Laksmi to lift each leg both forwards and backwards in her daily training. These exercises would have helped Laksmi gain extra flexibility needed to be able to lie down again. We are not aware of any other elephant, which is capable of lying down on the side of a leg with a stiff elbow joint. Such an issue might result in a tedious process in an elephant when lying down (Schiffmann *et al*. 2018a).

Laksmi's daily duration of lying down decreased from an average of 4 h, to 2 h before it ceased completely (Fig. 3). After resuming lying rest, the absolute amount of lying rest showed an increasing trend (Fig. 3). The breakthrough in this process seemed to be the steep loamy bank in the forest, which allowed her to find a comfortable position and facilitated the movement of getting back up again (Fig. 1B).

In this specific case, the positive development was made possible through the dedicated work of Laksmi's caregivers and the opportunity to provide her with a forest environment containing a variety of opportunities. This situation might be unique and of course only feasible in a free contact management system. Nevertheless, this case is highly instructive for any management system, emphasizing the importance of providing an elephant reluctant to lay down, with many different structures in the environment to facilitate resumption of lying rest.

Finding a substrate that allows the construction of slopes steeper than 45° would be progressive in the care of geriatric and/or physically handicapped elephants. The loamy bank had a small ditch at the bottom that provided a sure foothold so the elephant was confident that she would not slide down (Fig. 1 A–C).

This report emphasizes the importance of close monitoring of the resting behaviour in elephants under our care. In doing so, we may continuously extend our understanding of elephant resting behaviour and subsequently fulfil their requirements for lying rest. The documentation and sharing of such cases will effectively contribute to this process.

Acknowledgements

In the treatment and care of Laksmi, a dedicated team of vets and therapists supported the keepers in facilitating her to resume lying rest. Instrumental in making it a success were namely Lowri Davies and Kate Mayne. We thank Prof. Marcus Clauss for his valuable comments on a previous version of the manuscript.

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Elephant and Human Mortality in the Bannerghatta-Hosur Landscape, Southern India

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Introduction

India is home to more than 50% of the world's Asian elephants with around 28,000 individuals (MoEF 2017), of which approximately 10,000 occur in the southern states (Project Elephant 2008). Historically, elephants inhabited a large part of southern India (Baskaran 2013). The Nilgiris-Eastern Ghats landscape holds the largest contiguous population of the species (Sivaganesan *et al*. 2005).

The stretch from Bannerghatta National Park in South Karnataka to the North Cauvery Wildlife Sanctuary and the Hosur scrublands (both located in northern Tamil Nadu) are critical for elephant movement within the Eastern Ghats, and are known collectively as the Bannerghatta-Hosur Landscape. The Bannerghatta-Hosur Landscape also includes certain areas that receive an efflux of elephants from the Bannerghatta National Park and the North Cauvery Wildlife Sanctuary such as Tumakuru in Karnataka and Koundinya Wildlife Sanctuary in Andhra Pradesh.

Elephants in the region exhibit seasonal migration, through corridors that connect Bannerghatta National Park and North Cauvery Wildlife Sanctuary (Ramkumar *et al*. 2017). Urbanisation and habitat loss have forced them to travel through human settlements and agriculture (Sukumar 1989).

Around 300 elephants are thought to pass through the Bannerghatta-Hosur Landscape every year (AERCC 1998). Small groups of elephants from the Bannerghatta National Park move through human-dominated landscapes into the northern ranges of the Tumakuru District in the dry season (Sridevi & Reddy 2018), and east into the Hosur forests in Tamil Nadu before reaching Andhra Pradesh through the Koundinya Wildlife Sanctuary (Manakadan *et al*. 2009). However, due to habitat loss, anomalous movement is becoming more frequent, leading to the establishment of populations in areas outside historical elephant ranges (this includes Koundinya Wildlife Sanctuary). These movements have resulted in an increase in human-elephant conflict (HEC).

HEC has become a major issue throughout India in recent times (Lenin & Sukumar 2011). At least 200 people and 100 elephants die every year from HEC (MoEF 2010). In addition, almost 500,000 households are affected by crop depredation (Sukumar 2006). Despite the increasing conflict, farmers may have a positive attitude towards elephants, which could change unless the conflict is mitigated (Stone *et al*. 2019).

Methods

The Bannerghatta-Hosur Landscape is comprised of the Bannerghatta National Park, which is 260 km^2 in extent, and lies between 12º34' – 12º50' N, and 77º31' – 77º38' E, and the North Cauvery Wildlife Sanctuary, which is 504 km^2 in extent and is situated between 12°07' – 12°44' N and 77°30' - 78°27' E.

The Bannerghatta-Hosur Landscape is estimated to hold close to 650 elephants, with Bannerghatta National Park harbouring up to 164 elephants, and the North Cauvery Wildlife Sanctuary-Hosur region holding around 500 individuals (MoEF 2017).

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The Bannerghatta-Hosur Landscape is bordered by the Cauvery Wildlife Sanctuary to the south-west, which forms a critical corridor for elephant movement into and out of the Eastern Ghats (Ravindranath *et al*. 2011).

The vegetation in the study area is dominantly dry deciduous forests and scrub forests. The area is characterised by a dry season from March to May followed by a rainy season from June to November, with rainfall in the early months owing to the south-west monsoon, and later from the north-east monsoon. Most areas outside the protected areas are heavily cultivated.

Records of human and elephant casualties due to conflict from 1980–2020 were obtained from Forest Department records, newspapers, and scientific publications.

Results and discussion

Seasonal variation of casualties

There were 153 human and 69 elephant deaths recorded over the study period (Fig. 1). Human deaths were high in September, December and January and elephant deaths in September and December.

The elephant population in Bannerghatta-Hosur Landscape increases due to movement of elephants into the area in September – November, when major crops are harvested (Thirunavukarasu 2014). Concurrently human-elephant conflict increases, as elephants raid the mature crops and most human and elephant casualties occurred during the period of high crop-raiding. Elephants raid more when crops are mature leading to more conflict (Naha *et al*. 2020), which is consistent with our finding of increased HEC incidents in September. However, October and November did not show an increase in casualties and the increase in December and January were after the harvesting season.

Causes of elephant and human mortality

Human deaths happened when farmers attempted to protect crops from elephants, and from

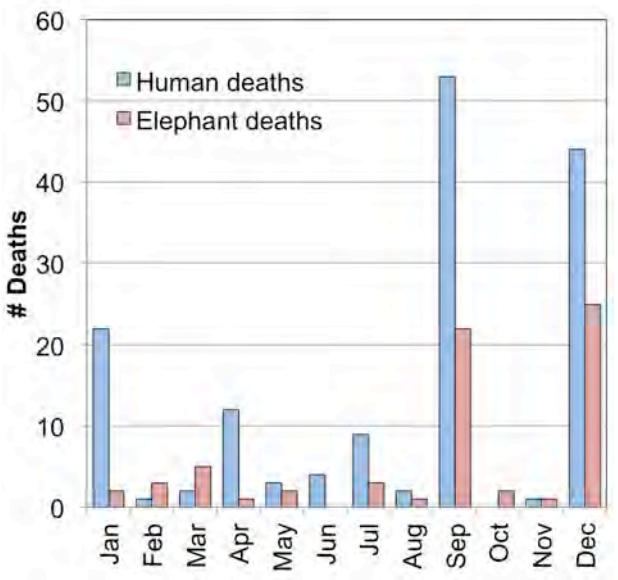


Figure 1. Human and elephant casualties by month.

accidental encounters while collecting firewood and around forest edges after dark.

Of the 69 recorded elephant deaths, electrocution (Fig. 2) caused the highest mortality accounting for 81.15% of deaths, followed by poaching/gunshot wounds (10.1%), and railway accidents (8.7%). Electrocutions were mostly caused by illegal electric fences placed around farmlands, or low-slung electrical wires from pylons.

Temporal variation of casualties

Almost all (89.7%) elephant deaths occurred between 20:00 to 00:00 hrs. Elephants in an anthropogenic environment tend to become more nocturnal to avoid humans and raid farms under the cover of darkness (Loarie *et al*. 2009). To protect crops, farmers may erect lethal electrical barriers, causing elephant deaths during the night. Some casualties (8.8%) also occurred



Figure 2. An adult makhna succumbed to electrocution death in a park-edge village.

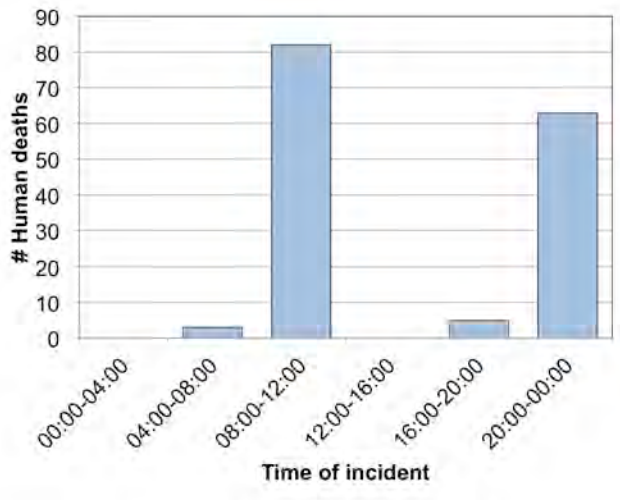


Figure 3. Human casualties by time of incident.

between 12:00 to 16:00 hrs due to shooting, by poachers or farm owners trying to protect crops.

Most human casualties occurred between 08:00 to 12:00 hrs, and from 20:00 to 00:00 hrs (Fig. 3). Many casualties occurring early in the day were due to encountering elephants accidentally while collecting firewood (10.5% of deaths) and open defecation (7.8% of deaths). Most villagers in Karnataka still practice open-defecation, as many households in South Karnataka do not have access to toilets. As this practice is usually conducted in the early hours of the morning and close to forest patches, the possibility of encountering elephants is particularly high. Farmers guarding crops accounted for many of the deaths at night. The majority of landowners in the study region guard their crops after nightfall, to drive away elephants, leading to confrontations and human mortality.

Spatial variation of casualties

The majority of human casualties were concentrated towards the Bannerghatta National Park side of the Bannerghatta-Hosur Landscape (Fig. 4), whereas the majority of elephant casualties occurred in the eastern regions of the North Cauvery Wildlife Sanctuary. Koundinya Wildlife Sanctuary recorded mainly elephant casualties towards the periphery of the park, while the Tumakuru District recorded exclusively human casualties due to conflict.

Acknowledgements

The authors dedicate this publication to the legendary elephant scientist, Ajay Desai (1957–2020), who was an untiring campaigner for

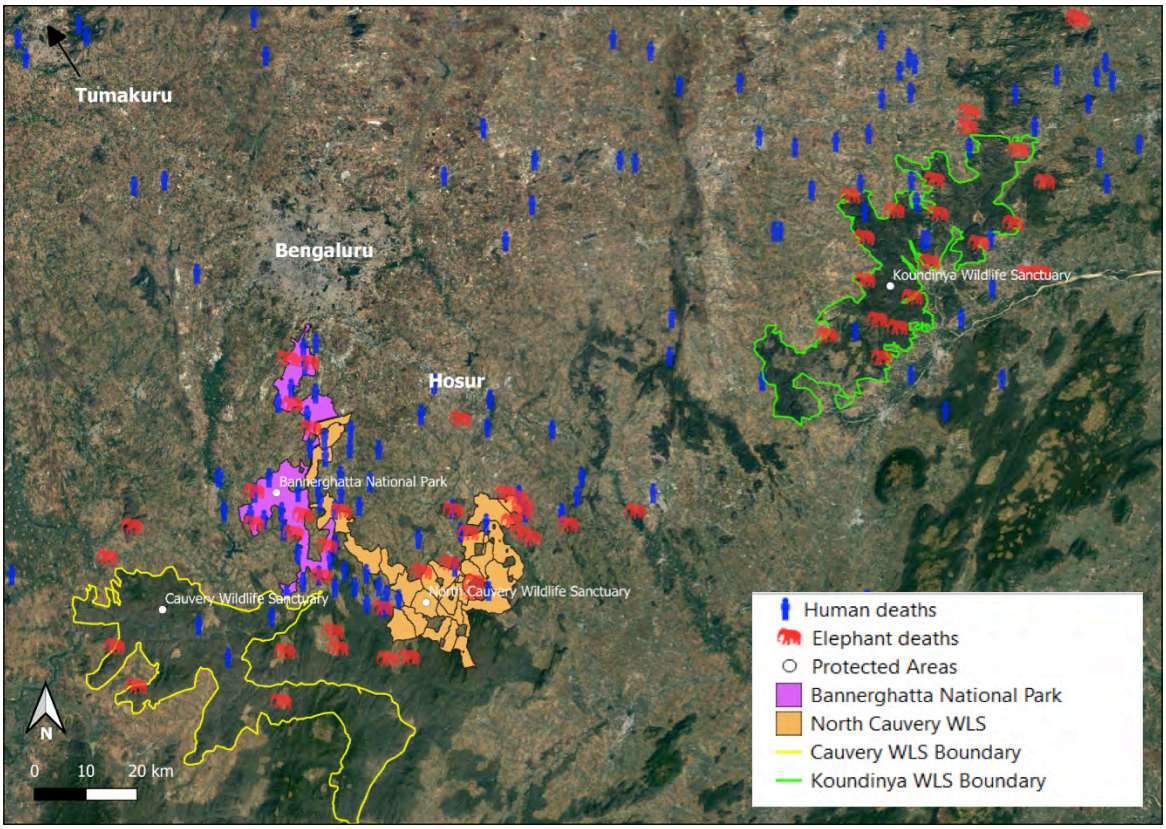


Figure 4. Map of human and elephant casualties within the study area.

Asian elephant conservation. We miss him dearly. We are indebted to the support rendered by A Rocha India and the Forest Departments of Bannerghatta and Hosur Divisions. We thank the anonymous reviewer for the valuable inputs in refining this manuscript.

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Human-Elephant Conflict in Joypur Forest Influence Areas, West Bengal, India

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Introduction

Human-elephant conflict (HEC) has multidimensional causes in different spatial domains with increasing anthropogenic pressure on ecosystems being one of the most crucial factors. Movement of elephants is connected with contact between elephants and people, therefore with HEC. Species such as elephants have large home ranges and use different habitats to fulfil their biological requirements (Meyer *et al*. 2019). Elephants consume 10% of their body weight and drink 250 l of water per day (Sukumar 2003). Asian elephants (*Elephas maximus*) may move to human dominated areas to meet their basic needs. Such movement may occur due to unavailability of resources in their natural habitat (Sitompul *et al*. 2013; Guha 2017) or their greater availability and accessibility in human areas (Chatterjee 2016).

The Joypur forest is a protected area in Bankura District, West Bengal. It and surrounding area is part of the extended range of elephant herds from Dalma (Mandal & Chatterjee in press). Elephants frequent this area throughout the year. From about two decades ago some bulls have been resident in the area (Kulandaivel 2010). HEC has increased in recent years in the area around Joypur forest.

We collected information on patterns of HEC in the area around Joypur forest and analysed geospatial attributes to identify possible reasons.

Methodology

The study area

The Joypur forestis situated between 87°18'54.46" E to 87°29'46.94" E and 22° 55'49.12" N to 23°24'7.10" N. It covers three forest ranges; Joypur, Bishnupur and Bankadaha under the Panchet Forest Division. The vegetation is mostly dry deciduous, dominated by Sal (*Shorea robusta*). We defined the Joypur forest influence area as the area outside the forest boundary within a circle of 11 km radius, centred on the Joypur forest (Fig. 1). Paddy is cultivated in the Joypur forest influence area from July to August with rainwater and in the dry season (pre winter to post summer) vegetables are cultivated with irrigation water. Most villages are located at the forest fringe.

Information collection

Information on HEC incidents was obtained from the Forest Department and from victims' family members and neighbours. A total of 93 households were chosen for gathering information related to HEC. The oldest person or a person who experienced HEC was chosen for interview from each household.

Geo-spatial analysis

Moderate and large sized water bodies were identified and demarcated from Google images. The distance from the centre of the forest to each water source was measured. Agricultural encroachment into the forest was assessed using LISS –III, P6 satellite images of 1980 and Landsat 8 (OLI/TIRS) images of 2018. Measurements were done using ArcGIS 10.3v software.

Results and discussion

HEC in study area

According to the Bankura Forest Division report, 17 people were killed by elephants from 2010 to 2018 in the Panchet Forest Division. Of these, 14 were in the Joypur, Bankadaha, and

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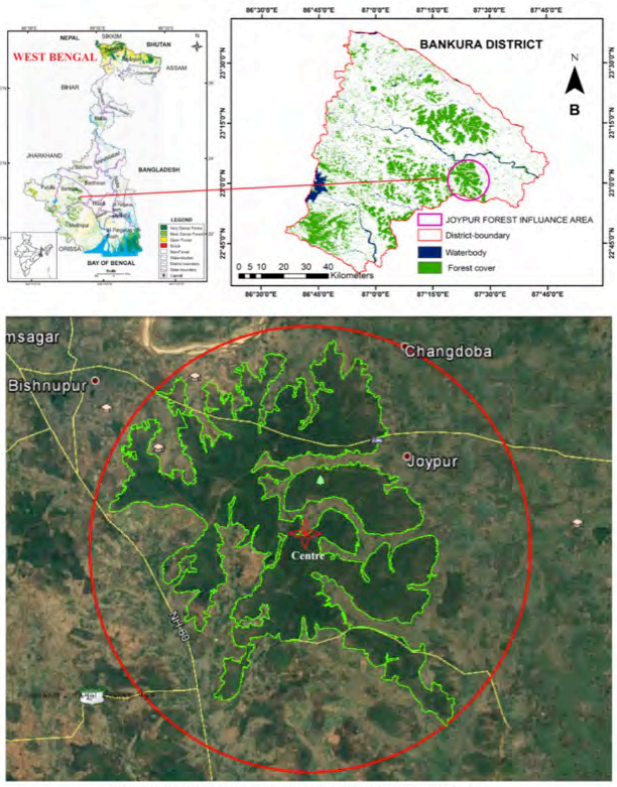


Figure 1. Location map of the study area.

Bishnupur forest ranges. Allhuman deaths were allegedly due to resident bull elephants and not by herds, as reported by District Forest Officer Panchet Forest Division. Most human deaths happened during the early morning or afternoon with 10 deaths occurring outside the forest and 7 inside.

Some residents said that deaths occurred in the early morning and afternoon, as resident elephants regularly come from inside the forest to fringe areas for drinking water and consuming agricultural crops at those times. According to the District Forest Officer, conflict probability was high in the morning and afternoon because villagers go to the forest for toilet and collecting forest produce in the morning, and in the afternoon they are working in paddy fields adjacent to the forest when elephants come to these areas for drinking and raiding crops.

Water availability

The number of water sources increased with distance from the forest centre (Fig. 2B). Most perennial water sources were outside the forest and 6 were within 1–2 km from the centre and 42 between 7–8 km. There were 12 water sources inside the forest, which dried up during the dry season from January to May.

Of the 17 human deaths recorded, 15 occurred between December and April. In this period the weather becomes very dry and only some of the

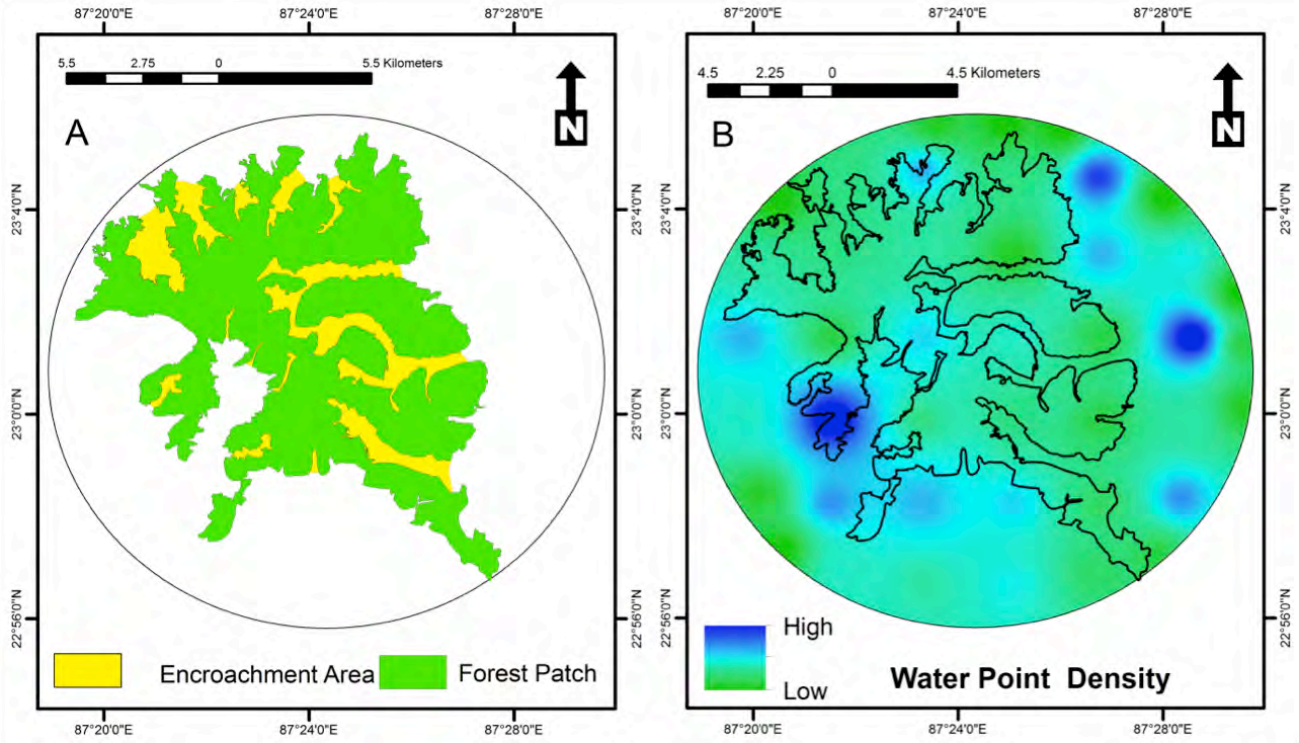


Figure 2. Forest encroachment (A) and water point density (B) maps of the Joypur forest and influence area.

water sources outside the forest and near the forest fringe villages held water. Therefore, it is possible that during the dry season elephants did not have access to water inside the forest and were compelled to venture out, leading to HEC incidents.

Forest encroachment due to agricultural expansion is another common factor that creates HEC. We found that there was extensive encroachment into the forest in the study area (Fig. 2A). As vegetables are cultivated in the encroached lands after the monsoon, the presence of villagers in the forest was high at that time.

Food availability

Food sources near the forest fringe may be another cause of HEC incidents. During the wet season elephant movement towards the fringe area was infrequent as the forest was productive and food was plentiful. In the dry season, food availability in the forest was less and elephants move to the fringe area for food (Mandal & Chatterjee 2019). Especially as vegetable and paddy were cultivated during the dry season, HEC incidents may be more frequent.

We conclude that lack of perennial water sources inside the forest and their presence in the forest fringe areas, and encroachment maybe the main contributory factors for HEC in the study area. Landuse management, preventing encroachment, allowing forest regeneration in encroached areas and perennial water source development inside the forest may limit elephant movement towards forest fringe areas, therefore help in mitigating HEC in the study area.

Acknowledgements

We thank the villagers for sharing information. Special thanks to the District Forest Officer of the Panchet and Bankura Forest Divisions for providing information.

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The Tal-Kholgarh Elephant Corridor in Odisha, India

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Introduction

The Asian elephant (*Elephas maximus*) is a high profile and charismatic species with important ecological as well as cultural associations in India. But it is also one of the most conflict-prone wildlife species in India, causing large-scale damage to crops, houses and human lives. Due to loss of habitat, elephants may extend their range and raid crops to meet their energy requirements. During such forays, elephants may intrude into agricultural lands and human settlements. Confrontation is inevitable under such circumstances, resulting in elephant and human deaths and property damage. Each year about 400 people and 100 elephants lose their lives and nearly 500,000 families suffer crop damage in India (Sugumar & Jayaparvathy 2013).

Human-elephant conflict (HEC) refers to negative interactions between elephants and people. Conflicts occur when human populations encroach upon elephant range, reducing access to resources required by elephants. HEC is becoming more frequent due to increase of human populations and has become one of the most challenging problems in wildlife management (Mohanty & Mishra 2017). Many solutions to HEC have been tried such as electric fences, trenches, bees, thorn plants, and chilli pepper. However, such deterrents are not always effective and often require intensive maintenance to ensure their efficacy.

Role of wildlife corridors in conservation

Fragmented wildlife populations are more vulnerable to extinction owing to environmental, demographic and genetic variability (Sukumar 1989). Landscape connectivity enhances the populations of many species (Gilpin & Soule 1986). Corridors facilitate connectivity across habitats and increase diversity by improving the survival of species (Varma *et al*. 2008). Corridors may be created for a specific species (Harrison 1992) or to create habitat connectivity in general. Re-connecting habitat-fragments with corridors can decrease population fluctuations and corridors can establish and stabilize populations, improving ecological function and biological diversity. But corridors can also have negative effects due to increase of mortality and disease spread (Henein & Merriam 1990).

The main goal of elephant corridors is to prevent the decline of elephant populations. Elephants have large home ranges of up to a few hundred km^2 and are mega herbivores. Providing more space and natural resources for elephants may minimize their venturing into human settlements and crop fields and can reduce HEC. Therefore, corridors may also help manage HEC (Wollman 2012; Roy & Sukumar 2015). Planting preferred fodder species in and close to the entrance of corridors, may increase the chance of elephants using them. Artificial water holes can be created to ensure that elephants remain within an area and corridors that provide access to perennial water sources, may be used more by elephants.

The Wildlife Trust of India, other NGOs and the Government Project Elephant have identified 101 elephant corridors across the country. Of these, 28 are located in south India, 25 in central India, 23 in north-eastern India, 14 in northern West Bengal and 11 in north-western India (WTI 2021).

Tal-Kholgarh elephant corridor

In Odisha, elephants used to be able to move easily along traditional routes. However, at

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present, many of them are blocked due to development and elephants are forced to use new movement pathways. The Tal-Kholgarh corridor was identified by the Government of India in 2010. It is in two sections with a total length of 6.3 km and 0.5 to 0.8 km in width (Fig. 1). It links four fragmented forest patches; Raun Reserve Forest, San Rengali Protected Forest, Tal Reserve Forest and Kholgarh Reserve Forest. It is located within the Rairakhol Forest Division, which is one of six divisions of the Sambalpur Circle, Odisha.

The habitat within the corridor consists of 33.13% shrub, 18.75% grass, 8.75% herbs and 39.37% barren land. The corridor has two mineral licks and three water holes. Elephants are seen throughout the year in the Rairakhol Division. Two watchtowers and one protection camp are present for elephant monitoring. The elephant population in Rairakhol Division decreased from 165 in 2002 to 16 in 2017 (Fig. 2). Of 7 elephants that died from 2010–2017, one was killed by poachers, five were natural deaths and one was due to unknown cause. Damages

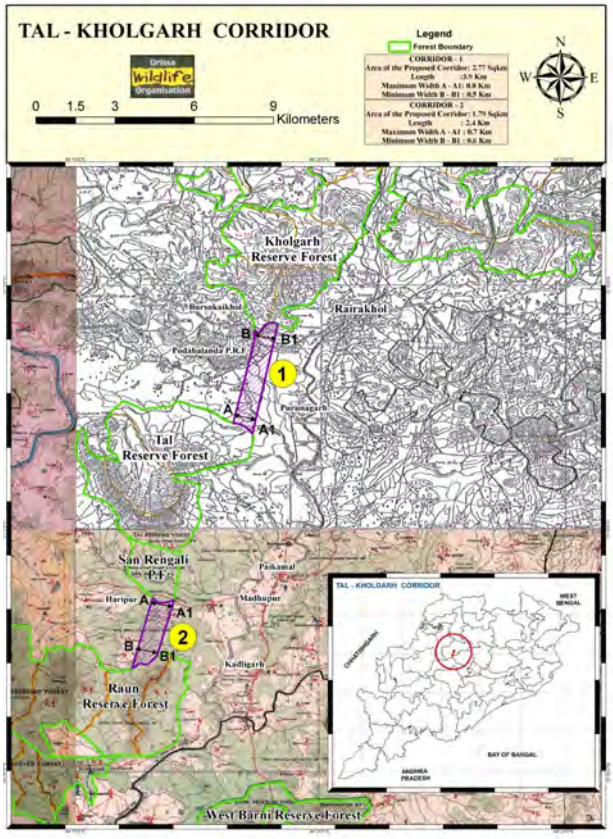


Figure 1. Locations of the two sections of the Tal-Kholgarh elephant corridor (numbered 1 & 2) in the Rairakhol Forest Division. Inset: Map of Odisha.

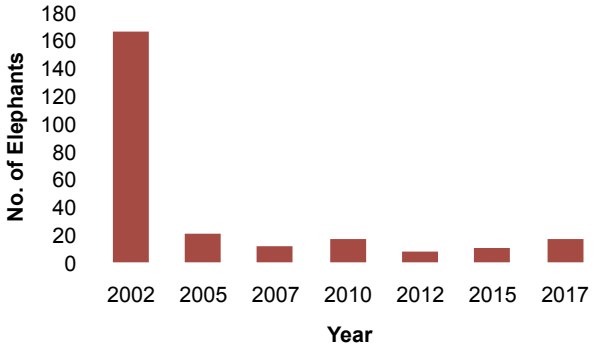


Figure 2. Elephant population in Rairakhol Forest Division from 2002 to 2017 (Source: Census Report of Forest and Environment Department, Govt. of Odisha).

including crop raiding, caused by elephants in the Rairakhol Forest Division have been increasing (Table 1, Fig. 3).

Although the Tal-Kholgarh elephant corridor was declared in 2010, elephant deaths and HEC incidents have continued. Currently around 22 elephants are thought to use the corridor. The corridor contains some good habitat, salt licks and water sources. However, a railway line crosses the corridor and other developmental activities also occur within it. There is also a significant amount of barren land within the corridor. The increasing HEC incidents and crop damages reported during the study period may reflect increasing trends of corridor fragmentation and disturbance. Studying the movement patterns of the elephants in relation to the corridor and providing more resources for elephants within the corridor would be desirable in its management.

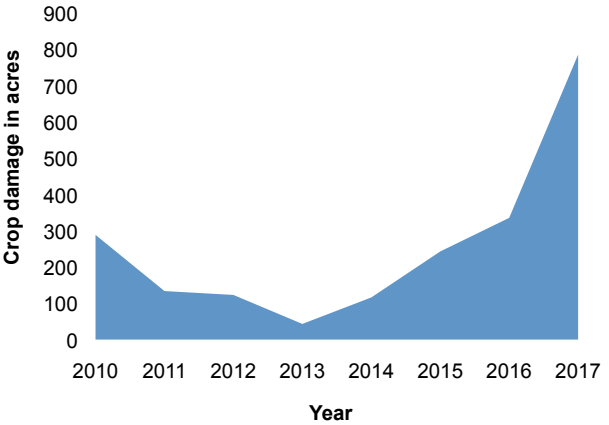


Figure 3. Crop damages due to elephants in Rairakhol Forest Division from 2010 to 2017.

Table 1. HEC incidents in Rairakhol Forest Division from 2010–2017.

	2010	2011	2012	2013	2014	2015	2016	2017
House damage	49	4	1	1	3	3	1	28
Human injury	0	0	0	0	4	1	0	0
Human death	1	1	0	1	3	3	1	2
Elephant death	1	0	2	2	0	0	1	1

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Toxocara elephantis Infection in a Juvenile Asian Elephant and Its Management

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Introduction

Parasites can adversely affect host health, productivity and foraging, and may also modify host behaviour to facilitate parasite transmission (Moore 1984). Parasitism has been shown to directly affect both the evolution and ecology of hosts through processes such as sexual selection (Hamilton & Zuk 1982) or parasite-mediated competition, which can lead to a reduction in population size, or the extinction of one host (Price *et al*. 1986). Parasitic infections can cause diseases and death in wild animals and can become a source of infection for domestic animals and vice-versa.

Globally, the Asian elephant (*Elephas maximus*) is listed as 'Endangered' in the IUCN Red List of Threatened Species (IUCN 2021) and is protected under CITES. Anthropogenic influence on habitats may result in increased parasite prevalence in elephants (Hing *et al*. 2013). Elephants in the wild are susceptible to many gastrointestinal parasites (Watve 1995; Dharmarajan 1999; Vidya & Sukumar 2002). The occurrence of gastrointestinal parasites is higher in wild elephants as compared to captive and semi-captive elephants (Abeysekara *et al*. 2018). Gastrointestinal nematode infections can result in diarrhoea and disruption of gastrointestinal motility (Bueno *et al*. 1982).

Toxocara sp. commonly known as roundworms, infect many species of animals. *Toxocara* infection is mostly seen in young animals, which get infected through faeco-oral or galactogenic transmission and the larvae develop into adults in the intestine, which produce eggs by three weeks (Sarma *et al*. 2012). Infection may cause diarrhoea, poor performance, intestinal and biliary obstruction, and sometimes death (Srivastava 1963). Previously *Toxocara elephantis* infection has been reported in an Asian elephant from a zoo in Switzerland (Fowler & Mikota 2008). This paper describes *T. elephantis* infection in a wild juvenile Asian elephant and its management.

Case study

A 5-year-old female Asian elephant at the Centre for Wildlife Rehabilitation and Conservation (CWRC), Borjuri, Panbari Reserve Forest near to Kaziranga National Park, Assam was showing mild diarrhoea, loss of appetite, weight loss and lethargy (Fig. 1). The animal was rescued during a flood and was at the rehabilitation centre for one week. Clinical examination revealed normal body temperature (36.4°C), congested conjunctival mucous mem-



Figure 1. Juvenile affected with diarrhoea.

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branes, increased pulse rate (38 bpm) and eupnoea (14 breaths/min). Dehydration was diagnosed based on weight loss, decreased water intake, diarrhoea and dryness of the tip of the trunk and skin. A diarrhoeic sample was collected in a sterile container for the detection of parasites/parasitic eggs/protozoans. A blood sample (approximately 5.0 ml) was collected by venipuncture of the auricular vein into vials with and without dipotassium ethylenediaminetetraacetic acid (K2-EDTA). The blood with anticoagulant was used for haematology and the blood without anticoagulant was allowed to clot and centrifuged at 2000 rpm for 10 min at 4ºC to separate serum. The separated serum was stored at -20°C till analysis.

The collected faecal sample was processed with a standard protocol (Heinrich 2016) and examined under the microscope for identification of parasites/parasitic eggs/protozoans (Soulsby 1982).

Haematological analysis was conducted with an automated blood analyzer (Autoread, IDEXX, USA). Biochemical analysis was carried out with an automated biochemical analyzer (Catalyst one chemistry analyzer, IDEXX, USA) using commercially available test kits following the manufacturer's instructions. Zinc concentration in the serum was estimated by atomic absorption spectrophotometer (AA 7000, Shimadzu, USA). Oxidant-antioxidant status in the serum was evaluated by measuring lipid hydroperoxide (LPO), superoxide dismutase (SOD) and total antioxidant capacity (TAC), with the help of commercially available test kits as per manufacturer's instructions (Cayman Chemical, USA).

Results and Discussion

Macroscopic faecal examination revealed the presence of adult ascarid worms in the stool (Fig. 2). Microscopic examination of the faecal sample showed the presence of *T. elephantis* ova, which were round-shaped with a thick outer shell (Fig. 3). Based on clinical and laboratory findings, the case was diagnosed as a *Toxocara elephantis* infection.



Figure 2. The presence of adult ascarid worms in the stool.

The haematological analysis revealed a slight elevation in haemoglobin (Hb), total erythrocyte count (TEC) and packed cell volume (PCV) levels (Table 1), which could be attributable to dehydration causing haemoconcentration. Total leukocyte count (TLC) was within the normal range, and eosinophilia was the major finding in the differential leukocyte count (DLC) (Table 1). Eosinophilia is generally caused when parasites migrate through tissues, therefore it is prominent only in early infection of ascariasis (Leder & Weller 2000). In serum biochemistry, there was an increase in total pro-

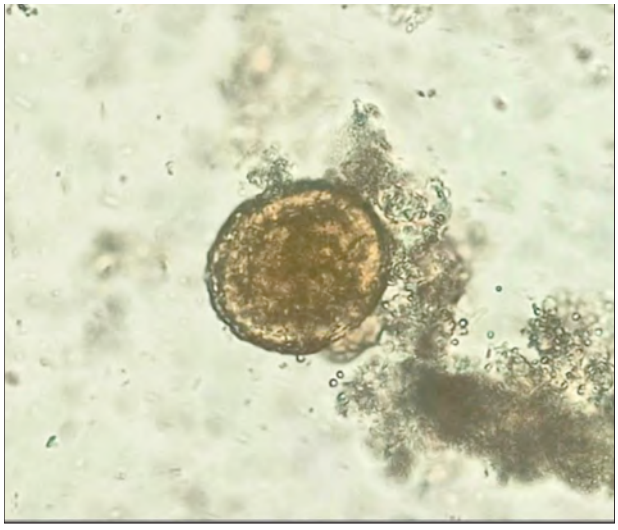


Figure 3. Microscopic examination of the faecal sample showing the presence of *T. elephantis* ova (X40).

Table 1. Haemato-biochemical and oxidative stress indices of *T. elephantis* infected elephant calf.

Parameters	Before treatment (Day 0)	After treatment (Day 10)	Normal reference range (Janyamethakul *et al*. 2017)
Hb (g/dl)	17.7	12.8	10.1–15.6
PCV (%)	47.9	34.3	27.8–43.0
TEC (x10^6 cells/μl)	4.93	3.02	1.9–3.1
TLC (x10^3 cells/μl)	18.15	15.40	7.20–23.22
DLC (x10^3 cells/μl)			
Neutrophils	10.83	9.25	0.83–13.51
Lymphocytes	4.90	4.64	1.06–12.03
Monocytes	1.11	1.25	0–3.29
Eosinophils	1.32	0.27	0–1.17
Basophils	0.00	0.00	0–0.036
Platelets (x10^5 cells/μl)	1.28	1.67	1.05–5.98
AST (U/l)	58.19	31.45	10.1–39.6
Creatinine (mg/dl)	1.97	1.02	0.9–1.8
BUN (mg/dl)	23.4	17.20	4.2–19.7
Total protein (g/dl)	9.79	8.32	6.6–9.3
Sodium (mmol/l)	153.0	123.0	105.0–131.0*
Potassium (mmol/l)	8.5	5.1	3.8–5.2*
Chloride (mmol/l)	121.0	97.0	91.0–102.0*
Zinc (ppm)	7.5	12.90	12.5–15.78*
LPO (μM)	7.05	4.67	4.16–4.64*
SOD (U/ml)	0.83	2.13	2.26–2.9*
TAC (mM Trolox equivalents)	1.02	2.67	2.9–3.6*

*Unpublished data

tein, sodium, potassium, chloride, aspartate aminotransferase (AST), blood urea nitrogen (BUN) and creatinine levels (Table 1). Increase in total protein and electrolyte levels may have been due to dehydration, whereas the increase in AST may have been due to cell necrosis caused by parasitic infestation (Benjamin 2013). Reduced renal function secondary to dehydration may have resulted in elevated levels of BUN and creatinine. Oxidative stress may play an important role in parasitic diseases (Deger *et al*. 2008). In the present case, the serum level of lipid hydroperoxide (LPO) was increased whereas the levels of superoxide dismutase (SOD), total antioxidant capacity (TAC) and zinc (Zn) were decreased (Table 1), which again may be due to *T. elephantis* induced diarrhoea. Elevation of oxidative parameters, and depletion of antioxidants and micro minerals were documented in *T. vitulorum* infection in buffalo calves (Sarma *et al*. 2012). The decreased level of Zn noticed in the present case may be due to its excessive utilization to neutralize the overproduction of reactive oxygen species (ROS) (Sarma *et al*. 2012).

The animal was treated with albendazole at 10 mg/kg, orally, once daily for 3 days, Dextrose normal saline at 3 l/day, IV, once daily for 5 days, Ringer's lactate at 2 l/day, IV, once daily for 5 days, zinc glycinate (ProFoodsTM) at 20 mg/kg, orally, once daily for 7 days and probiotic [*Lactobacillus bulgaricus* (Kaypeeyes Biotech Private Limited)] at 1x10^{10} colony forming units/50 kg, orally, once daily for 7 days. On the third day of treatment, there was improvement in appetite and faecal consistency. On the seventh day, the animal voided normal faeces without adult ascarid worms. A faecal sample was examined on the tenth day and found to be



Figure 4. Clinical recovery of the animal in response to treatment.

negative for *T. elephantis* ova. After completion of treatment, there was an improvement in haemato-biochemical and oxidative stress indices (Table 1), and the animal showed an uneventful recovery (Fig. 4).

The case study presented here illustrates the effective management of *T. elephantis* infection. As young animals can get toxocariasis through faeco-oral or galactogenic transmission, deworming should be done regularly to avoid infection.

Acknowledgements

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White Blood Cell Extraction and In-Vitro Assessment of Phagocytosis Using *Escherichia coli* in Asian Elephants

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Introduction

White Blood Cells (WBC) with phagocytic capacity, namely neutrophils and monocytes are the first line of defence against many infections (Abbas *et al*. 2007). The neutrophils of Asian elephants (*Elephas maximus*) are much larger than in other animals and are known as heterophils (Silva & Kuruwita 1993). Phagocytic activity of WBCs is altered in periodontitis in humans (Asif & Kothiwale 2010), decreased in septic dogs (Webb *et al*. 2007) and less in inflamed mammary glands compared to that of peripheral circulation in cattle (Prin-Mathieu *et al*. 2002). Neutrophil function in humans is impaired in chronic obstructive pulmonary disease (Jasper *et al*. 2019). Impaired *Escherichia coli* phagocytosis by neutrophils has also been observed in neonates, but improves with age (Wenisch *et al*. 2000; Filias *et al*. 2011). Phagocytic ability and consequently innate immunity, could also be influenced by estradiole and progesterone (Bartoskova *et al*. 2014).

Neutrophils have received much attention since they are the first line of defence against infection. Assessment of phagocytosis of WBCs could be used in determining cellular immunity against infections in elephants and identifying post-musth immune compromisation (Athapattu *et al*. 2018). Therefore, extraction of neutrophils of elephants and assessment of their functional differences and morphological changes in inflammation and in relation to musth, would be useful in understanding and managing such conditions.

Previously neutrophils have been isolated from elephant blood, using hetastarch sedimentation, and percoll centrifugation and phagocytocity examined using *Escherichia coli* (Smith *et al*. 1998). Here we report the isolation of WBC from elephant blood using phosphate buffered saline and assessment of their phagocytocity using *E. coli*.

Materials and methods

Five ml of blood was collected in duplicate from each of four apparently healthy, adult male captive Asian elephants, and differential blood counts done. Centrifuging the blood and taking the buffy coat and the top 1/4th of the red cell column, has been reported to give the best yield of WBCs in elephants (Smith *et al*. 1998). We repeated Smith *et al*.'s analysis, centrifuging blood and making smears from different portions of the centrifuged blood column, which confirmed their findings. Therefore, each sample was centrifuged at 2000 g for 10 min and the buffy coat with the top 1/4th of the red cell column used for extraction.

The procedure for cell extraction used by Silva & Jain (1988) was followed with some modifications. We used 5 ml of blood and centrifuged for 10 min while Silva & Jain (1988) used 10 ml of blood and centrifuged for 15 min. Silva & Jain (1988) used 30 ml of distilled water and allowed 40 sec for red cell lysis while we used 3 ml of distilled water over 1 minute. We then restored isotonicity by adding 2 ml of 2.7% Phosphate Buffered Saline (PBS) while Silva & Jain (1988) used 35 ml. Then the tube was centrifuged for 10 min at 200 g, the supernatant discarded and the remaining cell pellet was washed 3 times by adding 4 ml of 0.8% PBS, centrifuging at 200 g for 10 min, and discarding the supernatant. The cell pellet was then re-suspended in 1ml of 1:1 mixture of 0.8% PBS and elephant

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plasma whereas Silva & Jain (1988) used PBS with 2% of bovine serum albumin. The average phagocyte percentage in extracted cell pellets was estimated using 5 aliquots from each pellet. The viability of harvested WBCs was estimated using Tryphan blue (Strober 1997) stain with 5 aliquots per sample.

A pure colony of *E. coli* from an 18 h overnight culture was dissolved in 2 ml of 0.8% PBS and a series of two fold dilutions prepared. The optical density of each preparation was measured at 540 nm using a spectrophotometer. The viable bacterial count of each preparation was determined by the spread plate method (Silva *et al.* 1988). A curve was plotted with absorbance against bacterial count and the absorbance for $1x10^6$ cfu/μl was calculated using the plotted curve. Opsonization of *E. coli* was done by mixing 200 μl of prepared bacterial cell suspension with 200 μl of elephant serum and incubating at 37ºC for 30 min while slowly mixing every 5 min.

Phagocytocity was evaluated in two samples by the following procedure; 200 μl of opsonized *E. coli* at $1x10^6$ cfu/μl concentration was mixed with 200 μl of phagocyte cell preparation at $2x10^4$ /μl concentration and incubated at 37ºC for 30 min. Subsequently, the tubes were centrifuged, 5 smears prepared from each tube, air dried and stained with Leishman stain. A total of 500 WBC were counted per smear and the percentage of active phagocytic cells estimated – when stained with Leishman, engulfed bacteria appear as rod shaped dark purple structures inside the phagocytic cells.

Table 2. Phagocytic ability of isolated heterophils and monoytes.

Sample	Phagocytically active	
	Heterophils	Monocytes
1	41%	43%
2	39%	68%
Average	40%	55.5%

Results

A total of 31.4% – 66.2% of heterophils and monocytes present in the blood sample were harvested, with negligible contamination with red blood cells (Table 1) and 40% of heterophils (Fig. 1A, B) and 55.5% of monocytes (Fig. 1C, D) were able to phagocytize *E. coli* (Table 2).

Discussion

WBC counts

The normal range for total WBC counts in elephants is 4–21 $x10^3$ per μl (Silva & Kuruwita 1993). Therefore, the counts we observed were within the normal range, except in samples 3A and 3B. The elevated counts from this elephant may have indicated a sub clinical infection.

WBC extraction

We were able to extract on average 39.8% of the WBC in the blood samples used and isolate

Table 1. Differential WBC counts and percentage extracted.

Sample	Total WBC		Heterophils and monocytes in extract		
	Count in blood (per µl)	% extracted	Count (per µl)	% extracted from that in blood	Viability* (%)
1A	16.74×10^3	44.2	11.30×10^3	66.2	98
1B	15.90×10^3	36.0	6.05×10^3	33.0	100
2A	14.82×10^3	38.4	5.34×10^3	31.4	100
2B	17.23×10^3	47.4	10.44×10^3	48.1	100
3A	24.34×10^3	33.9	10.05×10^3	32.7	97
3B	24.34×10^3	35.4	12.23×10^3	39.8	100
4A	18.48×10^3	42.1	10.73×10^3	47.8	99
4B	15.60×10^3	41.3	10.04×10^3	47.3	100
Average		39.8		43.2	99.3

*Viability using Tryphan blue stain

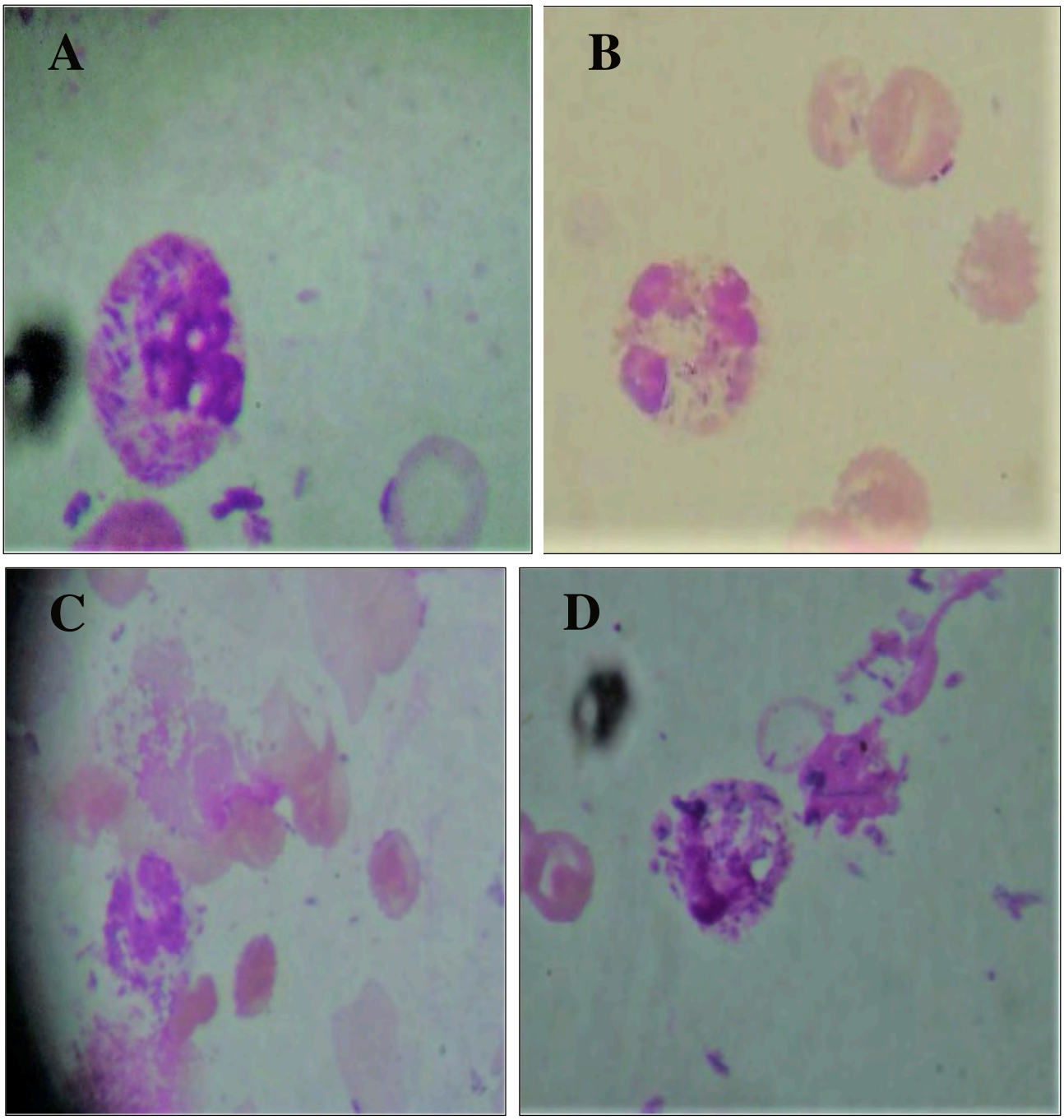


Figure 1. Heterophils (A, B) and monocytes (C, D) after *E. coli* phagocytosis.

43.2% of cells with phagocytic ability with 99.2% tryphan blue viability. Smith *et al.* (1998) were able to extract 98–99% of heterophils in elephant blood, by using hetastarch sedimentation and percol gradient centrifugation. Therefore, our extraction method was less efficient but provided satisfactory proportions of cells with acceptable purity and viability. Our method was also relatively cheap and could be easily performed in a basic laboratory using common reagents and without any sophisticated equipment.

Phagocytosis

The ability to phagocytize bacteria by heterophils and monocytes isolated by us was somewhat lower than the 66–86% reported by Smith *et al.* (1998). Silva and Jain (1988) detected a phagocytic ability of 45–95% in extracted bovine neutrophils. It is possible that the differences in extraction and opsonization as well as the small sample size, could have had some influence on the

values observed by us. However, absolute values of phagocytosis are irrelevant and establishing the normal ranges of the parameters of interest with our method by applying it to a wider sample, will enable its subsequent clinical application. We conclude that the method described was effective in extracting WBCs from the blood of Asian elephants and assessing phagocytosis.

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7th IUCN World Conservation Congress

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The IUCN World Conservation Congress (WCC) held once every four years, brings together leaders and decision-makers from government, civil society, indigenous peoples, business, and academia from across the globe, with the goal of conserving environment and harnessing the solutions that nature offers to global challenges.

The 7th IUCN World Conservation Congress was originally scheduled for June 2020, but was postponed due to the COVID-19 pandemic and was finally held from 3rd to 11th September 2021 in Marseille, France in a hybrid (in person and virtual) mode that had almost 6000 onsite participants and 3500 online participants from across the globe. The congress was formally inaugurated by the French president Emmanuel Macron marking a strong commitment to conservation.

The world is increasingly recognising the inextricable link between biodiversity conservation and human and economic wellbeing, a connection made all the more visible by the COVID-19 pandemic. The congress highlighted dual existential crises the planet faces – climate change and biodiversity collapse – and drew significant political attention, as it took place ahead of key global meetings on these two issues: the Glasgow Climate Change Conference (UNFCCC COP 26) and the UN Biodiversity Conference (Convention on Biological Diversity (CBD) COP 15) (Earth Negotiations Bulletin).

The main outcome document of the congress was the Marseille Manifesto, which highlights that humanity has reached a tipping point and the window of opportunity to respond to the interlinked climate and biodiversity emergencies is narrowing. Our existing systems do not work. Economic "success" can no longer come at nature's expense. We urgently need systemic reform.

The congress also resulted in the adoption of 28 resolutions on conservation and sustainable development issues. In addition to the decisions taken during the congress, 109 resolutions and recommendations were adopted through electronic vote by the IUCN Membership in October 2020. In total 148 resolutions and recommendations were taken up for voting through electronic votes and during the congress. Resolutions that attracted considerable discussion and/or attention included:

- on climate change, establishing a Climate Change Commission, as well as promoting integrated solutions on its linkages with biodiversity;
- on biodiversity, including contributions to the upcoming post-2020 global biodiversity framework (GBF);
- on rights, recognizing and supporting the rights and roles



Vivek Menon interacting with the indigenous peoples' delegates.

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- of Indigenous Peoples' and local communities' (IPLCs) in conservation, as well as protecting environmental defenders;
- on the ocean, protecting deep-ocean ecosystems through a moratorium on seabed mining and taking acting for biodiversity in areas beyond national jurisdiction;
- on health, promoting the One Health approach and addressing the drivers of biodiversity loss to protect human, animal, and environmental health, and prevent pandemics; and
- renunciation of the Doctrine of Discovery to rediscover care for Mother Earth.

Another highlight was the contributions from Indigenous Peoples, youth, local authorities, and the private sector, including during four summits organized on the first day of the congress (World Summit of Indigenous Peoples and Nature; Global Youth Summit; IUCN Local Action Summit; IUCN CEO Summit).

The two main components of the congress are Forum and Member's assembly. The Forum (from 4–7 September) provided the hub of public debate, bringing together people from all walks of life to discuss the world's most pressing conservation and sustainability challenges covering the seven congress themes (landscapes; freshwater; oceans; climate change; rights and governance; economic and financial systems; knowledge, innovation and technology) and the outcomes of the One Planet Summit presented by France.

The AsESG participated and delivered talk in two sessions on elephants. Dr. Sandeep Kr Tiwari spoke on impact on railways on elephants in India at the thematic session "*Corridors and Crossing: mainstreaming ecological connectivity into existing and planned infrastructures*" on 4th September. Mr Vivek Menon spoke on conservation of Borneo elephants at the session "*Assess-Plan-Act to reverse the Red within SSC*" on 5th September organised by the Species Survival Commission.

The Members' Assembly (8–10 September), IUCN's highest decision-making body involving governments and NGOs, took decisions on pressing conservation and sustainable development issues. The Members' Assembly also elected the organization's officials for the next four years, including the new IUCN president, Razan Al Mubarak from the United Arab Emirates (UAE). AsESG Chair, Mr Vivek Menon was also elected as the Councillor from the South and East Asia region.

Further reading

Summary Report, 3–11 September 2021
IUCN World Conservation Congress 2020
<https://enb.iisd.org/biodiversity/IUCN-Congress-2020/summary>

The Marseille Manifesto, 10 September 2021
IUCN World Conservation Congress Marseille
<https://iucn.s3.eu-west-3.amazonaws.com/en/CGR-2021-1.6-2_Marseille_Manifesto_IUCN-_World_Conservation_Congress_10_%20-September_2021.pdf>



The newly elected council of IUCN.

Obituary

Dr. Kalayansundaram Ramkumar (4.8.1978 – 1.6.2021)

Vivek Menon

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Dr. Ramkumar was a colleague of mine for over 14 years, a member of AsESG for this past quadrennium and a stout defender of elephants for all his two score and three years of life. His death due to COVID at such a young age was a terrible shock to all of us and we at AsESG pay homage to his departed soul.

Ramkumar hailed from Thittai village near Sirkazhi in the Mayiladuthurai District, Tamil Nadu. With a Master's degree in Wildlife Biology from A.V.C. College, Mayiladuthurai and a PhD from Bharathidasan University, Tiruchirappalli, Tamil Nadu, he joined WTI in 2007-08 and added value with his in-depth knowledge on looking at wildlife (especially elephants) and connectivity at the landscape level. He worked with us for 14 years till he passed on 1st June 2021 due to Covid. He was 43 years of age and leaves behind his wife and two very young children.

Firmly believing that land-use management is key to long-term conservation of elephants and minimising human elephant conflict, he worked relentlessly to identify and secure elephant corridors in India and their protection. He was instrumental in mapping the elephant corridors in India in phase-2 and was the co-editor of the publication "*Right of Passage: Elephant Corridors of India (2nd Edition)*", the most preferred reference for managers and researchers for securing corridors and elephant conservation in India. He also played a pivotal role in securing the Thirunelli-Kudrakote (Wayanad) corridor in Kerala and worked till his last day to secure the Mudahalli corridor in the BRT-Sathyamangalam landscape. He has authored several research reports, papers and popular articles.

Symbolizing the animal that was so close to his heart, he was indeed a gentle giant and strongly defended his observation and rational for defining an area as a corridor. His fierce passion for the species took him across the country looking for corridors, HEC mitigation and other elephant conservation issues.

Ramkumar was a person of diverse interests. While his colleagues knew him as a dedicated field professional and conservationist, he was "Ram" to the ones who worked closest with him. He was a fun loving person, enjoyed music and dance, had a passion for cooking and his friends remember him as a very caring and affectionate person.

The sudden passing of a person with whom one has worked for more than a decade is not just sad but also a grim reminder of the reality of this pandemic around us. His untimely passing is a great loss to elephant conservation and is deeply mourned by Wildlife Trust of India and the IUCN SSC Asian Elephant Specialist Group. His work and contribution towards elephant conservation will always be remembered.



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Book Review

Sanjeev Kumar Chadha's *Jumbos on the Edge: The Future of Elephant Conservation in India*

Hemanth Kumar

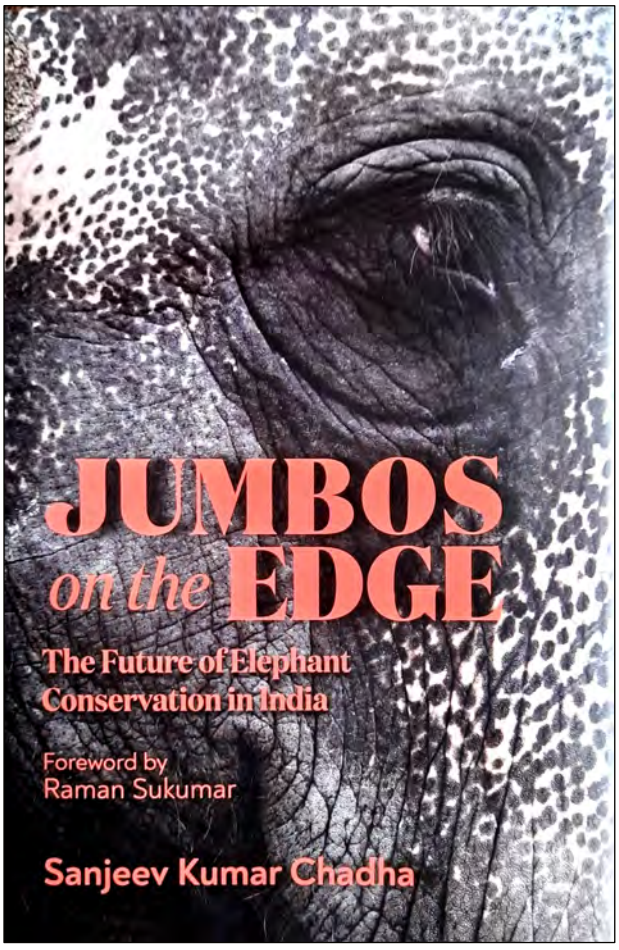
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Dr. Sanjeev Chadha is an Indian Forest Officer with immensely vast experience working in the field in different capacities and at various levels in policy making in India. His book "*Jumbos on the Edge: The Future of Elephant Conservation in India*" is an important book that stresses upon the need to have appropriate mitigation measures in elephant landscapes that will lessen the incidence of human-elephant conflicts. In the long run, such measures will greatly benefit in-situ conservation of these majestic animals that once ruled the country with large numbers.

The book focuses on elephants in Odisha but the case studies are useful for every part of India that faces such similar challenges. Elephants in Odisha constitute 74% of the total elephant numbers of the eastern region of India, but are confined only to 30% of the state's geographical area. This makes clearly evident why elephant populations in Odisha are subjected to serious conservation challenges — both elephant related and habitat related. And this is exactly why this book is such a timely publication – these various complex issues are dealt upon in detail linking theory with field experiences as these issues are of immediate concern for the survival of elephants in the Indian Sub-continent.

Dr. Chadha has used his years of experience on the ground to explain how habitat issues like habitat fragmentation, deterioration of habitat (availability of quality food and water), rapid changes in landscapes (by the way of roads, rail networks, encroachments, mining, illicit felling, various projects, industrialisation, sharing of grazing grounds by domestic cattle, etc.) and elephant related issues like hunting, retaliatory killings, accidents, electrocution, deaths due to human-elephant conflicts etc are affecting the populations of elephants adversely not just in Odisha but also in the state of Uttarakhand and other parts of India.

The author has also shared with the reader knowledge that he has access to due to his years in the forest service – this kind of viewpoint and with it the knowledge from the field and case studies make this book very useful for those in conservation and outside in other sectors like ecotourism, development and other stakeholders. He explains significant conservation issues of concern in the elephant reserves like Ma-



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hanandi Elephant Reserve, Sambalpur Elephant Reserve, South Odisha Elephant Reserve etc and shares important information on elephant corridors in Odisha.

The most interesting and informative case study comes from Dhenkanal District in Odisha. Through this case study, the author tried to explain the mitigative measures to be adopted for lessening the impact of human-elephant conflicts, which is extremely useful for the forest officers working in the field and for policy makers.

While numerous threats to wild animals and their habitat remain, linear infrastructure development has emerged as the single largest threat to the demographic viability of the wild populations. Linear infrastructure tends to fragment natural landscapes severing habitat connectivity, which is vital for the demographic and genetic viability of several endangered species.

Keeping the above in view, I personally found the chapter on "Conflict Mitigation Strategies" of immense value. The author explains with photographs how to deal with different kinds of developmental projects that are severely affecting the habitat – be it crop rotation, crop yields, fencing, engineering changes to development projects and many more valuable lessons.

Citation

Sanjeev Kumar Chadha (2021)
Jumbos on the Edge: The Future of Elephant Conservation in India
Natraj Publishers, India
Hardback, 218 p
ISBN 978-81-8158-3260

Recent Publications on Asian Elephants

Compiled by Jennifer Pastorini

Anthropologisches Institut, Universität Zürich, Zürich, Switzerland and
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If you need additional information on any of the articles, please feel free to contact me. You can also let me know about new (2021) publications on Asian elephants.

Y. An, S. Liu, Y. Sun, F. Shi & R. Beazley
Construction and optimization of an ecological network based on morphological spatial pattern analysis and circuit theory
Landscape Ecology 36 (2021) 2059-2076
Abstract. No permission to print abstract.

J.M.P.N. Anuradha, M. Fujimura, T. Inaoka & N. Sakai
Role of social and human capital in household resilience: Empirical evidence from an agricultural village community with exposure to significant environmental stresses in Sri Lanka
Global Social Welfare 8 (2021) 81-92
Abstract. No permission to print abstract.

T.K. Athira & T.N.C. Vidya
Elephant social systems: What do we know and how have molecular tools helped?
Journal of the Indian Institute of Science 101 (2021) 257-278
Abstract. No permission to print abstract.

R. Badola, T. Ahmed, A.K. Gill, P. Dobriyal, G.C. Das, S. Badola & S.A. Hussain
An incentive-based mitigation strategy to encourage coexistence of large mammals and humans along the foothills of Indian Western Himalayas
Scientific Reports 11 (2021) e5235
Abstract. Escalation of human–wildlife conflict (HWC) is a barrier to the conservation of ecological corridors across the globe. The existing mechanisms to counter HWC are either economically and socially taxing, or ineffective for long-term management. We assessed HWC in the corridor linking the Rajaji and Corbett Tiger Reserves in Uttarakhand, India, and its drivers, along with the benefits derived by local communities from the forest. We designed an innovative incentive-based mitigation mechanism to encourage coexistence of people and wildlife around the corridor. Costs incurred due to conflict and benefits derived from the forest were assessed using semi-structured questionnaire-based personal interviews (n = 757) with representatives from forest dependent households (hh). Fuelwood (1678.7 ± 131 kg hh^{-1} year^{-1}), fodder (4772 ± 186 kg hh^{-1} year^{-1}) and green/dry grass (3359 ± 104 kg hh^{-1} year^{-1}) contributed $3 \pm 1\%$, $6 \pm 0.5\%$ and $9 \pm 1\%$, respectively, to the annual income of dependent households. 69% of the households practising agriculture reported crop damage by wild animals, 19% of the households that owned livestock reported livestock loss, and 1.58% reported attack on humans resulting in injuries. The cost incurred due to crop raiding and livestock depredation was US$ 159.83 ± 1.0 hh^{-1} year^{-1} and US$ 229.32 ± 34.0 hh^{-1} year^{-1}, respectively. Crop loss was positively associated with the number of crops grown per season and cultivation of sugarcane, wheat and pulses, and negatively with distance from forest and cultivation of fodder and finger millet. Livestock depredation was negatively associated with distance from forest and positively with number of livestock owned, primarily calves. The accounting profit from cultivating a hectare of land, in the absence of crop depredation by wild animals, was estimated at US$ 3571.84 ha^{-1} year^{-1} and US$ 361.44 ha^{-1} year^{-1} for the plains and hills, respectively. This value can be used to calculate the payments to be paid to local communities to en-

courage them to adopt HWC resistant agricultural and pastoralism practices. The net present value of benefits from participating in the payments to encourage coexistence programme for 5 years, discounted at 12%, was US$ 12,875.7 ha^{-1} for the plains and US$ 1302.9 ha^{-1} for the hills. © 2021 The Authors.

V.C. Beeck, G. Heilmann, M. Kerscher & A.S. Stoeger

A novel theory of Asian elephant high-frequency squeak production

BMC Biology 19 (2021) e121

Abstract. Anatomical and cognitive adaptations to overcome morpho-mechanical limitations of laryngeal sound production, where body size and the related vocal apparatus dimensions determine the fundamental frequency, increase vocal diversity across taxa. Elephants flexibly use laryngeal and trunk-based vocalizations to form a repertoire ranging from infrasonic rumbles to higher-pitched trumpets. Moreover, they are among the few evolutionarily distantly related animals (humans, pinnipeds, cetaceans, birds) capable of imitating species-atypical sounds. Yet, their vocal plasticity has so far not been related to functions within their natural communicative system, in part because not all call types have been systematically studied. Here, we reveal how Asian elephants (*Elephas maximus*) produce species-specific squeaks (F0 300–2300 Hz) by using acoustic camera recordings to visualize sound emission and examining this alongside acoustic, behavioral, and morphological data across seven captive groups. We found that squeaks were emitted through the closed mouth in synchrony with cheek depression and retraction of the labial angles. The simultaneous emission of squeaks with nasal snorts (biphonation) in one individual confirmed that squeak production was independent of nasal passage involvement and this implicated oral sound production. The squeaks' spectral structure is incongruent with laryngeal sound production and aerodynamic whistles, pointing to tissue vibration as the sound source. Anatomical considerations suggest that the longitudinal closed lips function as the vibrators. Acoustic and temporal parameters exhibit high intra- and inter-individual variability that enables individual but no call-subtype classification. Only 19 of 56 study subjects were recorded to squeak, mostly during alarming contexts and social arousal but some also on command. Our results strongly suggest that Asian elephants force air from the small oral cavity through the tensed lips, inducing self-sustained lip vibration. Besides human brass players, lip buzzing is not described elsewhere in the animal kingdom. Given the complexity of the proposed mechanism, the surprising absence of squeaking in most of the unrelated subjects and the indication for volitional control, we hypothesize that squeak production involves social learning. Our study offers new insights into how vocal and cognitive flexibility enables mammals to overcome size-related limitations of laryngeal sound production. This flexibility enables Asian elephants to exploit a frequency range spanning seven octaves within their communicative system. © 2021 The Authors.

C.E. Bentley, J.M. Cracknell, A.C. Kitchener, Y. Martinez Pereira & R. Pizzi

Improved diagnosis of foot osteoarthritis in elephants (*Elephas maximus*, *Loxodanta africana*) using stereoradiography

Journal of Zoo and Wildlife Medicine 52 (2021) 67-74

Abstract. Diagnosis of foot disease in elephants is challenging. Owing to their large size, the available diagnostic tools and the expense of imaging are diagnostically limiting. Stereoradiography is the preparation of paired radiographs that form a three-dimensional (3D) image when viewed stereoscopically. Clinicians and veterinary students graded osteoarthritis in the feet of African (*Loxodonta africana*) and Asian (*Elephas maximus*) elephants taken postmortem with standard 2D radiographs, as well as 3D stereoradiographs. These gradings were compared with the actual gross pathology identified in the specimens. Although veterinary students diagnoses were no better than chance from 2D radiographs, 83.6% of the students could correctly differentiate severity between joints on stereoradiography; this is an absolute improvement of 30.1% (95% confidence interval [CI] = 19.6%–40.6%). Overall, participants were 27.4% (95% CI = 18.4%–36.3%) more

successful at diagnosing pathology on stereoradiographs. Half of participants were shown standard 2D radiographs first, the others stereoradiographs first, but the difference in gradings between the two groups was not statistically significant. Stereoradiography appears to hold the potential to improve diagnosis of osteoarthritis in elephant feet, particularly by less experienced clinicians, and the technique is low-cost and applicable under field conditions. © 2021 American Association of Zoo Veterinarians.

C. Boehlke, S. Schuster, L. Kauthe, O. Zierau & C. Hannig

Nutritional influences on enzyme activities in saliva of Asian and African elephants

Journal of Comparative Physiology B 191 (2021) 955-970

Abstract. Asian and African elephants show morphological adaptations to their ecological niche including the oral cavity. Variety and preferences of forage plants differ between both herbivorous elephant species. Diet can affect salivary enzymes. Asian elephants were shown to have a higher salivary amylase activity than African elephants. Species-specific differences were presumed to be influenced by feeding during collection procedure. This study aimed to determine the influence of feeding on enzyme activities in saliva of both elephant species to differentiate from species-specific effects. Additionally, season and housing conditions on salivary enzyme activities in non-fed elephants of both species were investigated. Salivary amylase (sAA), lysozyme (sLYS) and peroxidase (sPOD) activity were measured photometrically or fluorometrically. Results of this study reinforce previous observations of higher basic sAA activity in Asian elephants compared to African elephants. Salivary LYS and sPOD activity showed neither species-specific nor housing-specific differences. Independent from season, most elephants of both species revealed a lack of or low sPOD activity. Feeding caused a temporary decrease of sAA, sLYS and sPOD activity in both elephant species kept in four of eight tested zoos. Furthermore, sAA activity in Asian elephants was higher and sLYS activity lower in spring than in autumn. This study summarizes that sAA and sLYS are components of Asian and African elephant saliva in an active conformation in contrast to sPOD. Diet varying between season and zoos might influence sAA and sLYS activities primarily in Asian elephants but temporary low effects suggest sufficient buffer capacity of elephant saliva of both species. © 2021 The Authors.

A. Brady, B.J. McMahon & F. Naulty

Estimates of locomotion in Asian elephants *Elephas maximus* using video monitoring at Dublin Zoo, Ireland

Journal of Zoo and Aquarium Research 9 (2021) 124-133

Abstract. Welfare of elephants in zoos is a major concern within the public and zoo community. Asian elephants *Elephas maximus* are classified as endangered with one in three currently in human care. Elephants, in particular, are known to suffer from a number of health and behavioural issues when held in a zoo environment and physical activity is particularly important, with a lack of exercise leading to health issues, such as obesity, arthritis and foot problems. The aim of this study was to examine locomotory behaviour and associated habitat use in the adult members of the Dublin Zoo herd over a 2-month period using pre-recorded closed circuit television (CCTV) footage. Distance travelled was calculated using video footage and a grid overlay system to manually track the movements within the habitat. A total of 84 randomly selected 20-min focal observations were collected per individual over a 42 day period. Overall, the elephants in Dublin Zoo were found to display behaviours and travel distances comparable to those in the wild. The mean daily distance travelled (24 hours) was 9.35 km/day. Asian elephant herds in the wild travel distances of 5–10 km/day during non-extreme weather conditions. Free-ranging elephants are reported to spend 60–80% active hours feeding and up to 20 hours of their day is spent actively moving. The elephants in Dublin Zoo were found to spend 50% of their time foraging and 18% engaging in locomotion. Dublin Zoo elephants displayed locomotion and behavioural patterns more similar to the wild than to previous zoo studies. This study provides

baseline data on the Dublin Zoo herd adding to existing knowledge about locomotion in Asian elephants in urban zoo environments in addition to demonstrating the applicability of CCTV footage to zoo behavioural studies.

J. Caballero-Gómez, I. García-Bocanegra, N. Navarro, R. Guerra, E. Martínez-Nevado, P. Soriano & D. Cano-Terrizaa

Zoo animals as sentinels for Schmallenberg virus monitoring in Spain

Veterinary Microbiology 252 (2021) e108927

Abstract. Schmallenberg virus (SBV) is a newly emerged vector-borne pathogen that affects many domestic and wild animal species. A serosurvey was carried out to assess SBV exposure in zoo animals in Spain and to determine the dynamics of seropositivity in longitudinally sampled individuals. Between 2002 and 2019, sera from 278 animals belonging to 73 different species were collected from five zoos (A–E). Thirty-one of these animals were longitudinally sampled at three of these zoo parks during the study period. Seropositivity was detected in 28 (10.1%) of 278 animals analyzed by blocking ELISA. Specific anti-SBV antibodies were confirmed in 20 (7.2%; 95% CI: 4.2–10.3) animals of six different species using virus neutralization test (VNT). The multiple logistic regression model showed that "order" (Artiodactyla) and "zoo provenance" (zoo B; southern Spain) were risk factors potentially associated with SBV exposure. Two (8.7 %) of the 31 longitudinally-sampled individuals showed specific antibodies against SBV at all samplings whereas seroconversion was detected in one mouflon (*Ovis aries musimon*) and one Asian elephant (*Elephas maximus*) in 2016 and 2019, respectively. To the best of the author's knowledge, this is the first surveillance conducted on SBV in zoos in Spain. The results confirm SBV exposure in zoo animals in this country and indicate circulation of the virus before the first Schmallenberg disease outbreak was reported in Spain. Surveillance in zoological parks could be a complementary approach to monitoring SBV activity. Further studies are warranted to assess the impact of this virus on the health status of susceptible zoo animals. © 2020 Reprinted with permission from Elsevier.

K.L. Carrothers, L.E. Goodmiller, M.J. McLellan & A.M. Spicer

A novel approach to combatting proboscidean ivory trafficking using a multiplex High-Resolution Melt (M-HRM) assay

Forensic Science International: Genetics 53 (2021) e102511

Abstract. To support efforts in prosecuting wildlife crimes, we developed and validated a multiplex High-Resolution Melt (M-HRM) assay for the identification of proboscidean taxa commonly required to be identified or excluded in ivory seizures and forensic casework: Asian elephant (*Elephas maximus*), African elephant (*Loxodonta* spp.), mammoth (*Mammuthus* spp.), and mastodon (*Mammut* spp.). Five hundred and fifty (550) blood, tissue, and ivory samples from individuals of these 4 proboscidean taxa were used to develop and validate the 2 proboscidean-specific mitochondrial sites targeted by this assay. The 28-basepair (bp) 16S ribosomal RNA (rRNA) and 54-bp cytochrome b (Cytb) gene segments yield a combination of melt peaks that create composite melt profiles unique to each of the 4 proboscidean taxa. Wildlife forensic laboratories can use this sensitive, rapid, and cost-effective assay to assist efforts to combat the unlawful commercialization of proboscidean ivory and to stop the poaching crisis leading to the decline of these ivory-bearing species in the wild. © 2021 The Authors.

S. Chen, G.-Z. Sun, Y. Wang, C. Huang, Y. Chen, P. Liu, Y. Deng, D.-F. Cao, M.-X. Zhang, S. Ong, H.-P. Yang, Q.-Y. Wang, Z.-Y. Zhang, B. Wang, X. Zheng, Y. Lei, C. Li, J. Sun, M.-W. Bao, Z.-C. Yang, L. Guan, Y.-K. Sun, F.-Y. Zhou, J.-X. Liu, L.-L. Li, F. Wang, R.T. Corlett, R.-C. Quan, M.-Y. Chen, L. Zhang, K. Shi & A. Campos-Arceiz

A multistakeholder exercise to identify research and conservation priorities for Asian elephants in China

Global Ecology and Conservation 27 (2021) e01561

Abstract. China is home to a small but expanding population of wild Asian elephants (*Elephas maximus*). Both research interest and conservation efforts have increased in recent years, but these have been fragmented. Here we present

the results from a collaborative, multi-sectorial, multi-stakeholder exercise to identify priorities for Chinese elephant research and conservation. We first compiled a comprehensive list of issues, categorized under nine research and nine conservation themes, through an on-line survey of stakeholders. These issues were subsequently consolidated, timelined (as short-, mid-, or long-term issues), and ranked by their perceived priority in a two-day workshop attended by 44 people representing 28 organizations. The initial list of 656 issues (337 research and 319 conservation) was consolidated into a list of 251 (121 research and 130 conservation) issues. After priority ranking, we retained the top-three issues within each theme (making a total of 55 priority issues, due to a tie), which are then discussed in detail in this paper. Most (87%, n=55) priority issues were classified as short-term, suggesting that the exercise might have succeeded in identifying the current priorities, but not emerging issues that might require attention in future. Some issues appeared in various forms in different themes. Among research questions, participants highlighted the importance of understanding the carrying capacity of the current elephant range habitats, elephant movement patterns and expected range changes, the drivers of human-elephant conflict (HEC), improvements to the current HEC financial compensation mechanism, and ways of engaging local communities in HEC mitigation. Regarding elephant conservation, recurrent issues included effectively engaging communities, improving HEC early-warning systems and financial compensation mechanisms, establishing a new national park within elephant range, and creating mechanisms for communication and collaboration among elephant research and conservation stakeholders in China. Our exercise was effective in engaging experts from a diversity of different sectors and organizations in discussions about Asian elephants in China, and generated a list of priorities that can help guide elephant research and conservation efforts. © 2021 The Authors.

D.E. Chusyd, T.R. Nagy, L. Golzarri-Arroyo, S.L. Dickinson, J.R. Speakman, C. Hambly, M.S. Johnson, D.B. Allison & J.L. Brown

Adiposity, reproductive and metabolic health, and activity levels in zoo Asian elephant (*Elephas maximus*)

Journal of Experimental Biology 224 (2021) jeb219543

Abstract. Many captive Asian elephant populations are not self-sustaining, possibly due in part to obesity-related health and reproductive issues. This study investigated relationships between estimated body composition and metabolic function, inflammatory markers, ovarian activity (females only) and physical activity levels in 44 Asian elephants (n=35 females, n=9 males). Deuterium dilution was used to measure total body water from which fat mass (FM) and fat-free mass (FFM) could be derived to estimate body composition. Serum was analyzed for progestagens and estradiol (females only), deuterium, glucose, insulin and amyloid A. Physical activity was assessed by an accelerometer placed on the elephant's front leg for at least 2 days. Relative fat mass (RFM) – the amount of fat relative to body mass – was calculated to take differences in body size between elephants into consideration. Body fat percentage ranged from 2.01% to 24.59%. Male elephants were heavier (P=0.043), with more FFM (P=0.049), but not FM (P>0.999), than females. For all elephants, estimated RFM (r=0.45, P=0.004) was positively correlated with insulin. Distance walked was negatively correlated with age (r=–0.46, P=0.007). When adjusted for FFM and age (P<0.001), non-cycling females had less fat compared with cycling females, such that for every 100 kg increase in FM, the odds of cycling were 3 times higher (P<0.001). More work is needed to determine what an unhealthy amount of fat is for elephants; however, our results suggest higher adiposity may contribute to metabolic perturbations. © 2021 The Company of Biologists Ltd.

G.R. Clements, S. Rostro-Garciá, J.F. Kamler, S.H. Liang & A.K.B.A. Hashim

Conservation status of large mammals in protected and logged forests of the greater Taman Negara Landscape, Peninsular Malaysia

Biodiversitas 22 (2021) 272-277

Abstract. Peninsular Malaysia contains a large

community of IUCN Threatened mammal species, although recent records in some protected areas is unknown. The greater Taman Negara Landscape is one of the national priority areas for tiger conservation, but the recent occurrence of large mammals in the landscape has not been sufficiently updated. Here, we conducted systematic camera-trap surveys in protected and logged forests of the Taman Negara Landscape: Merapoh in Taman Negara National Park (TNM), and the Dungun Timber Complex (DTC), respectively. We found that the diversity of large mammals in TNM appeared to be the same between 2000 and 2016. The detection frequencies (DF) of several Threatened species, such as Malayan tiger, dhole, and Malayan pangolin, were similar between surveys, suggesting the relative abundance of these species likely remained stable during the past 16 years. However, the DF of Asian elephant and Malayan tapir were lower compared to 2000. In DTC, overall mammalian diversity was relatively lower than in TNM, primarily due to the non-detection of two large ungulates: gaur and sambar. Nevertheless, we recorded several other Threatened species of mammals, suggesting there is potential for this forest reserve to preserve some of Peninsular Malaysia's most Threatened mammal species. Our results suggest that the Taman Negara Landscape is still an important global site for the conservation of several Threatened species, and we recommend an increase in wildlife law enforcement efforts to ensure the survival of its large and diverse mammalian community.

J.A.H. Crawley, O. Lierhmann, D.J. Franco dos Santos, J. Brown, U.K. Nyein, H.H. Aung, W. Htut, Z.M. Oo, M.W. Seltmann, J.L. Webb, M. Lahdenperä & V. Lummaa

Influence of handler relationships and experience on health parameters, glucocorticoid responses and behaviour of semi-captive Asian elephants

Conservation Physiology 9 (2021) coaa116,

Abstract. Declining wild populations combined with accumulating captive populations of e.g. livestock, pets, draught and zoo animals have resulted in some threatened species with substantial proportions of their populations in captivity. The interactions animals have with humans in captivity depend on handler familiarity and relationship quality and can affect animal health, growth and reproduction with consequences for the success of conservation programmes. However, assessments of how specific human–animal relationships affect a range of physiological and behavioural outcomes are rare. Here, we studied semi-captive Asian elephants with detailed records of elephant–handler (mahout) relationships and veterinary management, allowing assessment of multiple welfare indicators in relation to specific mahout–elephant relationship lengths and mahout experience. These included measures of physiological stress (faecal glucocorticoid metabolite [FGM], heterophil:lymphocyte ratio [H:L]), muscle damage (creatine kinase [CK]), immunological health (total white blood cell count [TWBC]) and behaviour (response to mahout verbal commands). We found no evidence that FGM or H:L related to aspects of the mahout–elephant relationship. Longer overall mahout experience (i.e. years of being a mahout) was linked to increased muscle damage and inflammation, but the lengths of specific mahout–elephant relationships were inversely associated with muscle damage in working-age elephants. Elephants responded more to familiar mahouts in behavioural tasks and faster to mahouts they had known for longer. In summary, our results found little evidence that the mahout–elephant relationship affects physiological stress in this population based on FGM and H:L, but mahout experience and relationships were linked to other physiological responses (CK, TWBC), and elephants require behavioural adjustment periods following mahout changes. © 2021 The Authors.

M.P. Deepthi, P. Kathireswari. J. Rini, K. Saminathan & N. Karmegam

Vermitransformation of monogastric *Elephas maximus* and ruminant *Bos taurus* excrements into vermicompost using *Eudrilus eugeniae*

Bioresource Technology 320 (2021) e124302

Abstract. No permission to print abstract.

R. Drinkwater, T. Jucker, J.H.T. Potter, T. Swinfield, D.A. Coomes, E.M. Slade, M.T.P. Gilbert, O.T. Lewis, H. Bernard, M.J. Struebig, E.L. Clare & S.J. Rossiter

Leech blood-meal invertebrate-derived DNA reveals differences in Bornean mammal diversity across habitats

Molecular Ecology 30 (2021) 3299-3312

Abstract. The application of metabarcoding to environmental and invertebrate-derived DNA (eDNA and iDNA) is a new and increasingly applied method for monitoring biodiversity across a diverse range of habitats. This approach is particularly promising for sampling in the biodiverse humid tropics, where rapid land-use change for agriculture means there is a growing need to understand the conservation value of the remaining mosaic and degraded landscapes. Here we use iDNA from blood-feeding leeches (*Haemadipsa picta*) to assess differences in mammalian diversity across a gradient of forest degradation in Sabah, Malaysian Borneo. We screened 557 individual leeches for mammal DNA by targeting fragments of the 16S rRNA gene and detected 14 mammalian genera. We recorded lower mammal diversity in the most heavily degraded forest compared to higher quality twice logged forest. Although the accumulation curves of diversity estimates were comparable across these habitat types, diversity was higher in twice logged forest, with more taxa of conservation concern. In addition, our analysis revealed differences between the community recorded in the heavily logged forest and that of the twice logged forest. By revealing differences in mammal diversity across a human-modified tropical landscape, our study demonstrates the value of iDNA as a noninvasive biomonitoring approach in conservation assessments. © 2020 The Authors.

L.J. Evans, B. Goossens, A.B. Davies, G. Reynolds & G.P. Asnera

Natural and anthropogenic drivers of Bornean elephant movement strategies

Global Ecology and Conservation 22 (2020) e00906

Abstract. Endangered Bornean elephants are severely threatened by ongoing habitat transformation and increasing levels of human-elephant conflict. Understanding how elephants move across intact and transformed landscapes, as well as within them, is therefore of vital importance for the successful implementation of conservation management initiatives. We combined remote sensing and GPS telemetry data to identify broad habitat utilization and key movement areas to aid elephant management and conflict mitigation in three spatially-isolated populations in central and eastern Sabah, Malaysian Borneo. Home ranges were estimated using Brownian Bridge Movement Models and specific behavioral movement traits were identified by pathway analyses. These behavioral traits enabled a fine-scale evaluation of movements between and adjacent to forest patches and the role of large-scale agriculture in shaping elephant movements. Both natural (topological) and anthropogenic (agricultural) landscape features were found to have a broad influence on elephant movements. All elephant populations exhibited human-mediated behavioral responses, regardless of disturbance level. Throughout their range, elephants appeared to actively select relatively degraded forests, as measured by aboveground carbon density. However, elephants actively avoided urbanized areas, including roads and villages. Throughout the elephant range, high-speed, low-trajectory movements were found at low aboveground carbon locations, with 27% of all such movements located in large-scale agriculture. Our results suggest that agriculture impacts movement strategies of elephants, with evidence of repeat agricultural use pointing towards an active rationale for this behavior. Elephants were also found to use ridgelines as movement pathways, providing further context for the protection of such forested areas. The Lower Kinabatangan population, located in small remnant forests, travelled further to meet their ecological needs, suggesting the population is under added strain. Our work represents the broadest landscape assessment of Bornean elephant movements to-date and has important implications for both future work and habitat-level protected area management strategies. © 2020 The Authors.

P. Fernando, M.K.C.R. De Silva, L.K.A. Jayasinghe, H.K. Janaka & J. Pastorini

First country-wide survey of the endangered Asian elephant: Towards better conservation and management in Sri Lanka

Oryx 55 (2021) 46-55

Abstract. The endangered Asian elephant *Elephas maximus* comes into widespread conflict with agrarian communities, necessitating active management. The species' distribution is of primary importance for management planning. However, data-based countrywide distribution maps have not been available for any of the 13 Asian elephant range states. We conducted a 5 × 5 km grid-based questionnaire survey in Sri Lanka to produce an island-wide elephant distribution map. Elephants occur over 59.9% of Sri Lanka and people are resident in 69.4% of elephant range, indicating the challenge of separating people and elephants at a landscape scale. Elephants in Sri Lanka have lost 16.1% of their range since 1960 but their current distribution remains largely contiguous. We found the range of adult males was 15.1% greater, and less seasonal, than that of herds, possibly because males have a higher tolerance for conflict with people. The distribution of conflict coincided with the co-occurrence of humans and elephants. We conclude that a human-elephant coexistence model is the only viable option for effectively mitigating human-elephant conflict and conserving elephants in Sri Lanka. The findings are currently being used to effect a paradigm change in elephant conservation and management in the country. © 2019 Fauna & Flora International.

A. Feuerbacher, C. Lippert, J. Kuenzang & K. Subedi

Low-cost electric fencing for peaceful coexistence: An analysis of human-wildlife conflict mitigation strategies in smallholder agriculture

Biological Conservation 255 (2021) e108919

Abstract. With a growing global population, human-wildlife conflicts (HWCs) are intensifying and cost-effective mitigation strategies to conserve biodiversity and support rural livelihoods become increasingly relevant. This article presents evidence on how low-cost electric fencing (EF) technology can contribute to a peaceful coexistence between farmers and wildlife. Applying an economic analysis, the effectiveness of smallholders' predominant HWC mitigation strategies in Bhutan are assessed. In Bhutan, HWCs are severe and investments in EF are expanding with about 10% of agricultural land already fenced. The analysis reveals high effectiveness and profitability of EF compared with labor-intensive crop guarding strategies despite smallholders' high time preference. EF profitability particularly depends on net labor savings from reduced time-use for crop guarding. Results emphasize the need for collective action at the community level, since due to small landholdings individually operated EF schemes are unprofitable in most cases. The findings are robust across ecological conditions and variations in key parameters, such as the discount rate (reflecting smallholders' time preference) and opportunity cost of labor. Particularly in contexts where hunting is banned, investments in EF technology could be a main ingredient of comprehensive policies for wildlife conservation and agricultural development. Further research is needed to investigate the biological implications of large-scale fencing policies, the relevance of spatial spillover effects and game-theoretic aspects of community-based EF schemes. © 2020 Reprinted with permission from Elsevier.

V.R. Goswami, D. Vasudev, B. Joshi, P. Hait & P. Sharma

Coupled effects of climatic forcing and the human footprint on wildlife movement and space use in a dynamic floodplain landscape

Science of the Total Environment 758 (2021) e144000

Abstract. With climate change, terrestrial fauna in riparian floodplain ecosystems must adapt to a predicted increase in frequency and magnitude of fluvial perturbations. Seasonal migration to seek refuge from floodwaters represents a central adaptation strategy, but may entail risky navigation of anthropogenic spaces in heterogeneous landscapes. Here, we demonstrate the opportunities and constraints large-bodied mammalian herbivores face during an adaptive response of obligatory flood-driven

refuge migration, across a human-dominated environment. Our study system, centred around a productive protected area – Kaziranga National Park in Assam, Northeast India – on the floodplains of the Brahmaputra River, is home to an abundance of large herbivores that undertake seasonal migrations in response to floods. We contrast species distribution data during a major flood event with those from the dry season to illustrate season-specific movement and space use decisions of large herbivores ranging in body mass from the 3000-kg Asian elephant *Elephas maximus* to the 20-kg muntjac *Muntiacus muntjak*. In the dry season, most large herbivores – a majority of which are endangered and threatened by anthropogenic pressures – avoided areas with a strong human footprint, while preferring spaces with high land-use diversity. During the floods, such species were pushed out of inundated habitats within the protected area, and they chose to move through woodlands and areas under bamboo cover on private lands, as they migrated to forested refugia on higher ground. Our results show how seasonal environmental constraints shaped by floods determine the internal motivation of animals to risk traversing a human-dominated space to seek refuge, which contextually defines how animals view and navigate the landscape. Such insights underscore the importance of dynamic and adaptive planning, and participatory conservation efforts, to facilitate connectivity in the changing environment and climate of the present Anthropocene. © 2020 Reprinted with permission from Elsevier.

S.K. Govind & E.A. Jayson

Human–wildlife interactions and people's attitudes towards conservation: A case study from Central Kerala, India

Animal Biodiversity and Conservation 44 (2021) 139-151

Abstract. This paper studies the human-wildlife interaction in Central Kerala, India, and attempts to understand local people's attitude toward wildlife and conservation. Data were collected from April 2009 to March 2014. A structured questionnaire survey was carried out among people living in the fringe areas of the forest (n = 210). Self–reported household crop loss was modelled as a function of agricultural, demographic and environmental factors. Wild pig (*Sus scrofa*) (57.1 %) was the main crop foraging species, followed by Asian elephant (*Elephas maximus*) (12.9 %). It was reported that 36 % of farmers' annual income was lost due to crop foraging by wild animals. Leopard (*Panthera pardus*) (69.76 %), Indian rock python (*Python molurus*) (13.95 %), dhole (*Cuon alpinus*) (9.3 %) and stray dogs (6.97 %) were responsible for the attacks on livestock. The factors that influenced crop loss according to the farmers were the extent of agriculture land that they owned (coefficient = 0.968), the distance to reserve forest from crop fields (–0.009), and age of respondents (0.78). Due to people's awareness concerning the importance of wildlife, reports on human-wildlife interaction in the newspapers and strict enforcement of wildlife laws, people's attitude towards conservation of wildlife was good, and they were not taking any negative precautions against wild animals. © 2021 The Authors.

E.M. Gross, B.P. Lahkar, N. Subedi, V.R. Nyirenda, E. Klebelsberg & O. Jakoby

Elephants in the village: Causes and consequences of property damage in Asia and Africa

Conservation Science and Practice 3 (2021) e343

Abstract. In recent years, reports of elephants causing damage in rural villages by destroying houses and foraging on stored food have been increasing, but little is known about the determinants and magnitude of this damage. In this study, we have examined the extent of property damage by elephants (*Loxodonta africana* and *Elephas maximus*), in one African and two Asian study areas over a six-year period. A total of 1,172 damaged constructions were observed on site, involving detailed damage assessment by trained enumerators and standardized interviews with witnesses. Depending on the study area, between 67.1 and 86.4% of damage events were attributed to single, individual elephants or pairs of males. The majority of properties were damaged in search for food (62.5–76.7% respectively). Property damage caused higher mean losses than crop damage on

farmland in all study areas. Results suggest that property damage by elephants has been largely underestimated and needs to form a focus in future human–elephant conflict research. We suggest a need to reduce the attractiveness of villages by storing food in locked and safe places, away from sleeping areas and to foster the development of elephant safe stores, appropriate to the particular cultural background of the target area. © 2020 The Authors.

T. Guntawang, T. Sittisak, V. Kochagul, S. Srivorakul, K. Photichai, K. Boonsri, T. Janyamethakul, K. Boonprasert, W. Langkaphin, C. Thitaram & K. Pringproa

Pathogenesis of hemorrhagic disease caused by elephant endotheliotropic herpesvirus (EEHV) in Asian elephants (*Elephas maximus*)

Scientific Reports 11 (2021) e12998

Abstract. Elephant endotheliotropic herpesvirus-hemorrhagic disease (EEHV-HD) is an acute fatal disease in elephants. Despite the fact that the underlying pathogenesis of EEHV-HD has been proposed, it remains undetermined as to what mechanisms drive these hemorrhagic and edematous lesions. In the present study, we have investigated and explained the pathogenesis of acute EEHV-HD using blood profiles of EEHV-HD and EEHV-infected cases, hematoxylin and eosin (H&E) stain, special stains, immunohistochemistry, quantitative polymerase chain reaction (PCR) and reverse transcriptase polymerase chain reaction (RT-PCR). It was found that EEHV genomes were predominantly detected in various internal organs of EEHV-HD cases. Damage to endothelial cells, vasculitis and vascular thrombosis of the small blood vessels were also predominantly observed. Increases in platelet endothelial cell adhesion molecules-1 (PECAM-1)- and von Willebrand factor (vWF)-immunolabeling positive cells were significantly noticed in injured blood vessels. The expression of pro-inflammatory cytokine mRNA was significantly up-regulated in EEHV-HD cases when compared to EEHV-negative controls. We have hypothesized that this could be attributed to the systemic inflammation and disruption of small blood vessels, followed by the disseminated intravascular coagulopathy that enhanced hemorrhagic and edematous lesions in EEHV-HD cases. Our findings have brought attention to the potential application of effective preventive and therapeutic protocols to treat EEHV infection in Asian elephants. © 2021 The Authors.

L.J. Hale, K. Shi, T.C. Gilbert, K.S.-H. Peh & P. Riordan

Social structure and demography of a remnant Asian elephant (*Elephas maximus*) population and the implications for survival

Oryx 55 (2021) 473-478

Abstract. The Asian elephant *Elephas maximus* is at risk of extinction as a result of anthropogenic pressures, and remaining populations are often small and fragmented remnants, occupying a fraction of the species' former range. Once widely distributed across China, only a maximum of 245 elephants are estimated to survive across seven small populations. We assessed the Asian elephant population in Nangunhe National Nature Reserve in Lincang Prefecture, China, using camera traps during May–July 2017, to estimate the population size and structure of this genetically important population. Although detection probability was low (0.31), we estimated a total population size of c. 20 individuals, and an effective density of 0.39 elephants per km^2. Social structure indicated a strong sex ratio bias towards females, with only one adult male detected within the population. Most of the elephants associated as one herd but three adult females remained separate from the herd throughout the trapping period. These results highlight the fragility of remnant elephant populations such as Nangunhe and we suggest options such as a managed metapopulation approach for their continued survival in China and more widely. © 2020 The Authors.

N.N.P. Htet, R. Chaiyarat, N. Thongthip, P. Anuracpreeda, N. Youngpoy & P. Chompoopong

Population and distribution of wild Asian elephants (*Elephas maximus*) in Phu Khieo Wildlife Sanctuary, Thailand

PeerJ 9 (2021) e11896

Abstract. The populations of wild Asian elephants (*Elephas maximus*) have increased re-

cently after a period of worldwide decline in protected areas. It is important to understand the dynamics and distribution of the remaining populations to ensure their conservation and prevent human-elephant conflicts. We monitored the population distribution of elephants between 2016 and 2019 in the Phu Khieo Wildlife Sanctuary, Thailand. We set one hundred forty-nine camera trap locations; cameras recorded 38,834 photos over 6,896 trap nights. Elephants were captured in 4,319 photographs. The maximum entropy modeling software MaxEntwas used to identify elephants' habitat preferences within 49 of the 149 total camera trap locations according to five environmental factors. One hundred fourteen elephants were identified. We identified 30 adult males, 43 adult females, 14 sub-adult males, nine sub-adult females, 11 juveniles, and seven calves. The age structure ratio based on adult females was 0.7:1:0.3:0.2 :0.3:0.2, and the ratio of reproductive ability between adult females, juveniles, and calves was 1:0.2:0.1. A suitable elephant habitat was determined to be 1,288.9 km^2 using Area Under the Curve (AUC). An AUC = 0.061 indicated good performance. Our model classified habitat preferences associated with elevation, forests, salt licks, human activity, and slope. According to our probability map this sanctuary can provide a suitable habitat for elephants. Our results indicate that effective management practices can protect wild Asian elephants in the region and reduce conflict between humans and elephants. © 2021 The Authors.

T. Jansson, B.V. Perera, A. Edner & Å. Fahlman

Standing sedation with xylazine and reversal with yohimbine in juvenile Asian elephants (*Elephas maximus*)

Journal of Zoo and Wildlife Medicine 52 (2021) 437-444

Abstract. Evaluation and improvement of immobilization methods are important for wildlife welfare and biodiversity conservation. The sedative and physiological effects of xylazine (50–110 mg per elephant; 0.09–0.15 mg/kg IM) were evaluated in 15 juvenile Asian elephants (*Elephas maximus*) in Sri Lanka. The time from xylazine injection until first sign of sedation, handling, and reversal with yohimbine (0.009–0.03 mg/kg IV) were recorded. Behavioral signs, level of sedation (no effect, light, moderate, or deep) and response to handling were assessed. Rectal temperature, pulse, and respiratory rates were recorded and arterial blood samples were analyzed 30 and 45 min after xylazine injection. The first sign of sedation occurred within 5–18 min. Standing sedation was induced in all elephants, but the level of sedation varied differently over time for each elephant. Twelve elephants remained standing throughout the sedation period, while 3 elephants became laterally recumbent. Sedative effects included lowered head and trunk, droopy ears, snoring, and penis protrusion. Pulse rate, respiratory rate, and rectal temperature ranged between 30–45 beats/min, 4–12 breaths/min, and 35.6–37.2°C, respectively, at 30 min after xylazine injection, and there were no changes over time. Pulmonary function and acid–base balance were adequate (range partial pressures of arterial oxygen 73–123 mmHg and carbon dioxide 33–52 mmHg, arterial hemoglobin oxygen saturation 96–99%, pH 7.34–7.54, lactate 0.9–2.5 mmol/l). Yohimbine was administered 46–110 min after the injection of xylazine, and the first sign of recovery occurred within 1–4 min. Resedation after reversal with yohimbine was observed in two elephants. In conclusion, xylazine at the doses used induced light to deep sedation with stable physiology and most elephants remained standing. © 2021 American Association of Zoo Veterinarians.

H.-L. Jim, F. Range, S. Marshall-Pescini, R. Dale & J.M. Plotnik

Investigating indirect and direct reputation formation in Asian elephants (*Elephas maximus*)

Frontiers in Psychology 11 (2021) e604372

Abstract. Reputation is a key component in social interactions of group-living animals and appears to play a role in the establishment of cooperation. Animals can form a reputation of an individual by directly interacting with them or by observing them interact with a third party, i.e., eavesdropping. Elephants are an interesting taxon in which to investigate eavesdropping as they are highly cooperative, large-brained,

long-lived terrestrial mammals with a complex social organisation. The aim of this study was to investigate whether captive Asian elephants (*Elephas maximus*) could form reputations of humans through indirect and/or direct experience in two different paradigms: (1) a cooperative string-pulling task and (2) a scenario requiring begging. Fourteen captive Asian elephants in Thailand participated in an experimental procedure that consisted of three parts: baseline, observation, and testing. In the observation phase, the subject saw a conspecific interact with two people – one cooperative/generous and one non-cooperative/selfish. The observer could then choose which person to approach in the test phase. The elephants were tested in a second session 2-5 days later. We found no support for the hypothesis that elephants can form reputations of humans through indirect or direct experience, but these results may be due to challenges with experimental design rather than a lack of capacity. We discuss how the results may be due to a potential lack of ecological validity in this study and the difficulty of assessing motivation and attentiveness in elephants. Furthermore, we highlight the importance of designing future experiments that account for the elephants' use of multimodal sensory information in their decision-making. © 2021 The Authors.

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

Effects of male age and female presence on male associations in a large, polygynous mammal in southern India: The Asian elephant

Frontiers in Ecology and Evolution 9 (2021) e616666

Abstract. We present a detailed study of male associations in the Asian elephant, using 6 years of data on identified, non-musth males. Adult males spent greater proportions of their time solitarily than in mixed-sex or in all-male groups. Old (over 30 years) males were sighted more frequently with their age-peers and less frequently with young (15–30 years) males than expected at random in all-male groups. Young males were not sighted more frequently with old males than with young males, and did not disproportionately initiate associations with old males. These results suggest that male associations, in the absence of females, may allow for old non-musth males to test strengths against age-peers. Social learning from older individuals did not seem to be important in male associations, unlike that observed in the African savannah elephant. We also found a constraint on the sizes of all-male groups, similar to that seen in female groups in our study population, and all-male groups were rarer and smaller than those in African savannah elephant. Although male associations were weak, most males had a significant top associate, with whom their association was the strongest, in female absence. In mixed-sex groups, male associations occurred at random, suggesting that males were tracking female groups independently. Differences in male social organization from that of the related African savannah elephant that occupies a similar niche possibly arise from differences in ecology. © 2021 The Authors.

S. Khammesri, Y. Mathura, K. Boonprasert, C. Ampasavate, D. Hongwiset, J.L. Brown & C. Thitaram

Successful treatment of elephant endotheliotropic herpesvirus infection in an Asian elephant (*Elephas maximus*) calf by oral acyclovir medication: Case report

J. of Veterinary Medical 83 (2021) 125-129

Abstract. Elephant endotheliotropic herpesvirus (EEHV) is a major cause of death in Asian elephant (*Elephas maximus*) calves. A 2-year, 11-month-old female, captive Asian elephant presented with facial edema and a mild fever. Blood samples were collected and showed EEHV1A positivity with a high viral load by real time PCR. Heterophil toxicity also was reported for the first time in this case. The calf was treated orally with acyclovir, 45 mg/kg tid for 28 days, which reduced the EEHV1A viral load to undetectable levels within 9 days and the calf survived. A successful outcome with oral acyclovir administration provides another and affordable option to treat EEHV hemorrhagic disease in Asian elephants, and one that is easier to administer in untrained calves. © 2021 The Japanese Society of Veterinary Science.

R.K. Koirala, W. JI, Y.P. Timilsina & D. Raubenheimer

Patterns, perceptions, and spatial distribution of human-elephant (*Elephas maximus*) incidents in Nepal

Journal of Threatened Taxa 13 (2021) 18441-18452

Abstract. Nepal has an estimated population of 109 to 142 wild Asian Elephants *Elephas maximus* L.. We carried out a survey of human-elephant incidents (HEI) of conflict in the buffer zones of Chitwan National Park and Parsa National Park Nepal, using a structured questionnaire, focal interviews, and secondary data collection. Furthermore, data of HEI were also extracted from published literature in order to analyse spatial-temporal patterns of competition throughout Nepal. Elephant related incidents were higher in the pre-winter season and concentrated along the southern forest boundary; incidents decreased with increasing distance from the park/reserve. Crop damage by elephants occurred in pre-monsoon and winter seasons with the most impact on rice (the major crop). Bulls (single or in pairs) were involved in crop raids (44%), property damage (48%), and human casualties (8%); family herds were only recorded to have raided crops (39%) and damaged properties (36%). The average herd size recorded was 10 individuals, with a maximum group size of ≤22 elephants. Generally, incidents per elephant was high in western Nepal, whereas human and elephant casualties were higher in central and eastern regions. To reduce human–elephant incidents 53% of local residents suggested restoring core and boundary areas with native elephant food plants, 40% suggested planting alternative crops along park boundaries, 6% favoured elephant translocation, and only 1% percent was in favour of culling elephants. Mitigation measures already in place include wooden watch towers used by villagers to detect elephant incursions. Low impact traditional averting techniques, such as drumming and the use of flame torches, were used to deter intruding elephants at the areas surveyed. In conclusion we suggest potential mitigation measures such as identifying elephant refugia and mitigate the impact and assessing the year-round availability of preferred foods; in addition, we advocate for introducing an equitable compensation to gain support from local communities adjacent to protected areas. © 2021 The Authors.

Intanon Kolasartsanee

Diversity and habitat use of terrestrial mammals in the area proposed for water resource development in Khao Soi Dao Wildlife Sanctuary, Thailand

Environment and Natural Resources Journal 19 (2021) 186-194

Abstract. The Khlong Ta Liu dam construction plan was re-proposed to be constructed in the forest area of Khao Soi Dao Wildlife Sanctuary in the Ta-riu tributary without a biodiversity impact assessment. Five camera traps were mounted at the hotspot points for terrestrial mammals next to the main trail for 376 trap nights from the forest edge to the forest interior. Fifteen species of terrestrial mammals were found. Two species found were categorized as having endangered status, while seven have vulnerable status. Grazers and browsers, i.e., sambar, gaur, northern red muntjac, and Asian elephant were mostly detected at the forest edge, while omnivores and frugivores, i.e., wild boar, greater hog badger, and northern pig-tailed macaque were largely detected in the forest interior. Dhole should be a carnivore species specific to the forest edge while clouded leopard should be in the forest interior. The Normalized Difference Vegetation Index (NDVI) may relate to species of terrestrial mammals detected at each habitat. Among the five habitats, three would be destroyed upon construction of the dam, including the habitat with the highest diversity of terrestrial mammals. The habitat that would likely be least impacted had the lowest species richness of terrestrial mammals. © 2021 Natural Resources Journal.

C.A. LaDue & B.A. Schulte

Pheromonal enrichment in the zoo: An empirical approach with Asian elephants (*Elephas maximus*)

Applied Animal Behaviour Science 235 (2021) e105228

Abstract. The use of odors is a popular form of sensory enrichment, yet few studies have in-

vestigated the longer lasting effects of biologically relevant chemical signals like pheromones. Asian elephants (*Elephas maximus*) are unique because they are commonly held in zoos and utilize two single-compounds to synchronize reproduction: frontalin (a pheromone produced by male elephants in musth) and (Z)-7-dodecenyl acetate (Z7-12:Ac, a pheromone produced by female elephants around ovulation). While Asian elephant chemical signaling dynamics have been well-studied, no reports exist on the broader behavioral effects (i.e., primer effects) of either of these pheromones. The purpose of this study was to describe the primer effects of both frontalin and Z7-12:Ac for potential enrichment applications. We bioassayed 50 elephants at 10 zoos using synthetic versions of these two pheromones that replicated the concentrations at which they are produced naturally. We found that behavioral diversity in response to these pheromones was influenced both by the degree of exposure to the chemicals and by properties of the receiver, such as sex, sexual experience, age, and social access, with models that included all or most of these factors explaining much of the variation in the bioassay data for frontalin ($R^2_{(c)} = 0.42$) and Z7-12:Ac ($R^2_{(c)} = 0.59$). Furthermore, both males and females exhibited distinct changes in activity levels in the presence of frontalin or Z7-12:Ac, with specific behavioral differences noted. For instance, frontalin stimulated increased activity (and decreased inactivity) among female elephants ($P < 0.001$). Foraging ($P = 0.029$) and walking ($P = 0.001$) increased when males were exposed to frontalin, but it also stimulated increased time spent engaged in stationary stereotypy ($P < 0.001$). On the other hand, Z7-12:Ac encouraged greater activity levels in female ($P < 0.001$) and male ($P = 0.010$) elephants. These results support the use of pheromones as enrichment opportunities for elephants, and suggest appropriate chemical signals should be considered for other species. Because these compounds hold biological, ecological, and/or evolutionary salience, they can have long-lasting effects and are particularly relevant to long-term management strategies. In conjunction with other forms of sensory enrichment—including biologically novel odors—pheromones have the potential to enhance the wellness of zoo-housed species. © 2021 Reprinted with permission from Elsevier.

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

Scars of human-elephant conflict: Patterns inferred from field observations of Asian elephants in Sri Lanka

Wildlife Research 48 (2021) 540-553

Abstract. Human-elephant conflict (HEC) is a major threat to Asian elephants as humans and elephants are forced to share common resources. In Sri Lanka, human-dominated landscapes adjacent to protected areas promote high rates of HEC, especially in the form of crop-foraging by elephants. Crop-foraging can be dangerous to both elephants and humans involved in the conflict. Gunfire is a common way for human communities to deter crop-foraging elephants, and gunshot wounds are commonly described in this elephant population on necropsy. We sought to quantify and describe unique scar patterns among Asian elephants in a protected area, Wasgamuwa National Park, attributed to HEC. We identified 38 adult female and 64 adult male elephants and recorded the age class and body condition of each with established standards. Using photographs, we counted the number, position, and relative size of all scars on each animal. Male elephants had significantly more scars than did females, and for males, the number of scars increased progressively with age. Additionally, male elephants with higher body conditions had more scars. Finally, males tended to have more scars towards the head, especially at older ages. Differences in total scar counts between the sexes in this population imply that male elephants in this area more frequently engage in HEC than do females, following observations previously described in the literature. Furthermore, the fact that male elephants acquired progressively more scars as they aged, and that fatter elephants had more scars, indicates that previous exposure to HEC may not have been a deterrent for future events among these males, and potentially, crops served as valuable food sources for these animals. Finally, the changing body locations of these scars with age in males possibly

shows plastic behavioural responses during crop-foraging or lower tolerance by farmers towards habitual crop foragers. These results emphasise the need for animal-based approaches to HEC mitigation. Similarly, conservation managers in Sri Lanka and other elephant range countries should investigate similar methods that estimate patterns of HEC to develop effective management strategies directly targeting animals most likely to engage in conflict. © 2021 CSIRO.

J. Leung, T. Beths, M. Lynch, S. Frith & S.H. Bauquier

A simple method to provide positive end expiratory pressure to treat hypoxaemia in an anaesthetised Asian elephant (*Elephas maximus*)

Journal of the South African Veterinary Association 92 (2021) e2118

Abstract. Hypoxaemia is a common complication in anaesthetised or immobilised elephants. It is presumably because of hypoventilation and ventilation-perfusion mismatch. To prevent hypoxaemia, orotracheal intubation and positive pressure ventilation are recommended. This case report describes a hypoxaemic period despite positive pressure ventilation in a 46-year-old female Asian elephant (*Elephas maximus*) anaesthetised with azaperone-etorphine, medetomidine and an etorphine constant rate infusion in lateral recumbency for a dental procedure. The hypoxaemia was corrected utilising positive end-expiratory pressure (PEEP) of 5–10 cm H_2O, a technique that has not previously been reported in the management of anaesthetised elephants. PEEP decreases atelectasis, shunt fraction, and increases lung compliance. Positive end-expiratory pressure was achieved by partial occlusion of the tailpiece of a manually triggered demand valve ventilator during expiration. This is a simple effective method of generating PEEP and correcting hypoxaemia without the need for any additional specialised equipment. However, PEEP decreased arterial blood pressure and should be implemented with caution if arterial blood pressure is not monitored. © 2021 The Authors.

O. Liehrmann, J.A.H. Crawley, M.W. Seltmann, S. Feillet, U.K. Nyein, H.H. Aung, W. Htut, M. Lahdenperä, L. Lansade & V. Lummaa

Handler familiarity helps to improve working performance during novel situations in semi-captive Asian elephants

Scientific Reports 11 (2021) e15480

Abstract. Working animals spend hours each day in close contact with humans and require training to understand commands and fulfil specific tasks. However, factors driving cooperation between humans and animals are still unclear, and novel situations may present challenges that have been little-studied to-date. We investigated factors driving cooperation between humans and animals in a working context through behavioural experiments with 52 working semi-captive Asian elephants. Human-managed Asian elephants constitute approximately a third of the remaining Asian elephants in the world, the majority of which live in their range countries working alongside traditional handlers. We investigated how the familiarity and experience of the handler as well as the elephant's age and sex affected their responses when asked to perform a basic task and to cross a novel surface. The results highlighted that when novelty is involved in a working context, an elephant's relationship length with their handler can affect their cooperation: elephants who had worked with their handler for over a year were more willing to cross the novel surface than those who had a shorter relationship with their handler. Older animals also tended to refuse to walk on the novel surface more but the sex did not affect their responses. Our study contributes much needed knowledge on human-working animal relationships which should be considered when adjusting training methods and working habits. © 2021 The Authors.

T. Mahmood, T.T. Vu, A. Campos-Arceiz, F. Akrim, S. Andleeb, M. Farooq, A. Hamid, N. Munawar, M. Waseem, A. Hussain, H. Fatima, M.R. Khan & S. Mahmood

Historical and current distribution ranges and loss of mega-herbivores and carnivores of Asia

PeerJ 9 (2021) e10738

Abstract. Ecosystem functioning is dependent a lot on large mammals, which are, however, vulnerable and facing extinction risks due to human impacts mainly. Megafauna of Asia has been declining for a long, not only in numbers but also in their distribution ranges. In the current study, we collected information on past and current occurrence and distribution records of Asia's megafauna species. We reconstructed the historical distribution ranges of the six herbivores and four carnivores for comparison with their present ranges, to quantify spatially explicit levels of mega-defaunation. Results revealed that historically the selected megafauna species were more widely distributed than at current. Severe range contraction was observed for the Asiatic lion, three rhino species, Asian elephant, tigers, and tapirs. Defaunation maps generated have revealed the vanishing of megafauna from parts of the East, Southeast, and Southwest Asia, even some protected Areas losing up to eight out of ten megafaunal species. These defaunation maps can help develop future conservation policies, to save the remaining distribution ranges of large mammals. © 2021 The Authors.

M.A.M. Moustafa, H.M. Chel, M.J. Thu, S. Bawm, L.L. Htun, M.M. Win, Z.M. Oo, N. Ohsawa, M. Lahdenperä, W.M.A. Mohamed, K. Ito, N. Nonaka, R. Nakao & K. Katakura

Anthropogenic interferences lead to gut microbiome dysbiosis in Asian elephants and may alter adaptation processes to surrounding environments

Scientific Report 11 (2021) e741

Abstract. Human activities interfere with wild animals and lead to the loss of many animal populations. Therefore, efforts have been made to understand how wildlife can rebound from anthropogenic disturbances. An essential mechanism to adapt to environmental and social changes is the fluctuations in the host gut microbiome. Here we give a comprehensive description of anthropogenically induced microbiome alterations in Asian elephants (n = 30). We detected gut microbial changes due to overseas translocation, captivity and deworming. We found that microbes belonging to Planococcaceae had the highest contribution in the microbiome alterations after translocation, while Clostridiaceae, Spirochaetaceae and Bacteroidia were the most affected after captivity. However, deworming significantly changed the abundance of Flavobacteriaceae, Sphingobacteriaceae, Xanthomonadaceae, Weeksellaceae and Burkholderiaceae. These findings may provide fundamental ideas to help guide the preservation tactics and probiotic replacement therapies of a dysbiosed gut microbiome in Asian elephants. More generally, these results show the severity of anthropogenic activities at the level of gut microbiome, altering the adaptation processes to new environments and the subsequent capability to maintain normal physiological processes in animals. © 2021 The Authors.

Y.S.S. Muir, B. Bryant, M. Campbell-Ward & D.P. Higgins

Retrospective anti-tetanus antibody responses of zoo-based Asian elephants (*Elephas maximus*) and rhinoceros (Rhinocerotidae)

Developmental & Comparative Immunology 114 (2021) e103841

Abstract. Tetanus toxoids (TT) commercially available for use in horses and livestock are commonly used to vaccinate elephants and rhinoceros that are in human care. Although recommendations for booster intervals have changed in human and horse protocols to reduce the risks associated with hyper-immunity (i.e. B-cell anergy and hypersensitivity reactions) these have generally not been adopted in zoo protocols. Additionally, there is no evidence to demonstrate commercial TT immunogenicity in rhinoceros. In this study, a preliminary analysis of rhinoceros antibody responses to TT was conducted, in addition to an exploration of the impact of various booster frequencies on antibody responses in elephant. Retrospective analysis of archived serum samples was conducted for 9 Asian elephants (*Elephas maximus*), 7 southern black (*Diceros bicornis minor*), one southern white (*Ceratotherium simum simum*), and two greater one-horned (*Rhinoceros unicornis*) rhinoceros. Pre-vaccination (baseline) samples and those following priming vaccination (rhinoceros only), annual and non-annual

boosters were targeted. A commercially available competitive ELISA kit was used to quantify serum anti-TT antibodies. Average baseline and post-vaccination anti-tetanus antibody concentrations were greater in elephant (92 ± 42 mg/l; 125 ± 76 mg/l) than in rhinoceros (47 ± 39 mg/l; 44 ± 37 mg/l). Rhinoceros antibody concentrations did not differ markedly following vaccinations from their naturally acquired high pre-vaccination concentrations. Eight elephants demonstrated antibody maintenance for 3–5 years without a tetanus booster. Additionally, although five out of nine elephants developed local reactions consistent with delayed type IV hypersensitivity following some boosters, there was no association between high antibody concentrations and increased incidence of adverse reactions. In addition, no decrease in antibody concentrations was detected as a result of annual vaccination in elephants, though this does not entirely rule out potential for B-cell anergy. © 2020 The Authors.

C. Pabutta, N. Bangkaew, P. Inthawong, P. Mahadthai, W. Jairak, N. Soda, M. Sukmak & S. Sripiboon

The first report on internal transcribed spacer region-based characterization of microfilaria in Asian elephants (*Elephas maximus*) in Thailand

Veterinary World 14 (2021) 2260-2266.

Abstract. Filarial infections can significantly impact the health of both humans and animals. In elephants, filariasis has been associated with cutaneous dermatitis and skin nodules. However, molecular evidence for such infections is limited in Thailand. This study aimed to identify the morphological and molecular characteristics of microfilaria in captive Asian elephants in Thailand. Whole blood collected from the ear vein of 129 captive Asian elephants was hematologically analyzed, and the blood parasites were evaluated using three standard techniques: The microcapillary test, thin blood smears, and polymerase chain reaction (PCR). Conventional PCR revealed that approximately 17% (22/129) of the sampled elephants were positive for microfilaria. Microscopy revealed that microfilariae are large, unsheathed, with extended nuclei, a short headspace, and a curved tail tapering at the end. Results of internal transcribed spacer region analysis show that the elephant microfilariae are closely related to *Onchocerca* spp. All of the elephants positive for microfilaria presented with neither skin lesion nor anemic signs. Microfilaria infection was not associated with age; however, microfilariae were more likely to be detected in male elephants due to differences in management systems. This is the first study to provide both morphological and molecular evidence of microfilaria in Thai elephants. There is an urgent need to investigate the long-term and large-scale effects of microfilaria on the health of elephants. © 2021 The Authors.

M.D. Patil, V.K. Patil & N.A. Mungi

Spatiotemporal movement pattern of Asian elephants *Elephas maximus* Linnaeus, 1758 in Sindhudurg District, Maharashtra, India

Journal of Threatened Taxa 13 (2021) 18099-18109

Abstract. The extension of the Asian elephant's *Elephas maximus* range in the northern Western Ghats (Sahyadri) was observed since 2002. This colonization was marked by elephant crop raiding events in the newly colonized Sindhudurg District, where the local community had no experience of living with elephants. The present study was conducted to understand the spatiotemporal patterns of crop depredation (raiding) and to prioritize areas to inform future interventions on managing this ecological phenomenon turned conflict. Data on crop raiding between 2002 and 2015 was obtained from compensation records with the state forest department, and mapped at village scale. Subsequently, we used three indices of crop raiding, viz., Crop Raiding Frequency (CRF), Relative Crop Raiding Intensity (RCRI), and Crop Raiding Vulnerability Index (CRVI). Results show a gradual northern movement of elephants and of the crop raiding zone over the period of 2002–2015. The rankings provided by CRVI, identified villages in a narrow strip of foothills of the Sahyadri mountains as severely vulnerable. With sufficient long term data, CRVI would be a highly useful index for prioritization of villages for resolving human-ele-

phant negative interactions; and other cases of human-wildlife interactions too. © 2021 The Authors.

E.N. Paul, P. Thompson, N. Miller, P. Meagher & L. Vogelnest

Dispersion of aerosolized bacteria from Asian elephants (*Elephas maximus*)

Journal of Zoo and Wildlife Medicine 52 (2021) 749-754

Abstract. Transmission of tuberculosis typically requires close and prolonged contact with an infected individual. However, several cases of transmission between elephants and from elephants to humans or other animals without direct contact or over long distances have been reported. Elephants have been shown to be capable of producing aerosolized bacterial droplets, suggesting a possible route of transmission that is magnified by the size and force of the elephant respiratory tract. To investigate the dispersion and viability of aerosolized bacteria generated from the elephant respiratory tract, a pre-existing model with a proxy organism was used. A six-stage Andersen sampler was used to detect the proxy organism, a commensal elephant respiratory bacterium, at different locations around an elephant barn at a zoo. The amount of proxy organism detected at various time points and distances from the elephants indicates they are capable of dispersing viable bacterial aerosols further than humans can. The concentration of these aerosols is dependent on proximity to the elephants and does not remain at a high level for prolonged periods of time. These findings support the model of aerosol-mediated transmission of bacteria from elephants and can be used to improve disease management practices and prevent the spread of pathogens from elephants in zoos and other facilities. © 2021 American Association of Zoo Veterinarians.

U. Penjor, Ż. Kaszta, D.W. Macdonald & S.A. Cushman

Prioritizing areas for conservation outside the existing protected area network in Bhutan: The use of multi-species, multi-scale habitat suitability models

Landscape Ecology 36 (2021) 1281-1309

Abstract. Understanding the environmental and anthropogenic factors influencing habitat selection of multiple species is a foundation for quantifying human impacts on biodiversity and developing effective conservation measures. To determine the effect of multiple scales of environmental/topographic and anthropogenic variables and landscape patterns on habitat suitability of terrestrial mammals in Bhutan, assess the effectiveness of the current protected area network, identify areas of high species richness outside of the existing protected area, and evaluate the potential effectiveness of indicator and umbrella species for conservation planning. We modelled multi-scale habitat selection of sixteen species of terrestrial mammals across Bhutan using data from a nation-wide camera trap survey. We used the predicted species distribution maps to assess the multi-species conservation effectiveness of the existing protected area network. We performed simulations to identify high priority areas for multiple species based on their habitat suitability, proximity to existing protected areas and overall connectivity within the predicted distribution of species. We used correlation analysis among predicted occurrence maps and multivariate cluster analysis to identify potential indicator species. We evaluated the potential utility of each species as umbrella species by assessing how well optimal protected areas for that species would protect suitable habitat for all 16 species simultaneously. Protected areas and forest cover were strongly associated with habitat use of most modelled species. Additionally, topographical features, like terrain roughness and slope position, contributed to habitat selection of multiple species, but often in different ways. Environmental and topographical variables were mostly selected at medium to broad scales. Anthropogenic variables (agriculture and built-up areas) were negatively associated with habitat suitability of most species at both fine and broad scales. Conservation effectiveness assessment of existing protected areas found protected areas in south-central Bhutan have high effectiveness in terms of both mean and total richness protected. Similarly, biological corridors in the south-central region offered high mean richness protection. Our simulation of optimal areas for ad-

ditional protection found areas abutting protected areas in southern Bhutan offered high relative species richness protection. Our umbrella species analysis found muntjac, wild pig, serow, sambar and Asian golden cat are the most effective umbrella species for broader biodiversity protection. Our indicator species analysis found tiger, gaur, dhole, clouded leopard, Asian black bear and common leopard as effective indicator species. This study highlights the need to protect optimally located species-rich areas outside the current protected areas. This kind of multi-species habitat assessment provides important information to optimize future conservation and development plans at national and regional scales. © The Authors 2021.

K.L. Perrin, A.T. Kristensen, M.F. Bertelsen & D. Denk

Retrospective review of 27 European cases of fatal elephant endotheliotropic herpesvirus-haemorrhagic disease reveals evidence of disseminated intravascular coagulation

Scientific Reports 11 (2021) e14173

Abstract. Elephant endotheliotropic herpesvirus haemorrhagic disease (EEHV-HD) is widely acknowledged as the most common cause of mortality in young Asian elephants (*Elephas maximus*) in captivity. The objective of the current study was to perform a blinded, retrospective pathology review of European EEHV-HD fatalities, constituting the largest systematic assessment of EEHV-HD pathology to date. Findings between viral genotypes were compared with the aim to investigate if disseminated intravascular coagulation (DIC) could be substantiated as a significant complicating factor, thereby increasing the understanding of disease pathophysiology. Immunohistochemical staining confirmed endothelial cell (EC) damage and the presence of EC intranuclear inclusion bodies, demonstrating a direct viral cytopathic effect. Microthrombi were observed in 63% of cases in several organs, including lungs, which, together with widespread haemorrhage and thrombocytopenia reported in EEHV-HD case reports, supports the presence of overt DIC as a serious haemostatic complication of active EEHV infection. Death was attributed to widespread vascular damage with multi-organ dysfunction, including severe acute myocardial haemorrhage and subsequent cardiac failure. Systemic inflammation observed in the absence of bacterial infection may be caused by cytokine release syndrome. Findings reinforce the necessity to investigate cytokine responses and haemostatic status during symptomatic and asymptomatic EEHV viraemia, to potentially support the use of anti-inflammatory treatment in conjunction with anti-viral therapy and cardiovascular support. © The Authors 2021.

K.L. Perrin, S. Saxmose Nielsen, T. Martinussen & M.F. Bertelsen

Quantification and risk factor analysis of elephant endotheliotropic herpesvirus-haemorrhagic disease fatalities in Asian elephants (*Elephas maximus*) in Europe (1985–2017)

Journal of Zoo and Aquarium Research 9 (2021) 8-13

Abstract. Elephant endotheliotropic herpesvirus-haemorrhagic disease (EEHV-HD) is frequently stated to be the most common cause of death in captive Asian elephant *Elephas maximus* populations in Europe and North America. However, the impact on the European population has not been quantified. The aim of this study was to quantify and describe EEHV deaths in Asian elephants in Europe between 1985 and 2017, and to evaluate potential risk factors. Asian elephants born in the study period were tracked for eight years, or until death, depending on which occurred first. Excluding stillborn and perinatal deaths (<1 day old), 44 elephants died within the study period. EEHV-HD accounted for 57% of these cases, and was therefore the most frequent cause of death. While all known Asian elephant endemic EEHV-genotypes were represented, EEHV-1A was responsible for 80% of EEHV deaths. The median age of EEHV fatalities was 2.6 years and there was no difference in risk between males and females. The only significant risk factor for EEHV death, analysed using Cox regression analysis, was an institutional history of a previous EEHV death. Importantly, exposure to new elephants was not associated with an increased risk of EEHV death.

T. Pitakarnnop, K. Buddhachat, P. Pakdeenarong & K. Nganvongpanit

Elemental distribution in animal carpal and tarsal bones using differences in X-ray fluorescence energy

Biological Trace Element Research 199 (2021) 874-887

Abstract. No permission to print abstract.

S.S. Pokharel, H. Yoneda, M. Yanagi, R. Sukumar & K. Kinoshita

The tail-tale of stress: An exploratory analysis of cortisol levels in the tail-hair of captive Asian elephants

PeerJ 9 (2021) e10445

Abstract. Assessment of physiological states by measuring biomarkers, such as cortisol, has significantly contributed to the monitoring of health, welfare and management of animals. Immunoreactive cortisol in hair (hC) has been used widely for deciphering 'stressful' past-events in various wild and captive animals. However, no such studies have been done in long-lived mammals. In this first exploratory study in elephants, we assessed (i) tail-hair growth rate (TGR) and (ii) hC levels in tail-hair samples from six captive Asian elephants from two zoos in Japan for comparing hC levels with zoo-keepers' records of distinct biological events over a c.0.5–2.0-year period. Tail-hair samples were cut into segments (based on monthly growth rate), pulverized or minced and a validated cortisol enzyme-immunoassay employed to measure hC levels. When the hC levels of all individuals were compared with the keepers' records, a posteriori, most of the high hC levels were found to be associated with 'stressful' or distinct behavioural events such as pathological (anaemia, colic infection, skin infection, oral sores), psychosocial (reluctance in entering the enclosure, presence of a calf) and husbandry practice-related (contact trials/ space sharing) conditions, indicating that tail-hair indeed can be a potential 'retrospective' calendar of physiological health of an animal. Our observations open up the possibility of using the tail-hair as an alternative matrix to reconstruct the physiological history of elephants. © 2021 The Authors.

N.A. Prado, J.L. Brown, J.A. Zoller, A. Haghani, M. Yao, L.R. Bagryanova, M.G. Campana, J.E. Maldonado, K. Raj, D. Schmitt, T.R. Robeck & S. Horvath

Epigenetic clock and methylation studies in elephants

Aging Cell 20 (2021) e13414

Abstract. Age-associated DNA-methylation profiles have been used successfully to develop highly accurate biomarkers of age ("epigenetic clocks") in humans, mice, dogs, and other species. Here we present epigenetic clocks for African and Asian elephants. These clocks were developed using novel DNA methylation profiles of 140 elephant blood samples of known age, at loci that are highly conserved between mammalian species, using a custom Infinium array (HorvathMammalMethylChip40). We present epigenetic clocks for Asian elephants (*Elephas maximus*), African elephants (*Loxodonta africana*), and both elephant species combined. Two additional human-elephant clocks were constructed by combining human and elephant samples. Epigenome-wide association studies identified elephant age-related CpGs and their proximal genes. The products of these genes play important roles in cellular differentiation, organismal development, metabolism, and circadian rhythms. Intracellular events observed to change with age included the methylation of bivalent chromatin domains, and targets of polycomb repressive complexes. These readily available epigenetic clocks can be used for elephant conservation efforts where accurate estimates of age are needed to predict demographic trends. © 2021 The Authors.

P. Prompiram, W. Wiriyarat, B. Bhusri, W. Paungpin, W. Jairak, S. Sripiboon & T. Wongtawan

The occurrence of elephant endotheliotropic herpesvirus infection in wild and captive Asian elephants in Thailand: Investigation based on viral DNA and host antibody

Veterinary World 14 (2021) 545-550

Elephant endotheliotropic herpesvirus (EEHV) is a serious disease, threatening the life of young elephants. Many elephants have been infected with no clinical signs and may serve as carriers

spreading this disease. It is important to monitor the disease through clinical signs and molecular diagnosis. In this study we investigated the occurrence of EEHV and the efficiency of different techniques used to monitor EEHV infection in various samples and populations of Asian elephants. Blood and trunk swabs were collected from live elephants, while visceral organs (lung, digestive tract, spleen, lymph nodes, and kidney) were collected from dead elephants. EEHV was detected by polymerase chain reaction (PCR) in whole blood, trunk swabs, and visceral organs as samples, while elephant anti-EEHV immunoglobulin G (IgG) in serum was detected by enzyme-linked immunosorbent assay (ELISA). A total of 162 samples were analyzed in this study: 129 from healthy, 26 from dead, and 7 from sick elephants. The present study showed that the overall incidence of EEHV was 40.1% (n=65/162). Approximately 46.2% (n=12/26) and 85.7% (n=6/7) of dead and sick elephants were positive for EEHV by PCR, respectively. All sick elephants that were young and affected by EEHV clinical disease tested negative for the IgG antibody ELISA, suggesting primary EEHV infection in this group. In addition, 2.3% (n=3/129) of subclinical infections were detected using PCR, and trunk swab samples showed slightly higher sensitivity (5.3%, n=2/38) to detect EEHV than whole blood (1.2%, n=1/84). As many as, 48.4% (n=44/91) of healthy elephants were EEHV seropositive (ELISA-positive), suggesting that many elephants in Thailand had previously been infected. Overall, 30% of dead wild elephants had been infected with EEHV (n=3/10). Moreover, statistical analysis revealed no significant differences in the EEHV detection rate between different age groups or sexes ($p>0.05$). PCR is better than ELISA to detect EEHV active infection in dead/sick elephants and to monitor EEHV in young elephants. ELISA is suitable for detecting previous EEHV infection and carriers, particularly adults. Theoretically, we could use both PCR and ELISA to increase the sensitivity of testing, along with observing abnormal behavior to efficiently monitor this disease. Identification of EEHV carriers within elephant populations is important to prevent transmission to healthy individuals, especially young elephants with high mortality from EEHV. This is the first report from Thailand regarding EEHV infection in wild elephants, showing the importance of preventing disease transmission between captive and wild elephants. © 2021 The Authors.

U. Rajhans, G. Wankhede, B. Ambore, S. Chaudhari, N. Nighot, V. Dhaygude & C. Sonekar

Sero-diagnosis of tuberculosis in elephants in Maharashtra, India

J. of Threatened Taxa 13 (2021) 18713-18718

Abstract. Tuberculosis is a highly contagious zoonotic disease caused by *Mycobacterium* spp. A study was conducted to detect the presence of *Mycobacterium* in captive elephants. A total of 15 captive elephants were screened from various regions in Maharashtra. The blood and serum samples collected were subjected to rapid test kit, BacT/ALERT 3D system, Ziehl-Neelsen (ZN) staining and PCR. All the samples were found seronegative using rapid test kit and whole blood PCR. Whereas, all samples were signalled culture positive in BacT/ALERT 3D system which were further subjected to PCR, only one amplicon was produced of 176 bp of RD4 gene (*Mycobacterium bovis*) and no acid-fast organism was detected upon ZN. Due to the atypical nature of this organism, diagnosis of this disease in elephants using various tests is complicated unlike the diagnostic tests that are validated in domestic animals. Therefore, many tests have sub-optimal sensitivity and specificity in elephants. As TB is a zoonotic disease, transmission can occur between human-livestock-elephants interface. Therefore, the zoos and state forest authority should inculcate a protocol of periodic TB screening for mahouts and elephants in captivity along with protocol of elephant-visitor interaction, thus helping in conservation of this endangered species in India. © 2021 The Authors.

A.K. Schulz, J.N. Wu, S.Y.S. Ha, G. Kim, S. Braccini Slade, S. Rivera, J.S. Reidenberg & D.L. Hu

Suction feeding by elephants

Journal of the Royal Society Interface 18 (2021) e20210215

Abstract. Despite having a trunk that weighs over 100 kg, elephants mainly feed on lightweight vegetation. How do elephants manipulate such small items? In this experimental and theoretical investigation, we filmed elephants at Zoo Atlanta showing that they can use suction to grab food, performing a behaviour that was previously thought to be restricted to fishes. We use a mathematical model to show that an elephant's nostril size and lung capacity enables them to grab items using comparable pressures as the human lung. Ultrasonographic imaging of the elephant sucking viscous fluids show that the elephant's nostrils dilate up to 30% in radius, which increases the nasal volume by 64%. Based on the pressures applied, we estimate that the elephants can inhale at speeds of over 150 m/s, nearly 30 times the speed of a human sneeze. These high air speeds enable the elephant to vacuum up piles of rutabaga cubes as well as fragile tortilla chips. We hope these findings inspire further work in suction-based manipulation in both animals and robots. © 2021 The Authors.

C.S. Sepalage & R.S. Rajakaruna

Gastrointestinal helminth and protozoan infections of wild mammals in four major national parks in Sri Lanka

J. of Threatened Taxa 12 (2020) 17093-17104

Abstract. A cross-sectional, coprological survey of gastrointestinal (GI) parasites of wild mammals in four major National Parks in Sri Lanka: Wilpattu, Udawalawe, Wasgamuwa, and Horton Plains was carried out during November 2016 to August 2017. Fresh fecal samples were collected and analyzed using sedimentation technique, iodine & saline smears, and Sheather's sucrose flotation for morphological identification parasite eggs, cysts, and larvae. A modified salt flotation was carried out for egg counts. Seventy samples from 10 mammal species: Asian elephant, spotted deer, water buffalo, sambar, Indian hare, Asian palm civet, sloth bear, wild boar, grey langur, leopard, and four unknown mammals (two carnivores, one herbivore and one omnivore) were analyzed. Most were infected (94.3%) with more than one GI parasites. The highest prevalence of infection was recorded in Horton Plains (100%), followed by Wasgamuwa (92.8%), Wilpattu (90.4%) and Udawalawe (75.0%) with a significant difference among four parks (Chi square test; $\chi 2=35.435$; df=3; $p<0.001$). Nineteen species of GI parasites were recorded, of which *Entamoeba*, *Isospora*, *Balantidium*, *Fasciola*, *Moniezia*, *Dipylidium*, strongyles, *Toxocara*, *Trichiurus* and hookworms were the most common. Strongyles (62.1%) and *Entamoeba* (80.3%) were the most prevalent helminth and protozoan infections, respectively. Overall, there was no difference in the prevalence of protozoans (84.3%) and helminths (87.1%; $\chi^2=1.0$; df=1; p=0.317). In carnivores, *Entamoeba*, *Balantidium*, *Moniezia*, strongyles and *Strongyloides* were common and in herbivores, *Entamoeba*, strongyles, *Strongyloides* and *Toxocara* were common. The quantitative analysis showed strongyles (17.639 EPG) and Isospora (18,743 OPG) having the highest infection intensity among helminthes and protozoans, respectively. This study provides baseline information of GI parasites and their distribution in wild mammals in the four national parks. Although the prevalence of GI infections was high, their intensity shows that they could be incidental infections. When the prevalence of an infection is high but the intensity is low, it is unlikely to be a major health problem leading to the endangerment of a species. Parasitic diseases can not only affect conservation efforts, but they are also natural selection agents and drive biological diversification, through influencing host reproductive isolation and speciation. © 2020 The Authors.

T.T. Shameer, N.A. Mungi, B. Ramesh, S.V. Kumar & P.S. Easa

How can spatio-temporal overlap in mammals assist in maximizing biodiversity conservation? A case study of Periyar Tiger Reserve

Biologia 76 (2021) 1255-1265

Abstract. No permission to print abstract.

J.L. Siegal-Willott, P. Anikis, D.L. Neiffer, T. Barthel & L.R. Goodrich

Use of intracarpal interleukin receptor antagonist protein (IRAP) and hyaluronic acid in a multimodal therapeutic regime for os-

teoarthritis in an Asian elephant (*Elephas maximus*)
Journal of Zoo and Wildlife Medicine 52 (2021) 401-405
Abstract. An approximately 41-yr-old female Asian elephant (*Elephas maximus*) experiencing forelimb stiffness and decreased range of motion was diagnosed with bilateral carpal osteoarthritis (OA). Standing sedation combined with local anesthesia was used to deliver ultrasound-guided carpal articular injections of an autologous conditioned serum product, interleukin receptor antagonist protein, combined with hyaluronic acid. Within 2 mo of completing therapy, improved range and speed of motion were evident. Reduced inflammation was suggested by decreased carpal articular prostaglandin E2 levels. Subjectively improved clinical signs lasted approximately 5–6 mo, at which point carpal articular injections were repeated. Joint inflammatory markers were useful in gauging response to treatment and may provide guidance in the diagnostic and therapeutic approach to elephant OA. On the basis of the positive response noted, interarticular autologous therapy combined with hyaluronic acid should be considered for carpal OA in elephants. © 2021 American Association of Zoo Veterinarians.

R.J. Snyder, L.P. Barrett, R.A. Emory & B.M. Perdue
Performance of Asian elephants (*Elephas maximus*) on a quantity discrimination task is similar to that of African savanna elephants (*Loxodonta africana*)
Animal Cognition 24 (2021) 1121-1131
Abstract. No permission to print abstract.

S. Sripiboon, P. Dittawong, P. Meetipkit, W. Songsuwankit, A. Jaidee, N. Detcharoenyos, S. Phetdee, P. Santhitisaree, N. Thongtip & W. Tangjitjaroen
Asian elephant (*Elephas maximus*) suffering from lightning strike successfully treated by integrative veterinary medicine
Journal of Zoo and Wildlife Medicine 51 (2020) 1067-1071
Abstract. A captive female Asian elephant (*Elephas maximus*), approximately 30 yr old, was struck by lightning and displayed obtundation, dysphagia, drooling, and muscle weakness. A physical examination, hematologic test, blood gas analysis, and electrocardiogram were performed. Treatments included the administration of mannitol, dexamethasone, antibiotics, analgesics, vitamins, and intravenous fluid. Conventional therapy resulted in improvement but not complete resolution of clinical signs. Therefore, acupuncture was integrated into the treatment protocol. Electroacupuncture and laser acupuncture were administered every other day; aqua acupuncture was administered once a week. No complications were observed during acupuncture treatment. Acupuncture, a form of traditional Chinese veterinary medicine (TCVM), contributed to the resolution of clinical signs in this case and may be an effective adjunctive treatment for other neurologic disorders in elephants. © 2021 American Association of Zoo Veterinarians.

W. Sukmantoro, A. Suyitno, Mulyadi, D. Gunaryadi, A. Seno, A.I. Kusuma & Darwis
Population, distribution, and habitat of Bornean Elephant in Tulin Onsoi, Nunukan District, Indonesia based on dung counts
Biodiversitas 22 (2021) 311-319
Abstract. The survey on population, distribution, and habitat of Bornean elephants is very important because it reduces the information gap about Bornean elephants' population and distribution. In more detail, the study can be used for updating information and the needs of local government in a spatial plan based on biodiversity conservation. The survey of Bornean Elephant was conducted in Tulin Onsoi Subdistrict, Nunukan District, North Kalimantan Province, Indonesia, starting in February 2018 to May 2019. The survey area's scopes are Agison, Sibuda, Apaan, and Tampilon subwater catchment areas in 34 (5 x 5 km^2) grids with a total of 850 km^2. The occupancy method with perpendicular line transect was used in this study. In the survey, the number of traces was 52 finding points with a total of 241 traces. The elephant dung identified in the dung piles (one-time defecation) was in 29 finding points with a total of 38 dung piles (0.22 dung piles per km). Based on Distance 6.0 and involved the formula

of the elephant population's density with standard defecation and dung decay ratio, the elephant population density in the Tulin Onsoi is between 4.8–5.7 individuals/100 km^2. Minimum convex polygon (MCP)-qHull showed that the area of the elephant habitat is 253.12 km^2 in Tulin Onsoi sub-district. Generally, the habitat conditions for the location are old secondary forests (37 %). Meanwhile, other habitats included in the survey area are primary forest, shrubs, and plantations, including community agriculture and roads. In the strategy of managing the Bornean elephant, efforts to stabilize or increase population are important things to do. Conservation-based spatial planning and close monitoring for the protection of small populations of this species and its threats, are options that can be selected for present and future in North Kalimantan.

Y. Sun, Y. Chen, J.J. Díaz-Sacco & K. Shi
Assessing population structure and body condition to inform conservation strategies for a small isolated Asian elephant (*Elephas maximus*) population in southwest China
PLoS ONE 6 (2021) e0248210
Abstract. The Asian elephant (*Elephas maximus*) population in Nangunhe National Nature Reserve in China represents a unique evolutionary branch that has been isolated for more than twenty years from neighboring populations in Myanmar. The scarcity of information on population structure, sex ratio, and body condition makes it difficult to develop effective conservation measures for this elephant population. Twelve individuals were identified from 3,860 valid elephant images obtained from February to June 2018 (5,942 sampling effort nights) at 52 camera sites. Three adult females, three adult males, one subadult male, two juvenile females, two juvenile males and one male calf were identified. The ratio of adult females to adult males was 1:1, and the ratio of reproductive ability was 1:0.67, indicating the scarcity of reproductive females as an important limiting factor to population growth. A population density of 5.32 ± 1.56 elephants/100 km^2 was estimated using Spatially Explicit Capture Recapture (SECR) models. The health condition of this elephant population was assessed using an 11-point scale of Body Condition Scoring (BCS). The average BCS was 5.75 (n = 12, range 2–9), with adult females scoring lower than adult males. This isolated population is extremely small and has an inverted pyramid age structure and therefore is at a high risk of extinction. We propose three plans to improve the survival of this population: improving the quality and quantity of food resources, removing fencing and establishing corridors between the east and wet parts of Nangunhe reserve. © 2021 The Authors.

N. Suwanchatree, P. Thanakiatkrai, A. Linacre & T. Kitpipit
Discrimination of highly degraded, aged Asian and African elephant ivory using denaturing gradient gel electrophoresis (DGGE)
International Journal of Legal Medicine 135 (2021) 107-115
Abstract. No permission to print abstract.

T.M. Taher, T. Lihan, N.A.T. Arifin, N.F. Khodri, M.A. Mustapha, P.A. Patah, S.H.A. Razali & S.M. Nor
Characteristic of habitat suitability for the Asian elephant in the fragmented Ulu Jelai Forest Reserve, Peninsular Malaysia
Tropical Ecology 62 (2021) 347-358
Abstract. No permission to print abstract.

Z.M. Thant, R. May & E. Røskaft
Pattern and distribution of human-elephant conflicts in three conflict-prone landscapes in Myanmar
Global Ecology and Conserv. 25 (2021) e01411
Abstract. Human-elephant conflicts (HEC) are detrimental for both humans and elephants. A better understanding of HEC enhances effective mitigation strategies and promotes the well-being of humans and wild elephants. This study assesses the pattern and distribution of HEC in three different HEC hotspots in Myanmar and identifies local factors that contribute to HEC. A face-to-face questionnaire survey was performed in three HEC landscapes in 30 villages. Our study showed that larger croplands were more vulnerable to crop attacks. Crop damage was found more frequent and was more severe in the more deforested landscapes. The land-

scapes with higher human density and where local people frequently encountered elephants, were at higher risk to elephant attack. Our results indicate that distance to the forest reserves influenced the incidents of HEC most. We suggest the implementation of land-use plans in the potential elephant migration areas to mitigate HEC and improve the local resilience to economic vulnerability due to HEC. © 2020 The Authors.

J. Thapa, S.K. Mikota, K.P. Gairhe, S. Paudel, D.K. Singh, I.P. Dhakal, C. Nakajima & Y. Suzuki

Tuberculosis seroprevalence and comparison of hematology and biochemistry parameters between seropositive and seronegative captive Asian elephants of Nepal

Journal of Veterinary Medical Science 83 (2021) 1278-1283

Abstract. We conducted a tuberculosis (TB) serosurveillance program of captive elephants in Nepal and compared hematology and biochemistry parameters between seropositive and seronegative elephants. A total of 153 elephants (male=20, female=133) from four national parks were tested for TB using the ElephantTB STAT-PAK® Assay (ChemBio Diagnostic Systems, Inc., Medford, NY, USA). The mean reported age for 138 elephants was 38.5 years (range 2–71 years). Seroprevalence for TB was 21.56% (33/153). The majority of seropositive elephants were female (n=30) and from Chitwan National Park (n=29). The occurrence of TB seropositive cases in other more remote national parks suggests TB may be widespread among the captive elephant population of Nepal. Hematology and biochemistry analyses were performed on 13 and 22 seropositive elephants, respectively and, nine elephants from a seronegative TB herd for comparison. Hematology parameters (hemoglobin, packed cell volume, platelet, white blood cells, and erythrocyte sedimentation rate) were comparable between the two groups. Total protein, globulin, and lactate dehydrogenase were significantly higher in seronegative elephants, and bilirubin was significantly higher in seropositive elephants whereas blood urea nitrogen, creatinine, glutamic oxaloacetic transaminase/aspartate aminotransferase (GOT/AST), glutamic pyruvic transaminase/alanine aminotransferase (GPT/ALT), gamma glutamyl transferase (GT), and albumin were not significantly different. The range of biochemical parameters that were significantly different between seropositive and seronegative elephants had narrow ranges. Thus, the potential of these parameters as a direct biomarker for TB diagnosis is limited based on the findings in this study. We recommend including blood parameters in future TB surveillance studies. © 2021 The Japanese Society of Veterinary Science.

M. Tollis, E. Ferris, M.S. Campbell, V.K. Harris, S.M. Rupp, T.M. Harrison, W.K. Kiso, D.L. Schmitt, M.M. Garner, C.A. Aktipis, C.C. Maley, A.M. Boddy, M. Yandell, C. Gregg, J.D. Schiffman & L.M. Abegglen

Elephant genomes reveal accelerated evolution in mechanisms underlying disease defenses

Molecular Biology and Evolution 38 (2021) 3606-3620

Abstract. Disease susceptibility and resistance are important factors for the conservation of endangered species, including elephants. We analyzed pathology data from 26 zoos and report that Asian elephants have increased neoplasia and malignancy prevalence compared with African bush elephants. This is consistent with observed higher susceptibility to tuberculosis and elephant endotheliotropic herpesvirus (EEHV) in Asian elephants. To investigate genetic mechanisms underlying disease resistance, including differential responses between species, among other elephant traits, we sequenced multiple elephant genomes. We report a draft assembly for an Asian elephant, and defined 862 and 1,017 conserved potential regulatory elements in Asian and African bush elephants, respectively. In the genomes of both elephant species, conserved elements were significantly enriched with genes differentially expressed between the species. In Asian elephants, these putative regulatory regions were involved in immunity pathways including tumor-necrosis factor, which plays an important role in EEHV response. Genomic sequences of African bush, forest, and Asian elephant gen-

omes revealed extensive sequence conservation at TP53 retrogene loci across three species, which may be related to TP53 functionality in elephant cancer resistance. Positive selection scans revealed outlier genes related to additional elephant traits. Our study suggests that gene regulation plays an important role in the differential inflammatory response of Asian and African elephants, leading to increased infectious disease and cancer susceptibility in Asian elephants. These genomic discoveries can inform future functional and translational studies aimed at identifying effective treatment approaches for ill elephants, which may improve conservation. © 2021 The Authors.

B.R. Tripathy, X. Liu, M. Songer, L. Kumar, S. Kaliraj, N.D. Chatterjee, W.M.S. Wickramasinghe & K.K. Mahanta

Descriptive spatial analysis of human-elephant conflict (HEC) distribution and mapping HEC hotspots in Keonjhar Forest Division, India

Frontiers in Ecology and Evolution 9 (2021) e640624

Abstract. Escalation of human-elephant conflict (HEC) in India threatens its Asian elephant (*Elephas maximus*) population and victimizes local communities. India supports 60% of the total Asian elephant population in the world. Understanding HEC spatial patterns will ensure targeted mitigation efforts and efficient resource allocation to high-risk regions. This study deals with the spatial aspects of HEC in Keonjhar forest division, where 345 people were killed and 5,145 hectares of croplands were destroyed by elephant attacks during 2001–2018. We classified the data into three temporal phases (HEC1: 2001–2006, HEC2: 2007–2012, and HEC3: 2013–2018), in order to (1) derive spatial patterns of HEC; (2) identify the hotspots of HEC and its different types along with the number of people living in the high-risk zones; and (3) assess the temporal change in the spatial risk of HEC. Significantly dense clusters of HEC were identified in Keonjhar and Ghatgaon forest ranges throughout the 18 years, whereas Champua forest range became a prominent hotspot since HEC2. The number of people under HEC risk escalated from 14,724 during HEC1 and 34,288 in HEC2, to 65,444 people during HEC3. Crop damage was the most frequent form of HEC in the study area followed by house damage and loss of human lives. Risk mapping of HEC types and high priority regions that are vulnerable to HEC, provides a contextual background for researchers, policy makers and managers. © 2021 The Authors.

D. Vasudev, V.R. Goswamia & M.K. Oli

Detecting dispersal: A spatial dynamic occupancy model to reliably quantify connectivity across heterogeneous conservation landscapes

Biological Conservation 253 (2021) e108874

Abstract. Connectivity shapes species distribution, spatial population dynamics and genetic structure, and is critical for conservation. It is imperative to reliably identify factors that limit connectivity across heterogeneous, fragmented landscapes. Viewing connectivity as the persistence of movement in space from source to destination—along potential corridors simulated from correlated random walks—we adapt the dynamic occupancy modeling framework to present an approach to reliably quantify connectivity. This approach allowed us to estimate the probability of spatial persistence of movement along potential corridors, while accounting for imperfect detection of animal use of the matrix. We use simulations to test our model, and data from sign surveys of Asian elephant *Elephas maximus* space use in Garo Hills, Northeast India, as a practical application of the method. Distance to forests and ruggedness predominantly shaped elephant connectivity patterns. Negative effects of distance to forests were intensified at the onset of dispersal, and in the more disturbed part of our landscape. We mapped locations critical to maintaining connectivity in our study landscape. We demonstrate that the widely used occupancy modeling approach, when combined with appropriate field data collection, permits explicit assessment of matrix impacts on connectivity while accounting for imperfect detection of animal movement. In so doing, we highlight the value of the approach in enabling inference on where animals move, as well as why. Obtaining a reliable understanding of factors shaping con-

nectivity is central to understanding and predicting species responses to environmental change, thereby facilitating effective long-term conservation in fragmented landscapes. © 2020 Reprinted with permission from Elsevier.

G. Vibha, H.G. Lingaraju & G.V. Venktaramana

Effectiveness of solar fence in reducing human-elephant conflicts in Manchahalli village, Mysuru, Karnataka, India

Current Science 120 (2021) 707-711

Abstract. Human-elephant conflict is not a new issue in the state of Karnataka, India. Primary conflict involves loss of lives on both sides, loss of property and damage to crops. Solar fencing is considered to be the most effective way to mitigate the conflict between humans and elephants. An assessment on the effectiveness of solar-powered fencing was carried out in Manchahalli village, which is located adjacent to Bandipur National Park (BNP), Karnataka and is prone to frequent raids by elephants. Hence, this area was chosen as the study site. Field survey was conducted between March and April 2019, to estimate whether the installation of solar fencing had reduced the damage caused by elephants on the crops. During the survey, questions related to the following factors were considered: area of land owned by farmers, distance from the forest boundary to the croplands, types of crops grown, types of crops damaged, year of installation of solar fence, damage caused to the solar fence, methods used before the installation of solar fencing and the perceived effectiveness of the solar fence. Among the 30 croplands that were surveyed, majority were at less than 2 km from the forest, followed by others ranging between 1 and 1.5 km. Although solar fencing was not helpful in reducing the raids completely, it proved to be more effective than any other conventional method previously used.

T.C. Weisbrod, R. Isaza, C. Cray, L. Adler & N.I. Stacy

The importance of manual white blood cell differential counts and platelet estimates in elephant hematology: Blood film review is essential

Veterinary Quarterly 41 (2021) 30-35

Abstract. Unique features of elephant hematology are known challenges in analytical methodology like two types of monocytes typical for members of the Order Afrotheria and platelet counts of the comparatively small elephant platelet. To investigate WBC differential and platelet data generated by an impedance-based hematology analyzer without availability of validated species-specific software for recognition of elephant WBCs and platelets, compared to manual blood film review. Blood samples preserved in ethylenediaminetetraacetic acid (EDTA) of 50 elephants (n = 35 *Elephas maximus* and n = 15 *Loxodonta africana*) were used. A Mann-Whitney test for independent samples was used to compare parameters between methods and agreement was tested using Bland-Altman bias plots. All hematological variables, including absolute numbers of heterophils, lymphocytes, monocytes, eosinophils, basophils, and platelets, were significantly different ($p < 0.0001$) between both methods of analysis, and there was no agreement using Bland-Altman bias plots. Manual review consistently produced higher heterophil and monocyte counts as well as platelet estimates, while the automated analyzer produced higher lymphocyte, eosinophil, and basophil counts. The hematology analyzer did not properly differentiate elephant lymphocytes and monocytes, and did not accurately count elephant platelets. These findings emphasize the importance of manual blood film review as part of elephant complete blood counts in both clinical and research settings and as a basis for the development of hematological reference intervals. © 2021 The Authors.

G. Wilson, R.J. Gray, R. Radinal, H. Hasanuddin, W. Azmi, A. Sayuti, H. Muhammad, A. Abdullah, B.S. Nazamuddin, H. Sofyan, H.S. Riddle, C. Stremme & A.A. Desai

Between a rock and a hard place: Rugged terrain features and human disturbance affect behaviour and habitat use of Sumatran elephants in Aceh, Sumatra, Indonesia

Biodiversity and Conservation 30 (2021) 597-618

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

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

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

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

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