

EVALUATION OF THE REHABILITATION PROGRAM FOR WILD ELEPHANT
ORPHAN CALVES AT THE ELEPHANT TRANSIT HOME, SRI LANKA

By

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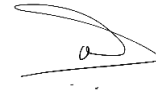
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DECLARATION

I do hereby declare that the work reported in this thesis was exclusively carried out by me under the supervision of Professor. RPVJ Rajapakse (Faculty of Veterinary Medicine and Animal Science, University of Peradeniya, Sri Lanka), Professor Ayona Silva-Fletcher (Royal Veterinary College, University of London, UK) and Dr. Janine L. Brown (Center for Species Survival, Smithsonian Conservation Biology Institute, Front Royal, Virginia, USA). It describes the results of my own independent research except where due reference has been made in the text. No part of this thesis has been previously submitted earlier or concurrently for the same or any other degree.


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TABLE OF CONTENTS

| | |
|---|----|
| DECLARATION..... | 3 |
| ACKNOWLEDGMENTS..... | 4 |
| TABLE OF CONTENTS | 6 |
| LIST OF TABLES..... | 10 |
| LIST OF FIGURES..... | 11 |
| LIST OF ABBREVIATIONS..... | 14 |
| ABSTRACT | 16 |
| CHAPTER 1 | 18 |
| GENERAL INTRODUCTION AND THE OBJECTIVES OF THE STUDY..... | 18 |
| 1.1 Mega Herbivore | 18 |
| 1.2 Elephant..... | 18 |
| 1.3 Asian Elephant..... | 19 |
| 1.4 Elephants in Sri Lanka | 23 |
| 1.5 Human Elephant Conflict in Sri Lanka | 24 |
| 1.6 Elephant Transit Home, Sri Lanka | 31 |
| 1.7 Objectives of the Study | 32 |
| 1.8 Research Permits | 33 |
| CHAPTER 2..... | 34 |
| ASSESSMENT OF THE ORPHAN ELEPHANT REHABILITATION PROGRAMME AT THE ELEPHANT TRANSIT HOME, UDAWALAWE | 34 |
| 2.1 Introduction | 34 |
| 2.1.1 Location of the ETH | 35 |
| 2.2 Overview of Rehabilitation Program in the ETH..... | 37 |
| 2.2.1 Occurrence and Identification of Orphaned Elephant Calves | 37 |
| 2.2.2 Management of Elephant Calves at the ETH..... | 38 |
| 2.2.3 Release of Rehabilitated Calves Back into the Wild | 40 |
| 2.2.4 Public Interest and Visitor Management of the ETH | 42 |
| 2.3 Results..... | 43 |

| | |
|--|----|
| 2.4 Discussion and Further Implications | 47 |
| 2.4.1 Genetic Considerations | 50 |
| 2.4.2 Selection of Elephants for Release and Choice of Locations for Release | 51 |
| 2.4.3 Improvement of the Rehabilitation Process | 54 |
| ASSESSMENT OF THE HEALTH COMPLICATIONS AND MORTALITIES OF | |
| ELEPHANT CALVES AT THE ELEPHANT TRANSIT HOME, UDAWALAWA, SRI | |
| LANKA | |
| 3.1 Orphan Elephant Calves in Sri Lanka | 56 |
| 3.2 Materials and Methods..... | 58 |
| 3.2.1 Health Stabilization and Rehabilitation Phases..... | 58 |
| 3.3 Results | 59 |
| 3.3.1 The Locations Where Orphans Were Found..... | 59 |
| 3.3.2 Age of Elephant Calves at Arrival | 59 |
| 3.3.3 Mortalities of Elephant Calves at the ETH | 60 |
| 3.3.4 Causes for mortalities of elephant calves | 62 |
| 3.3.5 Parasite associated mortalities | 63 |
| 3.3.6 Mortality due to wounds | 64 |
| 3.4 Discussion..... | 66 |
| CHAPTER 4 | 74 |
| DIURNAL PATTERN OF SALIVARY CORTISOL AND ITS VARIATION | |
| FOLLOWING EXOGENOUS ADRENOCORTICOTROPIC HORMONE (ACTH) | |
| STIMULATION IN ELEPHANT CALVES..... | |
| 4.1 Introduction | 74 |
| 4.2 Methodology | 79 |
| 4.2.1 Collection of Saliva | 79 |
| 4.2.2 Administration of ACTH | 80 |
| 4.2.3 Measuring of cortisol in Saliva | 80 |
| 4.2.4 Weather Parameters and Their Potential Influences on Stress Levels | 81 |

| | |
|--|-----|
| 4.2.5 Data analysis | 81 |
| 4.3 Results | 82 |
| 4.4 Discussion..... | 85 |
| CHAPTER 5 | 90 |
| EVALUATION OF THE WELFARE STATUS OF REHABILITATED AND RELEASED ORPHAN ELEPHANT CALVES USING FAECAL GLUCOCORTICOID METABOLITES | 90 |
| 5.1 Introduction | 90 |
| 5.2 Materials and Methods..... | 94 |
| 5.2.1 Study Animals and Study Locations | 94 |
| 5.2.4 Faecal Extraction for fGCM Analysis | 96 |
| 5.2.5 Statistical analyses | 97 |
| 5.3 Results | 97 |
| 5.4 Discussion..... | 100 |
| CHAPTER 6 | 103 |
| GROWTH PATTERNS OF ELEPHANT CALVES AT THE ELEPHANT TRANSIT HOME, SRI LANKA AND A COMPARATIVE ANALYSIS OF BODY CONDITION SCORES WITH WILD ELEPHANT CALVES | 103 |
| 6.1 Introduction | 103 |
| 6.2 Materials and Methods..... | 106 |
| 6.2.1 Monitoring Bodyweight Gain in Elephant Calves | 106 |
| 6.2.2 Body Condition Scoring of Elephant Calves | 106 |
| 6.3 Results | 110 |
| 6.3.1 Weight Gain of Elephants at the ETH..... | 110 |
| 6.3.2 Body Condition Scores | 111 |
| 6.4 Discussion..... | 113 |
| CHAPTER 7 | 122 |
| MONITORING ELEPHANTS AFTER RELEASING FROM THE ELEPHANT TRANSIT HOME INTO THE WILD..... | 122 |

| | |
|--|-----|
| 7.1 Introduction | 122 |
| 7.2 Methodology | 126 |
| 7.2.1 Studied Animals..... | 126 |
| 7.2.2 Monitoring of Released Elephants | 129 |
| 7.3 Results | 130 |
| 7.3.1 Monitoring of Released Elephants - Group 1 | 130 |
| 7.3.2 Observations of Group 2 after release into the MNP | 141 |
| 7.3.3 Monthly ranging distance of elephant groups | 149 |
| 7.4 Discussion..... | 151 |
| 7.4.1 Social organization of released elephants | 152 |
| 7.4.2 Distance Travel by Released Elephants | 153 |
| 7.4.3 Home Range of Released Elephants..... | 155 |
| 8.4.5 Survival of released elephants..... | 157 |
| CHAPTER 8 | 159 |
| CONCLUSION AND RECOMMENDATION | 159 |
| REFERENCES..... | 163 |
| Appendix A. Figures 1 and 2- Rescue and Health Stabilization Phase | 211 |
| Appendix B. Figures 3 and 4- Rehabilitation and release into the wild..... | 212 |

LIST OF TABLES

| | |
|--|-----|
| Table 1. 1 Estimated minimum and maximum number of Asian elephants (<i>Elephas maximus</i>) in the wild and in captivity in countries in Asia. | 22 |
| Table 1. 2 Number of free ranging elephants in Sri Lanka..... | 24 |
| Table 3. 1 Causes for mortalities of elephant calves after arrival at the ETH..... | 63 |
| Table 4. 1 Information on the four elephant calves (2 males and 2 females) from ETH used in the experiment..... | 79 |
| Table 4. 2 Comparison of mean salivary cortisol levels between male and female calves at each time point..... | 82 |
| Table 5. 1 Information on 10 elephants used in the study..... | 95 |
| Table 5. 2 Mean fGCM values pre-release, early post release, and late post release, | 98 |
| Table 6. 1 Overview of specific body condition score protocols for elephants | 105 |
| Table 6. 2 Daily weight gain of elephants in 5 age groups at ETH..... | 110 |
| Table 6. 3 Locations, age categories and respective BCS scores of elephants..... | 112 |
| Table 6. 4 Comparison of nutritional status of elephant calves 04 different locations | 113 |
| Table 7. 1 Information of Elephants Released in Group 1 to UNP..... | 127 |
| Table 7. 2 Information of Elephants Released in Group 2 to MNP | 127 |
| Table 7. 3 Mean monthly distance travelled by study elephants with GPS collars | 150 |

LIST OF FIGURES

| | |
|---|----|
| Figure 1. 1 Asian elephant distribution map | 21 |
| Figure 1. 2 Wildlife protected areas and elephant distribution in Sri Lanka | 29 |
| Figure 1. 3 Number of elephant deaths reported in Sri Lanka during 1990-2018 | 29 |
| Figure 1. 4 Annual elephant and HEC induced human deaths during 2017-2021 ... | 30 |
| Figure 1. 5 Causes of elephant deaths during 2017-2021 | 30 |
| Figure 1. 6 Geographical location of Elephant Transit Home in Sri Lanka | 32 |
| | |
| Figure 2. 1 Location of the Udawalawe National Park and Elephant Transit Home | 36 |
| Figure 2. 2 Annual numbers of calves received by ETH during 1995 to 2022 | 44 |
| Figure 2. 3 Age of elephant calves on arrival at ETH | 44 |
| Figure 2. 4 Shoulder height of elephant calves on arrival | 45 |
| Figure 2. 5 Number of local and foreign visitors from 2013 to 2018 | 46 |
| | |
| Figure 3. 1 Age of elephant calves at arrival | 60 |
| Figure 3. 2 Relationship between age of arrival and survival rate of elephant calves at the ETH | 61 |
| Figure 3. 3 Temporal distribution of mortality among orphan elephant calves after arrival at the Elephant Transit Home | 62 |
| Figure 3. 4 Types of parasites as causes for mortality in elephant calves at ETH... 64 | |
| Figure 3. 5 Causes of injury leading to mortalities among elephant calves at the ETH | 65 |
| | |
| Figure 4. 1 Box plot comparing mean cortisol values of individual calves five days before and nine days after ACTH stimulation | 83 |
| Figure 4. 2 Salivary cortisol levels in four elephant calves at different sampling times | 83 |
| Figure 4. 3 Pattern of average salivary cortisol secretion | 84 |
| Figure 4. 4 Mean baseline salivary cortisol values and such values after ACTH stimulation | 84 |
| Figure 4. 5 The fluctuations of average temperature and humidity throughout the study period | 85 |

| | |
|---|---------|
| Figure 5. 1 Schematic representation of the hypothalamic–pituitary–adrenal (HPA) axis..... | 92 |
| Figure 5. 2 Origin of Studied Elephant Calves..... | 95 |
| Figure 5. 3 Location of ETH and Releasing Site at the Udawalawe National Park . | 96 |
| Figure 5. 4 Monthly mean fGCM concentrations of male (n=6) and female (n=4) elephants while at the ETH | 98 |
| Figure 5. 5 Box plot of mean fGCM levels of pre-release, early post release and late post release periods..... | 99 |
| | |
| Figure 6. 1 showcases the algorithm for body condition scoring in elephants, | 107 |
| Figure 6. 2 Schematic representation of Body Condition Scoring for an Asian Elephant Calf..... | 108 |
| Figure 6. 3 Geographical distribution of study sites for observing wild elephant calves in the BCS..... | 108 |
| Figure 6. 4 Locations and age categories of observed animals for BCS | 109 |
| Figure 6. 5 Monthly mean average body weight gain in elephant calves in ETH... | 111 |
| | |
| Figure 7. 1 Released elephants drinking water at the Udawalawe reservoir one day after release. | 128 |
| Figure 7. 2 Released elephants at the Maduruoya reservoir one day after release | 128 |
| Figure 7. 3 Udawalawe National Park with Dahaiyagala Sanctuary and Waterhirakanda Nature Reserve | 132 |
| Figure 7. 4 Movement Pattern of Vakarai over 564 Days After Re-collaring | 133 |
| Figure 7.5 and 7.22 Monthly movement pattern of Vakarai | 137-139 |
| Figure 7.23 Monthly movement pattern of Gagani during 05.07.2017- 13.11.2019 | 136 |
| Figure 7.24 and 7.48 Monthly movement pattern of Gagani | 138-139 |
| Figure 7.49 Geographical locations of ETH and MNP in Sri Lanka..... | 142 |
| Figure 7.50 Geographical map of MNP and adjacent elephant ranging areas... | 142 |
| Figure 7.51 Ranging pattern of group 2a in a 22 months period | 143 |
| Figure 7.52 to 7. 73 Monthly ranging pattern of group 2a..... | 144-146 |

Figure 7.74 Pattern of movements in Group 2b during the first 384 days post
release..... 147

Figures 7.75 to 7.93 Pattern of movements of elephants in Group 2b during each
month of study 147-148

Figure 7.94-7.97 Average Monthly Distance Travelled by GPS-Monitored Released
Study Elephants 150-151

LIST OF ABBREVIATIONS

| | |
|------------------|---|
| CITES | Convention on International Trade of Endangered Species of Wild Fauna and Flora |
| FFPO | Fauna and Flora Protection Ordinance |
| DWC | Department of Wildlife Conservation |
| ETH | Elephant Transit Home |
| ACTH | Adrenocorticotrophic Hormone |
| VHF | Very High Frequency |
| GPS | Global Positioning System |
| GIS | Geographic Information System |
| UNP | Udawalawe National Park |
| LNP | Lunugamwehera National Park |
| MNP | Maduruoya National Park |
| IUCN | International Union for Conservation of Nature |
| HEC | Human Elephant Conflict |
| DPP [®] | Dual Path Platform |
| EEHV-HD | Elephant Endotheliotropic Herpesviruses -Haemorrhagic Disease |
| OIE | Office International des Epizooties/ World Organization of Animal Health |
| GC | Glucocorticoids |
| HPA axis | Hypothalamic-Pituitary-Adrenal axis |
| CRH | Corticotrophin Releasing Hormone |
| sGCM | Salivary Glucocorticoid Metabolite |
| fGCM | Faecal Glucocorticoid Metabolite |

BCS Body Condition Scores

EIA Enzyme-Linked Immunoassay

ABSTRACT

EVALUATION OF THE REHABILITATION PROGRAM FOR WILD ELEPHANT ORPHAN CALVES AT THE ELEPHANT TRANSIT HOME, SRI LANKA

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March 2023

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The Elephant Transit Home (ETH), established in 1995, aims to rehabilitate orphaned elephant calves in adherence to the ethical principles influenced by Buddhism and Hinduism. As the first Asian orphan elephant rehabilitation facility, this study evaluates the orphan elephant rehabilitation program by assessing health, welfare, growth, body condition scores, and post-release survival.

The evaluation involved analyzing health records and post-release monitoring data from 27 years of rehabilitating elephant calves at ETH. The assessment focused on health issues, mortalities, welfare status during rehabilitation, post-release survival, and reproduction success. The diurnal pattern of glucocorticoid hormone metabolites was studied as an indicator of stress, utilizing an ACTH challenge to determine the diurnal pattern of salivary glucocorticoid metabolites (sGCM). Faecal glucocorticoid metabolites (fGCM) were assayed over a 23-month period in 10 elephant calves to assess the welfare status before and after release. Additionally, the weight of elephant calves (133 weeks) and their body condition scores (BCS) (n=554) were measured to evaluate growth performance and compare it with that of wild counterparts. Post-release performance was monitored by tracking 19 elephants released into Udawalawe National Park (n=10) and Maduruoya National Park (n=9) using VHF and GPS collars.

Over the past 27 years, a total of 427 elephant calves were received at ETH, of which 162 were successfully released into the wild. Mortalities occurred during the health stabilization phase (175/427; 41%) and the rehabilitation phase (14/252; 5.5%) within ETH. A clear diurnal pattern in sGCM levels was observed, with a prominent rise during the morning. The response to the ACTH challenge confirmed that sGCM levels are a reliable indicator of stress. fGCM levels in rehabilitating elephants within ETH were higher than those of elephants in the wild. Growth rates and body condition scores (BCS) of elephant calves at ETH were significantly lower compared to other captive elephant facilities. The released elephants displayed explorative behavior, as well as fission and fusion behavior. Among the 19 calves released during the study

period, four deaths were recorded, two attributed to anthropogenic causes and two to natural causes.

The mortality rate during the rehabilitation phase of elephant calves at ETH (5.5%) is significantly lower compared to other captive facilities worldwide and some wild populations. The low fGCM levels in acclimatized post-released elephants indicate a better welfare status in the wild compared to the rehabilitation phase at ETH. The poor growth of orphan calves within ETH is likely attributable to the loss of access to their mother's milk, which leads to various health issues, such as malnutrition, weakened immune systems, and impaired growth. Although the BCS of elephant infants and calves at ETH is lower than that of wild counterparts, the values are similar to those of wild juveniles, suggesting food shortage may be a common issue for wild elephants as well. Post-release movements demonstrated that elephants established home ranges using explorative behavior similar to that of wild counterparts. Human-elephant conflict and natural health hazards may negatively impact the released animals. Overall, this study underscores the effectiveness of the wild elephant calf rehabilitation program at ETH.

CHAPTER 1

GENERAL INTRODUCTION AND THE OBJECTIVES OF THE STUDY

1.1 Mega Herbivore

About half of the mammalian genera greater than 5 kg in body weight became extinct during the late Pleistocene (Sukumar, 2003). Starting in the late Pleistocene era, earth experienced a rapid extinction of large terrestrial vertebrates, megafauna, from much of the Earth's surface where they once roamed in abundance (Smith *et al.*, 2016; Galetti *et al.*, 2018). The term Mega fauna has varied usage among scientists. In paleontological contexts it applies to species ≥ 45 kg in body mass (Martin, 1973) although some scientists specify >1000 Kg when referring to extinct mega herbivores (Gill, 2014; Owen-Smith, 1987). At present there are seven species of terrestrial mega herbivores over 1000 kg living in the world. These seven species include Asian and African elephants, black rhinoceros and white rhinoceros, Indian rhinoceros, giraffe, and hippopotamus. These species are naturally present on the continents of Africa and Asia. The surviving mega herbivores such as elephants, are often considered as ecological keystones because of their well-documented impacts on plant community composition, structure and function (Owen-Smith, 1988).

1.2 Elephant

Elephants are the largest terrestrial mammals in the world. Elephants belong to the family Elephantidae and are the only surviving members of the order Proboscidea. Based on the fossil record, the genus *Elephas* (Family Elephantidae) appeared to have originated by the early Pliocene era, over 5 million years ago, in Africa (Maglio, 1973). Currently, elephants naturally exist on the African and Asian continents and both of them are generalist herbivores, occupying similar niches in their respective environments (de Silva and Wittemyer, 2012). Asian and African elephant species have diverged for at least 6 million years (Shoshani and Tassy, 1996). Elephants have a sexually dimorphic social organization: males disperse when they become adults, but females have strong social bonds and they live with calves as herds (Eisenberg, 1980; Fernando and Lande, 2000; de Silva *et al.*, 2011; Vidya and Sukumar, 2005).

Herds are led by a matriarch: it is the oldest reproducing cow, who is also probably the mother, aunt or grandmother to most of the rest of the herd members (Santiapillai and Wijemohan, 2016). The basic social unit among elephants is the family, consisting of an adult cow and her immature offspring. The calves depend on their mothers and other family members for social support, survival, and learning during the early stages of life (Lahdenperä *et al.*, 2016).

African Elephants currently occur in 37 countries in sub-Saharan Africa (Blanc and Barnes, 2008; Riddle *et al.*, 2010). The African elephants are divided into two species: the African savannah, or bush elephants *Loxodonta africana* (Blumenbach, 1797), and the African forest elephants *Loxodonta cyclotis* (Matschie, 1900). The African savanna elephant is the largest terrestrial mammal in the world (Laursen, and Bekoff, 1978; Maisels *et al.*, 2013). The average weight of African savanna (bush) males ranges from 4700 kg to 6048 kg and females from 2160 to 3232 kg (Laursen, and Bekoff, 1978). The African bush elephant is listed as Endangered and the African forest elephant as Critically Endangered on the respective IUCN (International Union for Conservation of Nature) Red Lists and it is subject to various degrees of legal protection in all range states (Gobush *et al.*, 2021). In the CITES (Convention on International Trade of Endangered Species of Wild Fauna and Flora) listing African elephants are in Appendix I, except populations of Botswana, Namibia, Zimbabwe, and South Africa that are in Appendix II.

1.3 Asian Elephant

There is only one elephant species in Asia: the Asian elephants *Elephas maximus* (Linnaeus, 1758). The Asian elephant is believed to have descended from *Elephas hysudricus* in the late Pleistocene, approximately 0.25 million years ago (Maglio, 1973). Around 4,000 years ago, the Asian elephant had a continuous geographic range stretching from the Euphrates-Tigris region in present-day Iraq, through South and Southeast Asia, to the Yangtze Kiang in China. Additionally, there were four island populations in Sri Lanka, Java, Sumatra, and Borneo (Olivier, 1978; Santiapillai and Jackson, 1990; Sukumar, 2003).

However, the distribution of Asian elephants has significantly declined over time, and they are now restricted to small, isolated populations throughout most of their range. This decline is primarily attributed to habitat loss and fragmentation,

poaching for their ivory, and capture for taming purposes (Kemf and Santiapillai, 2000).

Today, Asian elephants range in 13 countries, namely Bangladesh, Bhutan, Cambodia, China, India, Indonesia (Kalimantan, Sumatera), Lao People's Democratic Republic, Malaysia (Peninsular Malaysia, Sabah), Myanmar, Nepal, Sri Lanka, Thailand, and Viet Nam (Choudhury *et al.*, 2008). Feral populations also occur in some of the Andaman Islands (India) (Choudhury *et al.*, 2008). Across the 13 countries where Asian elephants are found, their distribution covers an area of approximately 486,800 km² (Sukumar, 2003). However, it is important to note that the current range of Asian elephants represents only about 6% of their historical range (Sukumar, 2003; Vidya, 2016). The overall population of Asian elephants is composed of both wild and captive individuals. In the wild, the estimated population ranges between 48,323 and 51,680 individuals. On the other hand, in captivity, the population is estimated to be between 14,930 and 15,130 individuals (Menon and Tiwari, 2019).

The data provided in **Table 1.1** represents population estimates of elephants in both the wild and captive settings across various regions in Asia. The wild population ranges from 48,323 to 51,680 elephants, while the captive population ranges from 14,930 to 15,130 elephants. The data shows that India and Sri Lanka have the highest wild elephant populations, with India ranging from 29,964 to 34,667 elephants and Sri Lanka having 5,879 elephants. In terms of captive populations, Myanmar, Thailand, and India have the highest numbers. However, it's important to acknowledge that estimating and monitoring wild elephant populations in different countries can be challenging, and these population estimates may have some degree of uncertainty.

All populations of Asian elephants, including those in Sri Lanka, are listed under Appendix I of the CITES, which provides the highest level of protection. The global status of the Asian elephant species, as assessed by the IUCN Red List, is categorized as Endangered (Williams *et al.*, 2020). This designation reflects the significant threats and declining population trends faced by Asian elephants throughout their range. Furthermore, the subspecies of Asian elephant found in Sumatra, known as *Elephas maximus sumatranus*, is classified as critically endangered (Gopala *et al.*, 2011).

Based on morphological characteristics, three subspecies of Asian elephants have been identified. *Elephas maximus indicus* is found on the Asian mainland, *E. m. maximus* is found in Sri Lanka, and *E. m. sumatranus* is found on the Indonesian island of Sumatra (Shoshani and Tassy, 2005). These subspecies exhibit distinct

morphological features and have adapted to their respective habitats. In addition to these three subspecies, recent genetic studies have provided evidence for the existence of another subspecies, *Elephas maximus borneensis*, found on the island of Borneo (Fernando *et al.*, 2003).

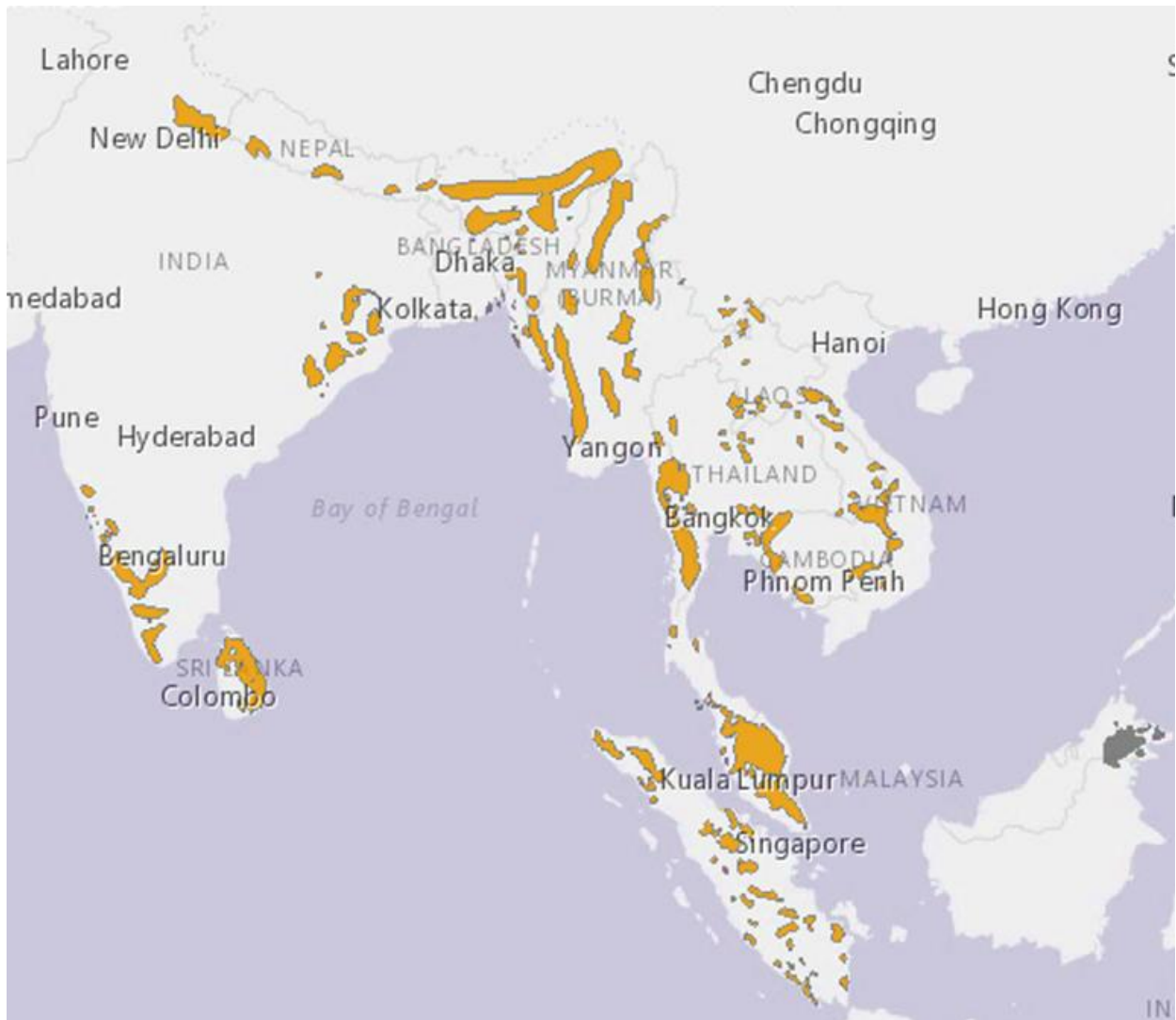


Figure 1. 1 Asian elephant distribution map (Choudhury *et al.*, 2008)

Table 1. 1 Estimated minimum and maximum number of Asian elephants (*Elephas maximus*) in the wild and in captivity in countries in Asia. (Source: Menon and Tiwari, 2019)

| | Wild population | | Captive population | |
|-----------------------|-----------------|-------|--------------------|-------|
| | Min | Max | Min | Max |
| South Asia | | | | |
| Bangladesh | 289 | 437 | 96 | |
| Bhutan | 605 | 761 | 09 | |
| India | 29964 | | 3467 | 3667 |
| Nepal | 109 | 145 | 215 | |
| Sri Lanka | 5879 | | 230 | |
| Sub total | 36846 | 37186 | 4017 | 4217 |
| Southeast Asia | | | | |
| Cambodia | 400 | 600 | 70 | |
| China | 300 | | 243 | |
| Indonesia | | | | |
| Sumatra | 1724 | | 467 | |
| Kalimantan | 60 | 80 | | |
| Lao PDR | 500 | 600 | 454 | |
| Malaysia | | | | |
| Peninsular | 1223 | 1667 | 92 | |
| Sabah | 2040 | | | |
| Myanmar | 2000 | 4000 | 5993 | |
| Thailand | 3126 | 3341 | 3783 | |
| Vietnam | 104 | 132 | 88 | |
| Sub total | 11477 | 14494 | 10913 | |
| Total | 48323 | 51680 | 14930 | 15130 |

1.4 Elephants in Sri Lanka

Sri Lanka holds a significant place in the fossil records of elephants, with evidence of their presence dating back thousands of years. The oldest known fossil records of *Elephas maximus*, the Asian elephant, have been discovered in Sri Lanka (Sumanarathna *et al.*, 2017). Fossil remains of two extinct elephant species, *Elephas hysudricus* and *Elephas maximus sinhaleyus*, have also been reported in Sri Lanka, dating back approximately 100,000 years (Deraniyagala, 1958).

Within the Asian elephant subspecies *Elephas maximus*, Sri Lanka is home to the subspecies *Elephas maximus maximus*, which is found exclusively on the island. This particular population of Asian elephants in Sri Lanka exhibits the highest mitochondrial DNA (mtDNA) diversity in Asia, highlighting the unique genetic heritage of these elephants (Vidya, 2016). The distribution of elephants in Sri Lanka primarily extends to the lowland regions of the dry zone, with a small remaining population inhabiting the Peak Wilderness protected area and the Sinharaja Forest Reserve, located in the wet zone of the country (DWC, 2013; Fernando *et al.*, 2021).

Notably, morphological variations among Sri Lankan elephants have been observed in the past. Smaller elephants known as 'ruhunu gataw' inhabit the southern dry forest region, while larger elephants referred to as 'vil aliya' are found in the riverine forest and villus (floodplain lakes) along the Mahaweli river. In fact, these larger elephants were previously described as a separate subspecies (Deraniyagala, 1955). However, the current understanding does not classify them as a distinct species, recognizing the variation within the broader *Elephas maximus* population (Fernando, 2000).

The dynamics of elephant populations in Sri Lanka have exhibited fluctuations in recent decades, making it challenging to determine clear trends over time. Published estimates of elephant populations are largely based on informed guesses and expert opinions from the authors. However, in 2011, the Department of Wildlife Conservation of Sri Lanka implemented a comprehensive nationwide direct count methodology to estimate the elephant population numbers (**Table 1.2**). According to this survey, the approximate number of elephants in Sri Lanka was reported to be 5,879 individuals. This figure ranks Sri Lanka as the country with the second-highest number of elephants among Asian elephant range countries, representing more than 12% of the global Asian elephant population (DWC, 2013; Menon and Tiwari, 2019).

Table 1. 2 Number of free ranging elephants in Sri Lanka

| Year | Number of elephants | Author |
|------|---------------------|-------------------------------|
| 1969 | 1600-2,200 | (McKay, 1973) |
| 1978 | 2,000-4,000 | (Olivier, 1978) |
| 1978 | 5000 | (Hoffmann, 1978) |
| 2000 | 3,150 - 4,400 | (Kemf and Santiapillai, 2000) |
| 2011 | 5879 | (DWC, 2013) |

1.5 Human Elephant Conflict in Sri Lanka

Sri Lanka, an island located in the Indian Ocean, has a land area of 65,610 km². Historically, elephants were distributed across the entire country, but currently, they are mainly restricted to the dry zone. Remarkably, Sri Lanka is home to over 12% of the global wild Asian elephant population, with their range representing only 1-2% of the total global Asian elephant range (Fernando *et al.*, 2011). Consequently, Sri Lanka boasts the highest density of Asian elephants per land mass.

With a human population of 21 million, Sri Lanka ranks 44th out of 248 countries in terms of population density, with an average of 325 people per square kilometer (DCS, 2012). The country's current human population growth rate is 0.7%, and there is an increasing demand for land for agriculture and urban development. This ongoing expansion of the human population poses a significant threat to elephants as it leads to habitat loss and fragmentation. As a result, human-elephant conflict (HEC) has been intensifying due to the diminishing space available for elephants to roam freely (Santiapillai, 2006; Fernando *et al.*, 2021). The elephant range in Sri Lanka is steadily decreasing, further exacerbating the challenges faced by these magnificent creatures.

The elephant has long held a significant cultural and symbolic role in Sri Lanka, forging a close connection between these majestic creatures and the people of the country. Sri Lankans have deep-rooted cultural traditions and religious beliefs that promote reverence and empathy towards both wild and captive elephants. However, the historical range and population of elephants in Sri Lanka have undergone substantial changes over time.

Prior to the colonization era that began in 1505, elephants roamed throughout the entire island of Sri Lanka. However, the period of British rule from 1815 to 1948 marked a significant decline in elephant populations as a result of widespread hunting and the establishment of large-scale plantations. This led to the complete loss of elephants from many parts of the country. As early as the 17th century, elephants were even reported to be present in urban areas such as Colombo, Ratnapura, and Kandy, highlighting their extensive historical distribution (McKay, 1973).

During a 350-year period, Sri Lankan elephants experienced a significant reduction in their range, with an estimated loss of 30% of their historical habitat. Unfortunately, the loss of elephant habitat continues to this day, with calculations indicating a further 15.2% reduction in forested land from 1960 onwards (Fernando *et al.*, 2021). As a consequence, future developments are anticipated to further shrink the available forested areas for wild elephants, exacerbating the issue of HEC.

Elephants are distributed mainly in the protected areas that were declared by the Department of Wildlife Conservation and Forest Department in Sri Lanka. With an increasing human population, the conversion of protected areas to development is inevitable. Therefore, habitat loss and fragmentation are the major threat to elephant in Sri Lanka. There are only a few studies that have assessed the home range of elephants in Sri Lanka. Those studies have revealed that home ranges of Sri Lankan elephants vary from about 29.6 to 400 km². The home range is larger in males (Weerakoon *et al.*, 2003). The home range of males varies between 29.6–160.7 km² (Fernando *et al.*, 2008, Weerakoon *et al.*, 2003). The core area for a typical herd is 21–25 km² (Marasinghe *et al.*, 2015a).

The management of wildlife protected areas in Sri Lanka falls under the responsibility of the Department of Wildlife Conservation. These protected areas constitute approximately 13% of the country's total land area and consist of three strict nature reserves, 26 national parks, seven nature reserves, 61 sanctuaries, and an elephant corridor. In addition to this wildlife protected areas, an additional 8% of the land area is designated as forest reserves, which are administered by the Forest Department of Sri Lanka and managed with the objective of sustainable utilization of forest resources. Elephants inhabit both the wildlife protected areas and forest reserves, although the protected areas themselves are often fragmented. The areas where elephants are known to range include two strict nature reserves, 17 national

parks, five nature reserves, 25 sanctuaries, and an elephant corridor, as depicted in **Figure 1.2**.

Habitat encroachment and crop raiding by elephants are key contributors to HEC, where both factors play significant roles in exacerbating the conflict dynamics. Human encroachment into elephant habitats disrupts their natural movement patterns, while crop raiding by elephants leads to economic losses for communities. According to a recent study by Fernando *et al.* (2021), elephants occupy approximately 59.9% of the land area in Sri Lanka, while human settlements are found within 69.4% of the elephant range. Inevitably, conflicts between elephants and humans arise in this situation, as nearly half of the Asian elephant's range is situated in fragmented and human-impacted landscapes. These frequent interactions between humans and elephants serve as the primary cause of HEC, as highlighted by Alfred *et al.* (2012) and Goswami *et al.* (2014).

As a consequence of these conflicts, over 150 elephants die each year in Sri Lanka due to anthropogenic causes, with an average of 15 elephant calves being orphaned (Perera *et al.*, 2018). Elephants suffer injuries or fatalities from gunshots, snares, locally-made explosive devices known as 'jaw bombs,' poisoning, falling into wells, or electrocution (Perera and Rajapakse, 2009; Fernando *et al.*, 2011; Perera, 2019; Perera *et al.*, 2021). Additionally, chronic stress is believed to affect most wild elephants due to human disturbances, and emerging infectious diseases pose further threats to their survival (Perera, 2013).

Sri Lanka holds the unfortunate distinction of reporting the highest number of elephant deaths globally, along with the second-highest number of annual human deaths resulting from HEC. Additionally, Sri Lanka has the highest per capita human death rate from HEC when compared to other countries (**Figure 1.3**). HEC have significant consequences for both human and elephant populations, leading to the loss of lives. Over the five-year period from 2017 to 2021, the average annual human mortality rate resulting from HEC was recorded at 112 individuals. In parallel, an average of 337 elephants per year experienced mortality, with the majority of these deaths attributed directly to HEC. This distressing data underscores the urgent need for effective measures and strategies to mitigate HEC and ensure the coexistence of humans and elephants in a harmonious and sustainable manner. (**Figure 1.4**).

Over the past five years, the main causes of HEC-related elephant deaths in Sri Lanka have been attributed to various factors. These include the use of jaw bombs,

which are homemade explosive devices commonly employed for poaching activities, as well as gunshot injuries, poisoning, electrocution, accidents involving falls into agricultural wells or abandoned gem pits, and collisions with trains (Perera, 2021; Perera, 2022) (**Figure 1.5**).

The utilization of jaw bombs poses a significant threat to elephants, resulting in fatal injuries and casualties. Gunshot injuries, often inflicted by humans, further contribute to the mortality rate among elephants involved in conflicts. Poisoning, either deliberate or accidental, also leads to the loss of elephant lives. Moreover, elephants are vulnerable to accidents when they fall into agricultural wells or abandoned gem pits, which can result in fatal injuries or even drowning. Additionally, the growing problem of collisions between elephants and trains has emerged as a significant cause of elephant fatalities in recent years.

Elephant conservation in Sri Lanka operates within the legal framework established by the Fauna and Flora Protection Ordinance No. 2 of 1937 (FFPO) and its subsequent amendments, including the Act No. 22 of 2009 (Perera and Kaigama, 2010). These legislative measures were enacted to safeguard elephants and their habitats. However, despite the implementation of elephant conservation laws, the survival of elephants remains under threat due to ongoing anthropogenic activities (Cabral *et al.*, 2022). The FFPO and its amendments provide a legal basis for the protection of elephants and their habitats, establishing regulations and guidelines for conservation efforts. These laws aim to prevent illegal hunting, trading, and exploitation of elephants, as well as the destruction or degradation of their habitats. However, the persistence of various anthropogenic activities, such as habitat encroachment, human-elephant conflicts, and poaching, continues to pose significant challenges to elephant conservation in Sri Lanka (Cabral *et al.*, 2022).

The conservation of elephants in Sri Lanka encompasses a range of activities aimed at mitigating HEC and ensuring the long-term survival of elephant populations. These efforts include restricting elephants to protected areas through the implementation of physical barriers such as electric fences and trenches. Additionally, injured or sick elephants are identified and provided with medical treatment, while orphaned elephant calves undergo rehabilitation to develop necessary skills for eventual release into the wild. Translocation programs are employed to address conflicts caused by problematic elephants, and habitat enrichment initiatives focus on improving the quality of protected areas. Traditional methods such as elephant drives

and the distribution of elephant thunder crackers are utilized as deterrents, and compensation and insurance schemes are in place to support affected communities. Furthermore, law enforcement plays a crucial role in enforcing regulations, while awareness campaigns and capacity building initiatives seek to educate stakeholders about elephant behaviour and the importance of conservation. Despite these conservation efforts, HEC in Sri Lanka remains a complex and persistent problem. The existing tools and strategies for mitigating conflicts may not fully address the ecological needs of elephants or provide long-term solutions. It is imperative to conduct further research and develop innovative methods that accommodate the ecological requirements of elephants while effectively addressing the root causes of conflicts.

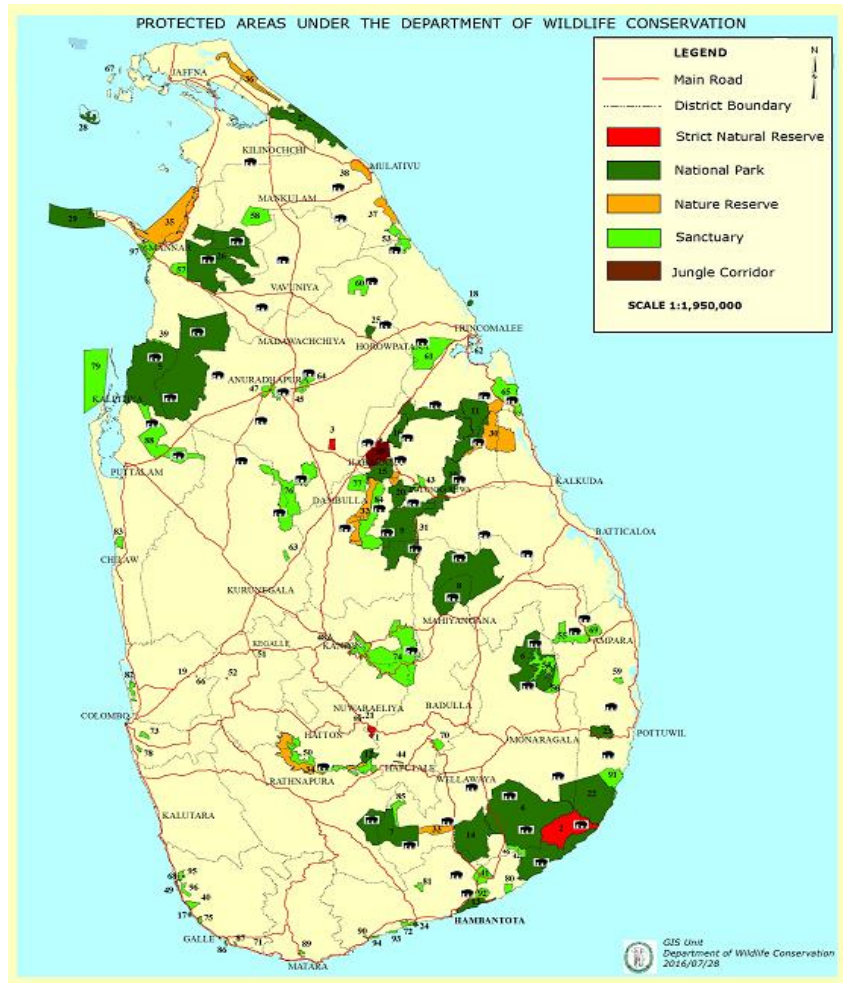


Figure 1. 2 Wildlife protected areas and elephant distribution in Sri Lanka (Source: GIS unit, DWC 2018)

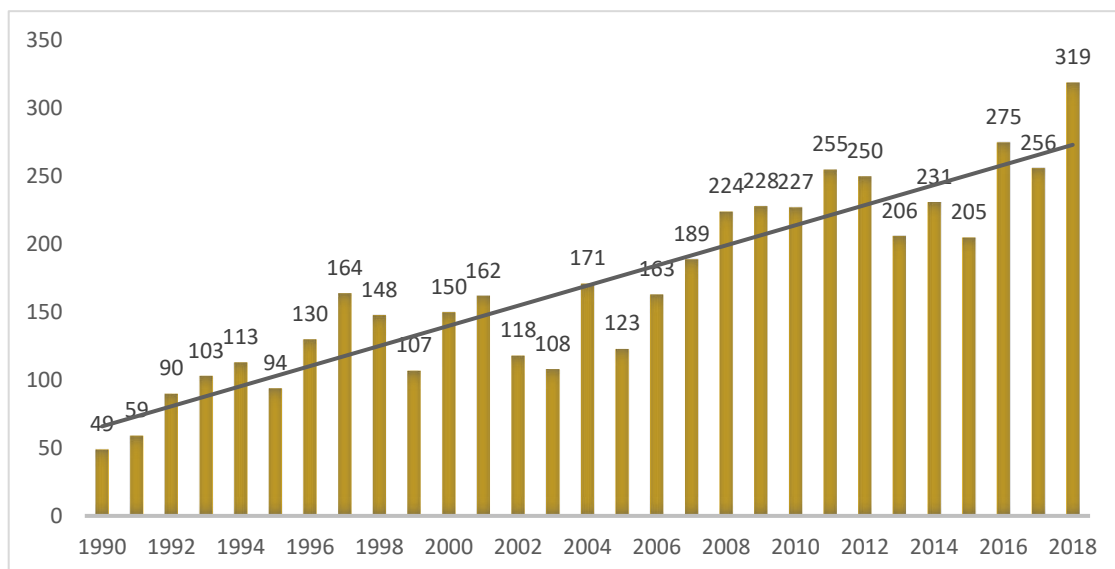


Figure 1. 3 Number of elephant deaths reported in Sri Lanka during 1990-2018 (Source- Annual Reports of Department of Wildlife Conservation-2020)

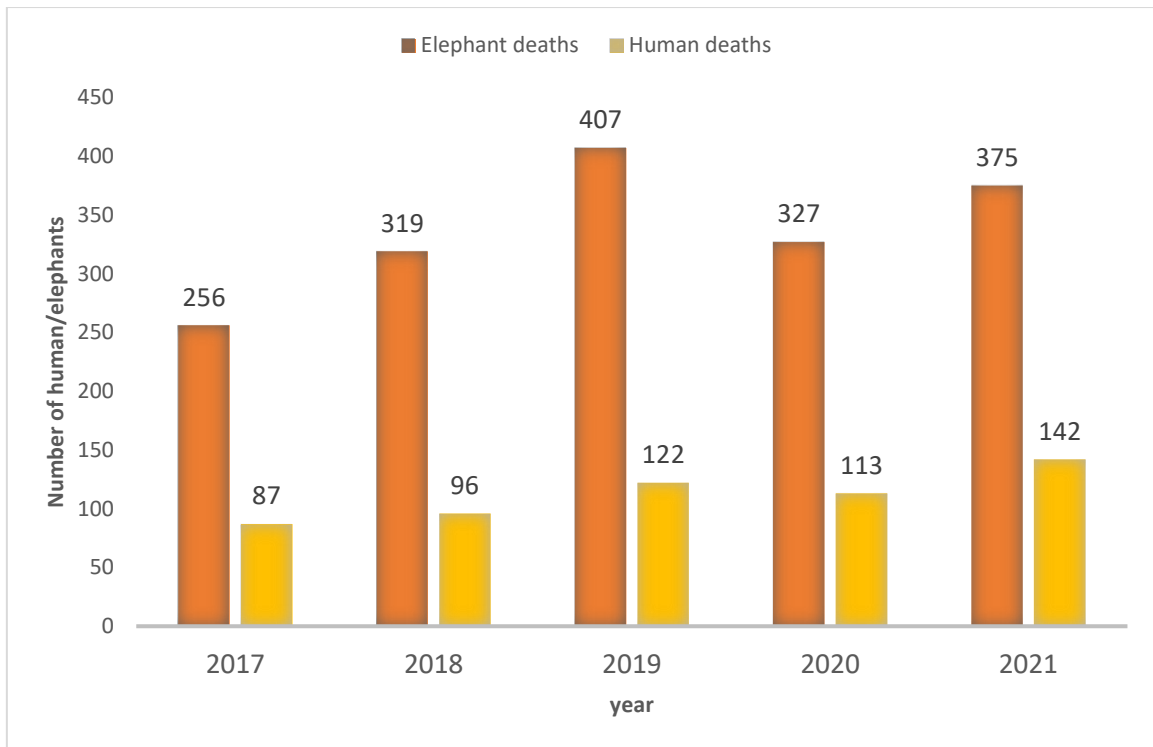


Figure 1. 4 Annual elephant and HEC induced human deaths during 2017-2021 (Source- Annual Reports, Department of Wildlife Conservation-2022)

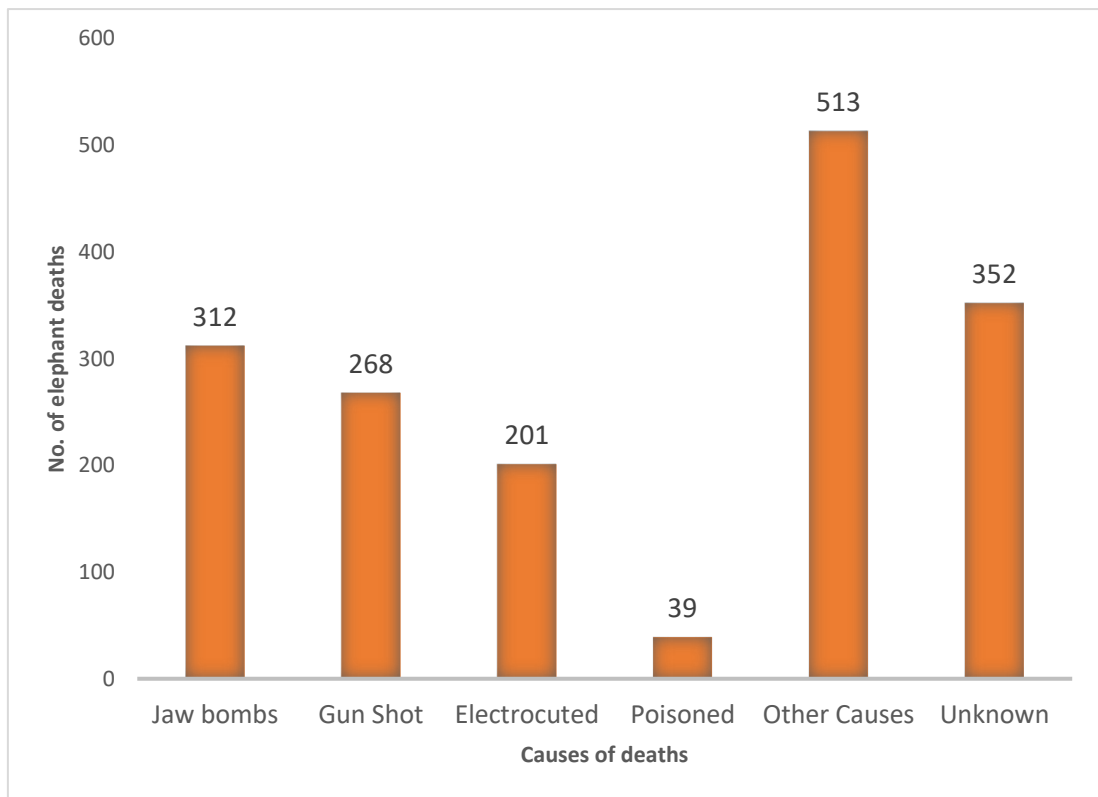


Figure 1. 5 Causes of elephant deaths during 2017-2021 (Source- Annual Reports, Department of Wildlife Conservation-2022)

The other causes of elephant deaths, including natural deaths related to old age and accidents (n=350), train and vehicular accidents (n=49), infected wounds excluding gunshot and jaw bombs (n=43), drowning due to falling into wells and canals (n=51), worm infestation (n=18), and polythene engulfment (n=2).

1.6 Elephant Transit Home, Sri Lanka

Wildlife rehabilitation plays a crucial role in caring for sick, injured, orphaned, and displaced wild animals, with the ultimate aim of returning them to their natural habitat and ensuring individual animal welfare (Guy, Conroe and Banks, 2013). This practice also holds significant potential for the conservation of threatened and endangered species such as Asian elephants. In Sri Lanka, which is home to a substantial population of Asian elephants, these magnificent creatures face numerous challenges, including habitat loss, fragmentation, and HEC. Addressing these challenges, the ETH serves as a sanctuary for vulnerable elephants, specifically those that are orphaned or injured. Situated in the western border of Udawalawe National Park in southern Sri Lanka (**Figure 1.6: Geographical location of Elephant Transit Home in Sri Lanka**), the ETH focuses on providing essential medical care, nutrition, and socialization to ensure the well-being of the elephants under its care. The dedicated team of experienced caretakers and veterinarians works closely with the orphans, helping them regain their strength and acquire the necessary skills for survival in the wild. The success of the rehabilitation process, as well as the elephants' survival during rehabilitation and post-release phases, heavily relies on well-designed management protocols. These protocols should be based on evidence-based practices, tailored to the specific needs of the species, and informed by contextual experiences. The rehabilitation of orphaned baby elephant calves not only contributes to Sri Lanka's wildlife conservation efforts but also inspires hope for the future of these magnificent creatures.

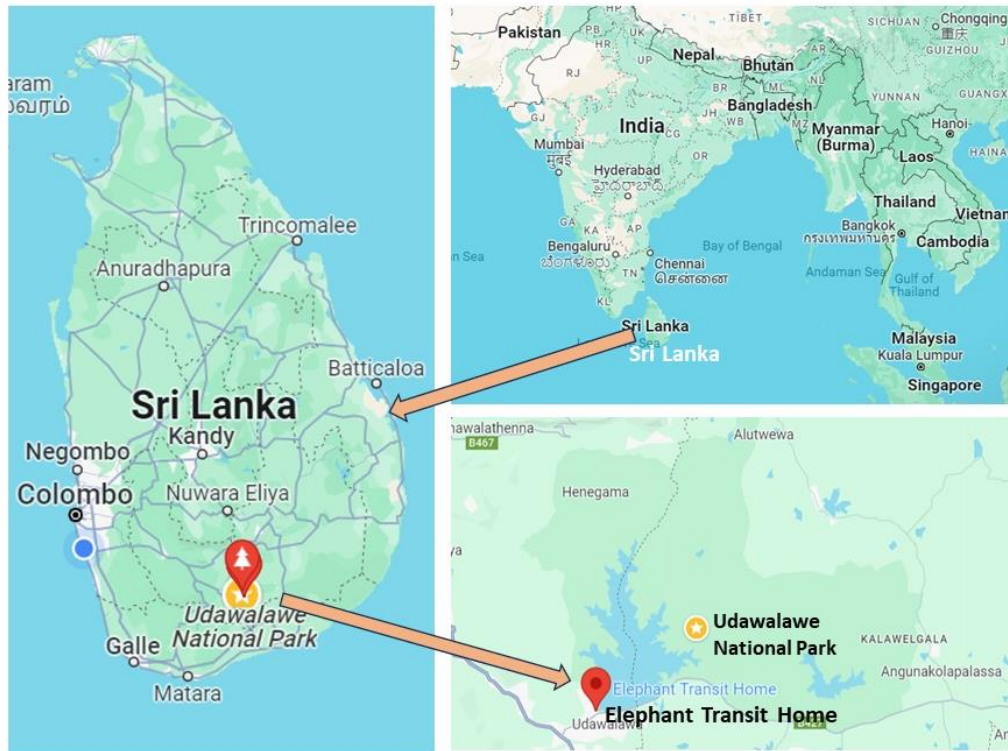


Figure 1. 6 Geographical location of Elephant Transit Home in Sri Lanka

1.7 Objectives of the Study

The ETH in Sri Lanka holds the distinction of being the world's first facility dedicated to the rehabilitation of orphaned Asian elephant calves, self-important an impressive 27-year history of compassionate care and successful reintegration. This comprehensive study was undertaken with the primary aim of evaluating the ETH and delving into various aspects of the orphan elephant rehabilitation program. The study encompassed the following specific objectives, each explored in detail within Chapters 2 to 7:

1. Assessing the overall outcome of the orphan elephant rehabilitation program at ETH, providing insights into the success and effectiveness of the facility's efforts.
2. Investigating health complications and mortalities among elephant calves during their stay at ETH, shedding light on the challenges faced and potential areas for improvement in terms of medical care and well-being.
3. Examining the diurnal pattern of salivary cortisol and adrenocorticotrophic hormone (ACTH) stimulation in elephant calves, offering valuable information about the stress responses and hormonal dynamics experienced by these animals during the rehabilitation process.

4. Evaluating the welfare status of elephant calves both before and after their release into the wild, highlighting any changes or improvements in their overall quality of life.
5. Analyzing the body weight growth pattern and body scoring of the elephant calves, providing important insights into their physical development and nutritional needs during rehabilitation.
6. Investigating the post-release monitoring program to track the progress and adaptation of the released elephants in their natural habitat, assessing their survival, behavior, and integration into existing elephant populations.

To address these objectives, the study incorporated relevant background information, outlined the materials and methods used, conducted data analysis, and presented the results and discussions within the respective chapters. By examining these diverse aspects, the study aimed to provide a comprehensive evaluation of ETH's orphan elephant rehabilitation program and contribute to the understanding and improvement of such initiatives in the future.

1.8 Research Permits

The researcher has been working as the officer in charge/veterinary surgeon of the ETH since 2010. The researcher also has previous experience of working at ETH in the years 1998 and 1999. During other years, the researcher provided his services whenever necessary. The data analyzed in this study were collected by the researcher and other veterinarians who worked at the ETH.

This study received the research permit by the research committee of the Department of Wildlife Conservation, Sri Lanka (2013). The research proposal was approved by the Higher Degree Committee of the Faculty of Veterinary Medicine and the University of Peradeniya, Sri Lanka (2014). The faecal and salivary samples for glucocorticoid analysis were exported and submitted to Chiang Mai University with the necessary FFPO and CITES permits.

CHAPTER 2

ASSESSMENT OF THE ORPHAN ELEPHANT REHABILITATION PROGRAMME AT THE ELEPHANT TRANSIT HOME, UDAWALAWE

2.1 Introduction

Sri Lanka, renowned as a global biodiversity hotspot, is home to a significant population of wild Asian elephants, encompassing over 12% of the species worldwide (Myers *et al.*, 2000; Menon and Tiwari, 2019). Among the thirteen countries where wild Asian elephants are found, Sri Lanka stands out with the highest recorded density of this majestic species. However, the current situation presents a formidable array of challenges, including the burgeoning human population, habitat conversion for anthropogenic purposes, and the fragmentation of jungles, all of which pose grave threats to the survival of elephants in Sri Lanka. Over the past four centuries, Sri Lankan elephants have experienced a substantial decline in their range, accounting for a staggering loss of 45% (Fernando *et al.*, 2021). Consequently, the elephant population is now compelled to endure the escalating exploitation of land and water resources by humans. The HEC predominantly occurs outside protected areas and has witnessed a disturbing escalation in recent decades (Fernando, 2011). On average, approximately 70 human lives and 250 elephant lives are lost each year as a consequence of HEC during the past decade (DWC, 2022). Elephants frequently suffer injuries from gunshots, entanglement in snares resulting in harm to their trunks and legs, damage caused by locally manufactured explosive devices known as 'jaw bombs,' poisoning, railway accidents, falling into wells, and electrocution (Perera and Rajapakse, 2009; Perera, 2013). It is widely believed that most wild elephants endure chronic stress due to the continuous disturbances inflicted by human activities (Perera, 2021).

The HEC in Sri Lanka results in a significant number of elephant calves becoming orphaned. These orphaned elephants have either lost their mothers due to killing or have been separated and lost contact with them. However, in the past, many of these orphaned calves did not survive, and those that did were often kept as captive elephants in poor living conditions. In 1975, the Department of Wildlife Conservation (DWC), the authorized government institution responsible for implementing the Fauna

and Flora Protection Ordinance, established the Pinnawela Elephant Orphanage to provide care for such orphan elephants (Pushpakumara *et al.*, 2016). Over time, the number of elephants rescued and cared for at the Pinnawela orphanage has steadily increased. Furthermore, since 1984, the population at the orphanage has grown through breeding, and it has also become a prominent tourist attraction, attracting international attention. However, it is important to note that the elephant orphanage primarily focuses on maintaining a population of captive elephants and does not have a program for rehabilitating and reintroducing elephants into the wild.

Due to growing concerns about the declining elephant population and the inadequate welfare of orphaned elephant calves in Sri Lanka, the DWC made the decision in September 1995 to establish a new facility with the primary objective of rehabilitating these calves and eventually reintroducing them into the wild. This facility came to be known as the Elephant Transit Home (ETH) (Jayawardena *et al.*, 2002). The establishment of the ETH faced criticism from certain environmentalists and members of the general public. Their main concern revolved around the feasibility of reintegrating hand-reared elephant calves back into the wild. They raised questions regarding the potential survival of traumatised elephant calves after undergoing rehabilitation by humans for an extended period and whether they would be able to successfully reintegrate with existing elephant herds (De Silva, 1998). At that time, there were no existing rehabilitation facilities specifically for Asian elephants anywhere in the world. However, some successful experiences of rehabilitating African elephants in Kenya had been reported (Sheldrick, 1990), although these cases were not extensively documented at the time.

2.1.1 Location of the ETH

The ETH is located at the western border of the Udawalawe National Park (UNP), as depicted in **Figure 3.1**. The park is situated on the boundary of Sabaragamuwa and Uva Provinces in Sri Lanka and covers an area of approximately 308 km². Its geographical coordinates range from latitudes 6°25'–6°34'N and longitudes 80°46'–81°00'E, with an average altitude of 118 m (de Silva *et al.*, 2013). The UNP is renowned for its diverse wildlife, with elephants serving as the flagship species. The elephant population within the park is estimated to range between 804 and 1160 individuals (de Silva and Wittemyer, 2012). The habitats within UNP encompass open savannah-like grasslands, dense scrub, riverine forest, secondary

forest, a permanent river, seasonal streams, water holes, and extensive human-made reservoirs (DWC, 2008; Perera *et al.*, 2021). The Udawalawe reservoir, covering a maximum area of 3400 ha, stands as the largest man-made reservoir in the UNP (DWC, 2008). Adjacent to this reservoir, the ETH is strategically situated at the western border of the UNP.

The rehabilitating elephant calves at the ETH have an area of approximately 100 hectares in which they roam. The Udawalawe reservoir experiences two annual monsoons, typically taking place from October to December and March to April, leading to fluctuations in water levels. During periods of low water levels, grasslands emerge in the reservoir bed, and after rainfall, these grasslands become submerged under water. The rehabilitating elephant calves are confined within their designated territory in the forest, separated from human dwellings by electric fences. However, there is no physical barrier between the wild elephants of the park and the rehabilitating elephant calves.

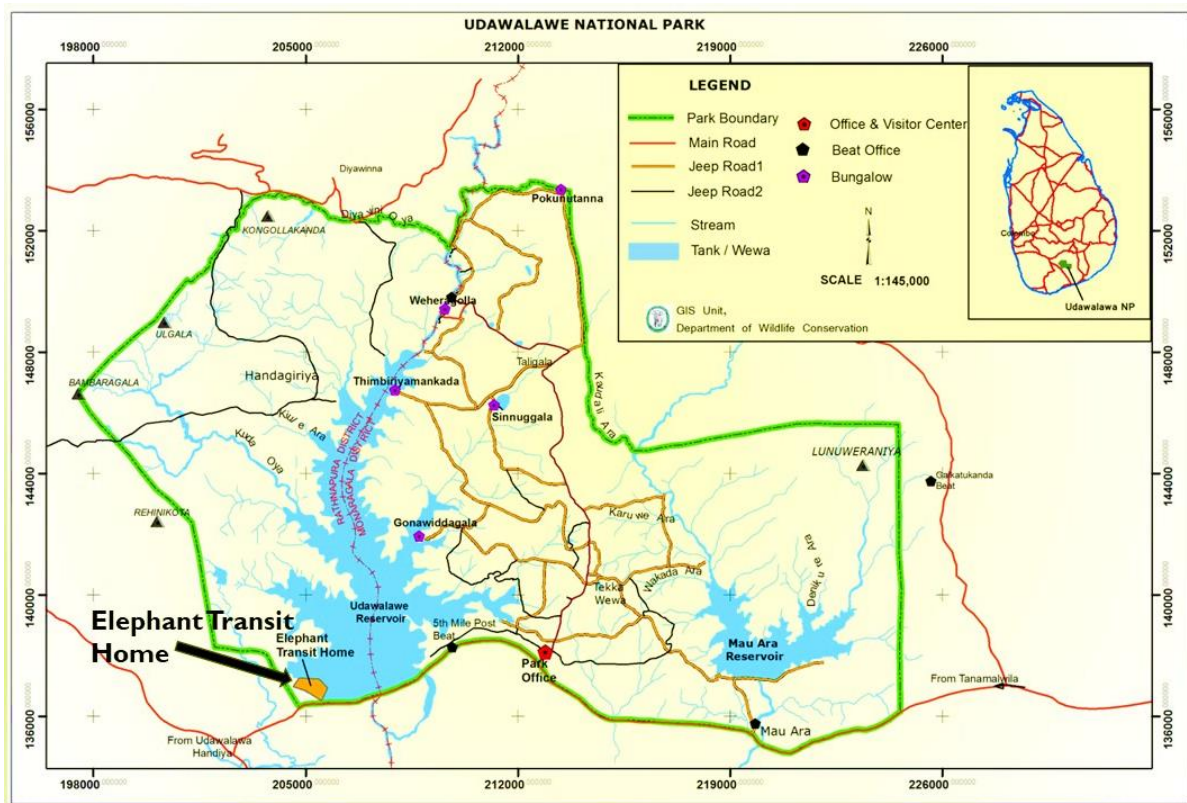


Figure 2. 1 Location of the Udawalawe National Park and Elephant Transit Home (Source: GIS unit, DWC 2008)

2.2 Overview of Rehabilitation Program in the ETH

2.2.1 Occurrence and Identification of Orphaned Elephant Calves

Wildlife rehabilitation is a widespread practice in numerous countries, leading to the rescue, care, and release of millions of animals annually (Pyke and Szabo, 2018). Rehabilitation is commonly required for wild animals due to various reasons such as motor vehicle collisions, abandonment, domestic animal attacks, and targeted rescues in response to environmental disasters like oil spills or wildfires (Tribe and Brown, 2000; Mullineaux, 2014).

The ETH receives elephant calves from across the country that are injured or orphaned due to various circumstances. If a calf's mother dies suddenly, such as from gunshot injuries, electrocution, or railway accidents, the rest of the herd or small group may leave the carcass, leaving the calf with the deceased mother for some time. In cases where the mother dies from chronic issues like parasitic infection or secondary infections from gunshot wounds or vehicular accidents, the calf and mother may gradually separate from the herd. In such situations, the calf remains with the mother, and when the mother eventually dies, the calf becomes unable to rejoin the herd. Sometimes, elephant calves become lost and separated from their mothers and respective herds, and they may be rescued by villagers or wildlife officers.

Rescued wild animals experience stress from the initial adverse event, as well as stress caused by transportation, treatments, captivity management, and release (Narayan and Vanderneut, 2019). Most of the orphaned elephant calves received by the ETH are found outside formal wildlife protection areas by villagers. Orphaned calves in the wild have a strong fear of humans and tend to avoid people, running away if possible. However, weakened, depressed, or collapsed elephant calves are often helpless when discovered by local people. At that moment, villagers have the opportunity to observe them and recognize that a calf is alone and in need of help. Compassionate individuals assist such elephant calves and usually bring them to their village. Sometimes, villagers find orphaned calves trapped in wells, canals, or toilet pits. While providing the best care they can, villagers inform the relevant government authorities, often the local police station, government agent, or the DWC. Once the

DWC officers receive the information, they respond, take custody of the orphaned animals, and transport them directly to the ETH. If necessary, field officers of the DWC provide emergency first aid to injured or sick calves. In certain cases, elephant calves receive primary healthcare at regional wildlife health centers before being transported to the ETH.

Not all elephants received at the ETH are orphans. In some rescue operations, calves are forcibly removed from wild herds to save their lives. This occurs when elephant calves have critical injuries, such as gunshot wounds, vehicular accidents, snares, landmines, or jaw-bomb explosions. Taking calves from the herd becomes the only option when they require repeated treatment for their critical health problems. After a few weeks under human care, it becomes impractical to reintroduce these calves back into their herd, and they must undergo a period of rehabilitation. It is important to note that capturing and domesticating wild elephants is illegal in Sri Lanka. If authorities discover such illegal activities, the responsible individuals are prosecuted, and the elephant calves are confiscated and handed over to the ETH for care and rehabilitation.

Orphaned calves, those forcibly separated from their herds, or confiscated elephants are transported to the ETH by jeeps or lorries. Depending on the distance, this journey may take several hours to several days. During transportation, calves may experience discomfort from their existing injuries and fear associated with the presence and handling by people, as well as the unfamiliar and new environment.

2.2.2 Management of Elephant Calves at the ETH

Upon arrival at the ETH, the first task is to assess the health status of the elephant calves and identify any physiological or psychological issues they may have. The ETH has a specialized hospital with indoor and outdoor elephant pens for acclimatization and temporary holding. Although having a quarantine facility would be advantageous, the ETH currently does not possess one. Nevertheless, during the initial period, newly arrived elephant calves are kept in separate pens.

The veterinary team conducts a comprehensive clinical examination as soon as the elephant calves arrive at the ETH. This examination includes measuring temperature, auscultation, assessing hydration status, inspecting for visible wounds,

fractures, and external parasites such as ticks, fleas, and lice, as well as evaluating body condition. Blood and faecal samples are examined, and the calf's behavior is monitored. Body measurements, such as height and weight, are recorded, and the calf's age is estimated based on these measurements and the stage of teeth development. Based on the findings from the clinical, blood, and faecal examinations, an appropriate treatment plan is determined. Initially, newly arrived calves are fed diluted powdered milk. If calves develop diarrhea or exhibit intolerance after milk feeding, temporarily suspend the milk feeding and address the issue following the established protocols.

Apart from veterinary interventions, providing suitable feed for the newly arrived calves poses a significant management challenge. Bottle feeding newborn calves is a time-consuming task. The ETH utilizes human infant milk formulas as replacements for elephant mother's milk. Gastrointestinal problems, including infections, indigestion, formula intolerance, and chronic diarrhea, contribute to most of the deaths of young calves at the ETH. The composition of elephant milk differs significantly from human milk (Kunz *et al.*, 1999; Uemura *et al.*, 2007), which may contribute to digestive issues when young elephant calves are fed formulas designed for human infants. To address these problems, different types of infant formulas have been used at the ETH, and in cases of suspected milk intolerance, the formula milk is temporarily replaced with electrolyte rehydration solutions, soy-based milk, rice broth, or fruit juice.

During rehabilitation at the ETH, all elephant calves live together as a single herd consisting of very young animals and juveniles up to approximately eight years of age. Once the health of the newly arrived elephant calves has stabilized, they are gradually introduced and integrated into the existing herd. The response of the herd varies depending on the size and gender of the new arrival and the character of the herd members, as individuals within the herd have diverse personalities. If the introduced calf is small, older males typically show no interest, regardless of the gender of the calf. However, if the new arrival is an older and larger male calf, the senior males in the herd may express more interest and engage in interactions to compare size and strength through pushing behaviors. Sometimes, the senior males may charge at the newcomer, but within two to three days, they usually settle down and tolerate the new arrival. If the newcomer is female, there is usually little immediate interaction with the group. However, when a small calf is introduced, all the female

herd members typically show interest. They follow the new arrival, exhibit guarding behaviors, and engage in vocal communications. Small calves introduced into the herd often find older females that display instinctive maternal behavior, and the introduced calf may interact and follow one of the older females thereafter. This allo-parenting behavior appears to bring a great deal of comfort to the newcomer (Moss *et al.*, 2011).

At the ETH, the elephant calves are fed milk five times a day at four-hour intervals, including nighttime and even midnight if necessary. The smaller, weaker, or sick calves may receive additional milk feeds between the predetermined intervals. During the periods between milk feeds, the calves are free to forage and find their own food in the nearby forest. When natural food sources are scarce, supplemental forage is provided. Elephant calves spend approximately 70% of their daytime foraging (Club and Mason, 2002). They have interactions with humans during milk feeding and when they require veterinary attention. At all other times, they are free to exhibit natural behaviors according to their preferences, including foraging, drinking, bathing, playing, and sleeping.

As of September 2022, there are currently 53 elephants undergoing rehabilitation at the ETH. The ETH staff consists of 57 members, led by a veterinary surgeon as the officer in charge. There are 37 elephant caretakers whose main responsibilities include feeding and monitoring the calves, collecting and providing pastures when needed, maintaining cleanliness, assisting in health management activities, and participating in post-release monitoring. Other staff members are involved in office duties and managing visitor activities at the ETH. Additionally, the ETH staff is involved in rescue operations and other wildlife health management activities in the field. The ETH also provides training and research opportunities for undergraduate and post-graduate veterinary and biology students, conducts training programs for veterinarians and wildlife managers, and organizes awareness programs for school children and the general public.

2.2.3 Release of Rehabilitated Calves Back into the Wild

The decision to release an individual elephant back into the wild is based on an assessment of its ability to survive in its natural environment. This assessment takes

into account two main factors. Firstly, age and body size play a crucial role. If the calf is estimated to be over five years old, with a normal height and size, and shows no physical injuries, abnormalities, or health issues, it will be considered for release. Secondly, feeding and social behavior are taken into consideration. The calf should be able to forage between milk feeds and exhibit normal social and play behaviors. Trained keepers at the ETH observe and follow the calves throughout the day, noting and reporting any abnormal behaviors. The assessment of key survival skills includes observing the elephant's foraging and social behavior. Elephant calves deemed capable of successful rehabilitation are released in small groups. When forming these groups, attention is given to the friendliness and cooperative behavior among the individuals to be released. Selected individuals in the released group are fitted with radio collars for post-release monitoring, and if there are not enough collars available, canvas neck belts are used as an alternative. These collars and belts are placed on the elephants approximately two months before release and are kept on for about two years, after which they are removed.

Prior to release, a veterinary examination is conducted to assess the calf's readiness in terms of appropriate age, physical fitness, independence, recovery from disease or injury. The specific requirements for release and assessment may vary between species to optimize survival (Anderson, Gress, and Fry, 1996; Werner, Peach, and Browne, 1997). The decision to release elephant calves into the wild is made after a general clinical examination confirms the calf's health by the veterinary surgeon. Faecal samples are examined for parasites, and if eggs are found, deworming is conducted. As the calves are reared at the western border of the UNP, integration with wild elephants is naturally anticipated. The calves are not screened for diseases before release since they have had minimal human contact and the likelihood of developing any human or livestock-related diseases is considered minimal.

When releasing rehabilitated calves into the wild, the ETH follows a "hard release methodology," which means that until the day of release, the calves undergo routine management at the ETH. On the day of release, at dawn while they are being fed milk, the animals are sedated by administering an intramuscular injection of a sedative (Xylazine hydrochloride). Once sedated, they are loaded onto an elephant transporting lorry. Each lorry carries 4-5 sedated calves, and the number of lorries is increased based on the number of calves to be released. These calves are then

transported to a predetermined release site in one of the national wildlife parks. If the park is nearby, the animals are loaded at dawn, transported, and released in the early morning. If the park is far away, the animals are loaded and transported at night and released at dawn.

During the release, the calves are mildly sedated. Long-term monitoring of the animals after release has shown that they gradually acclimate to their new environment and integrate with existing wild herds. If elephants are released with VHF collars, they can be monitored for approximately three years post-release. If the collars are found to hinder the growth of the elephant calf in the wild, the elephant is sedated, and the collar is removed. GPS collars are guaranteed to work for two years but may sometimes continue functioning beyond that period. In cases where the VHF or GPS collar is not functioning properly, appropriate measures are taken to remove it. Even after the removal of the collar, the ETH staff can identify the released elephants based on morphology (phenotypically) and locate the individual animals. Therefore, monitoring continues informally.

2.2.4 Public Interest and Visitor Management of the ETH

Wildlife rehabilitation plays a crucial role in conservation and raising public awareness of animal welfare issues (Aitken, 2018). It often attracts attention from the community and media, serving as effective tools for education and fundraising (Tribe and Brown, 2000; Mo *et al.*, 2020).

At the ETH, visitors are permitted to observe elephant calves during their milk feeding sessions, which occur four times a day. A specially designed raised platform, located approximately 40 meters away from the feeding area, allows visitors to observe the calves. The milk feedings take place at three-hour intervals, starting from 6:00 a.m. and continuing until 6:00 p.m., with additional feedings at 10:00 p.m. and 2:00 a.m., totaling seven feedings within a 24-hour period. Visitors are allowed to observe the calves at 9:00 a.m., 12:00 noon, 3:00 p.m., and 6:00 p.m. However, interaction with the elephant calves is not permitted, and visitors are not allowed to approach closer than the observation platform. The presence of visitors does not disturb the calves, as they quickly become accustomed to the platform. Typically, around 50 elephants are milk-fed at any given time, which takes approximately 20-30 minutes. After the milk feeding, the elephant calves return to the park. The ETH also

features an information center where visitors can explore displays and gather information about elephants, the ETH, and conservation issues.

The ETH is managed by the DWC, Sri Lanka, with the animals, property, and facilities belonging to the government. The staff members are government employees. The annual operating cost of the ETH is estimated to be around 220 million Sri Lankan rupees (approximately \$0.71 million), and the entrance fee charged to visitors, along with donations and a sponsorship "foster parent" scheme, generates over 300 million rupees (approximately \$0.9million) in revenue (see below).

To promote public interest and engagement in elephant welfare and conservation issues, the ETH operates a "foster parent" scheme. Through this program, individuals or groups can adopt a specific elephant calf at the ETH. Although direct interaction with the elephant calf is not allowed, participants contribute a portion of the expenses associated with caring for the calf at the ETH. They have the opportunity to select and name the adopted calf, receive monthly updates about their adoptee, and are invited as special guests to the release event of the elephant they have sponsored. As of September 10th, 2022, 33 out of the 63 elephant calves have been adopted by local and overseas individuals who are members of the public.

2.3 Results

From September 1995 to September 2022, a total of 427 elephant calves were received at the ETH. The average number of elephant calves received per year was 15.7 ± 0.95 (**Figure 2.2**). Out of these calves, 241 were male and 186 were female. Upon arrival, the calves had varying ages, ranging from 1 day to several years old. Among the new arrivals, 4.7% (20) were estimated to be less than one week old, while 36% (153) were over 1 week but less than 1 month old. The majority of the calves, 70% (237), were between 3 to 6 months old, and 67% (295) were less than 1 year old. Additionally, 14% (61) of the received calves were over 2 years old (**Figure 2.3**). The size of the elephants, measured by shoulder height, ranged from 74cm to 158cm upon arrival at the ETH. Notably, 45% (192) of all received calves had a shoulder height of less than 90cm (**Figure 2.4**).

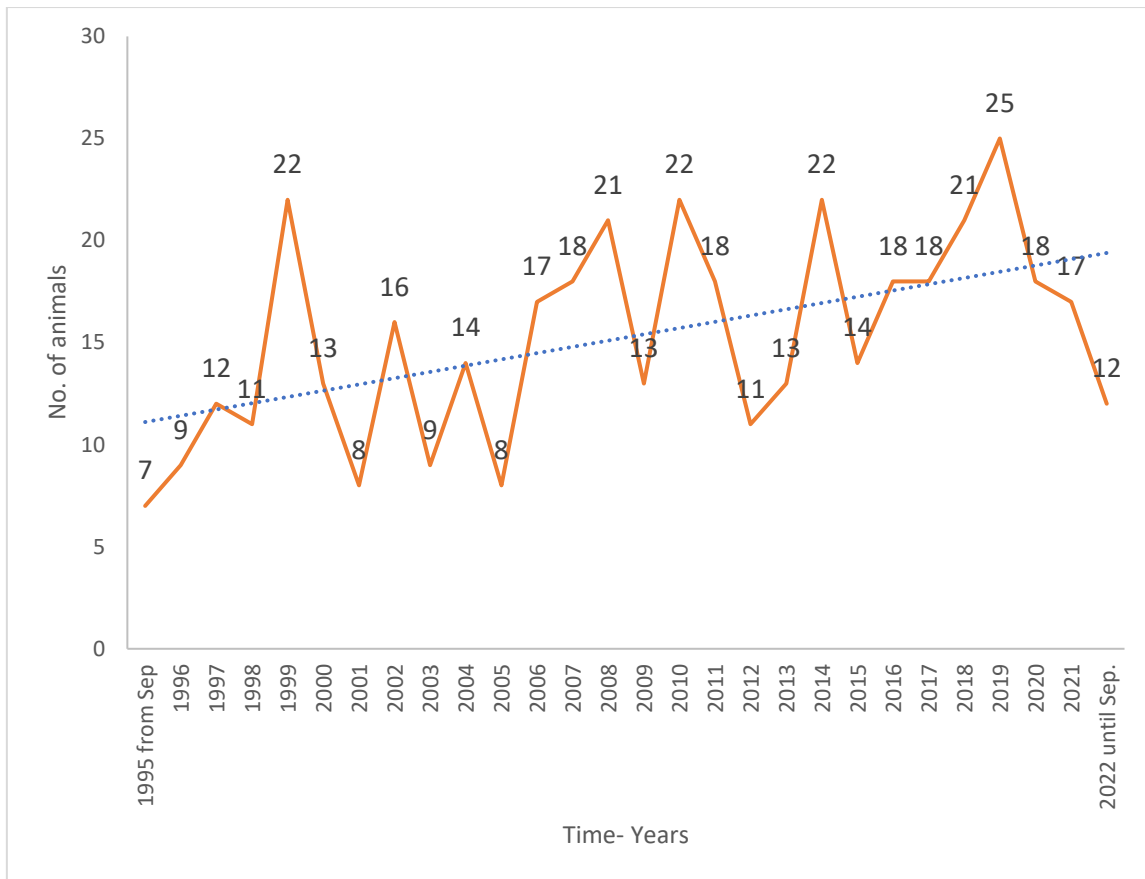


Figure 2. 2 Annual numbers of calves received by ETH during 1995 to 2022

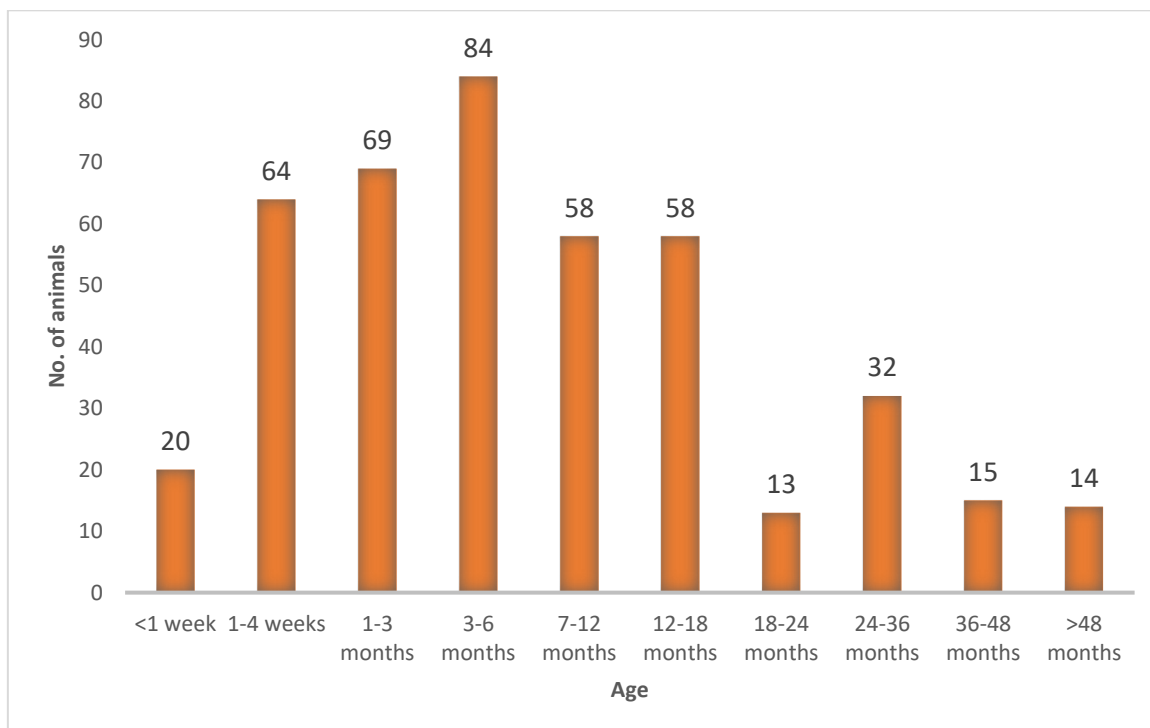


Figure 2. 3 Age of elephant calves on arrival at ETH

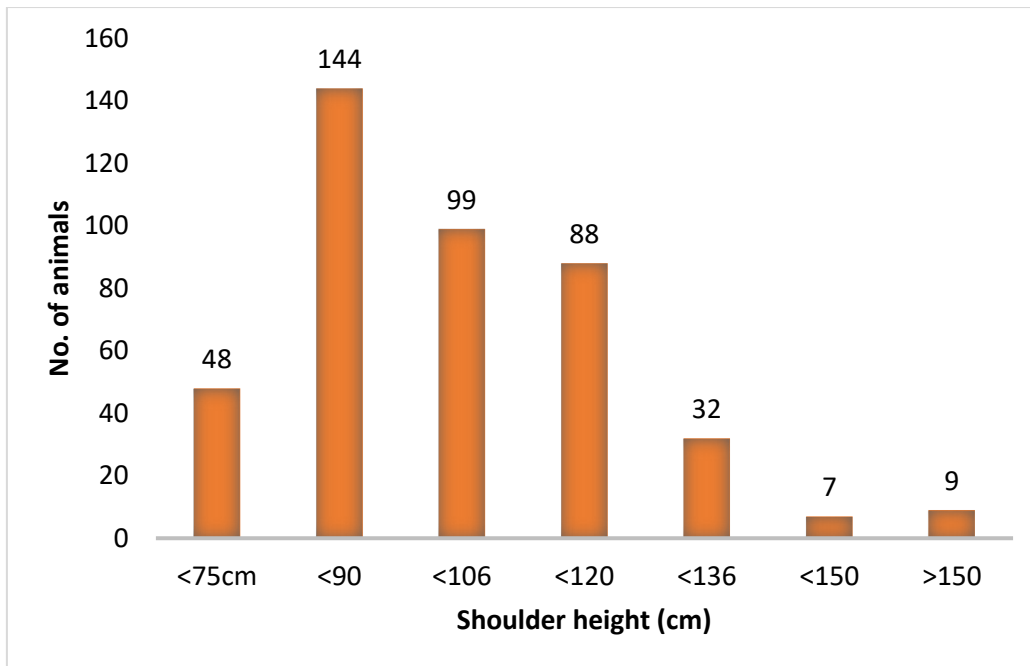


Figure 2. 4 Shoulder height of elephant calves on arrival

Since the first release of a group of elephants from the ETH in 1998, a total of 15 groups have been released until 2022. The cumulative number of elephants released so far is 162, comprising 79 males and 63 females. As per the guidelines set by the International Union for Conservation of Nature (IUCN, 2013), post-release monitoring is a crucial aspect of responsible conservation translocation. This monitoring includes collecting data on survival, reproduction, and dispersal. Initially, the released elephants were fitted with VHF collars for direct observation, but currently, both VHF and GPS collars are used for monitoring purposes.

After being released, the long-term survival of the elephants has shown positive outcomes compared to their wild counterparts. Some of the released calves have integrated into existing wild herds, which are led by a matriarch and consist of younger males and females. Certain released elephants have even become members of these herds. Additionally, some released calves initially join existing wild herds, but later separate to form new herds consisting solely of released elephants. Some released groups have also formed associations with previously released elephants. However, male calves released from the ETH tend to either join a wild herd temporarily or stay with herds of released elephants only for a short period. When they reach 8 to 9 years old, they leave the herd to associate with wild male groups or bachelor groups following adult bulls, exhibiting typical behavior observed in wild males.

The responses of newly released calves towards wild elephants vary. Some calves show curiosity and quickly engage with released young calves, while others do not respond at all. When released elephants enter a wild herd, existing herd members of similar ages become cautious and evaluate the newcomers. In some instances, they even chase the newcomers away from the herd. Interestingly, adult cows pay little to no attention to these interactions and fights among the juvenile elephants.

Out of the 162 elephants released from the ETH between 1998 and 2022, 16 deaths have been recorded, including 10 males and 6 females. The recorded causes of death include three juveniles killed by gunshot wounds, one sub-adult male due to electrocution, three juveniles succumbing to parasite infestation, four juveniles dying from jaw bombs, one juvenile falling from a hill, and one juvenile getting trapped in a mud hole. The cause of death for two juvenile elephants remains undetermined. Furthermore, the ETH has transferred an additional 23 elephant calves (16 males and seven females) to other captive elephant facilities in Sri Lanka.

Between 2013 and 2018, the ETH has welcomed a total of 310,855 foreign visitors and 972,965 local visitors. The number of visitors to the ETH has continued to increase annually (refer to **Figure 2.5**).

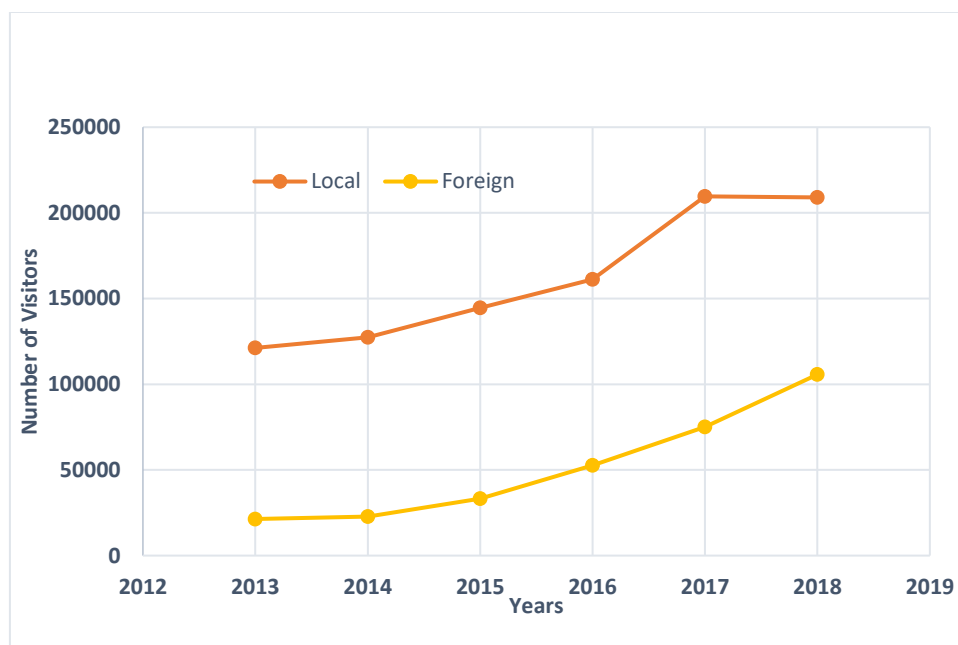


Figure 2. 5 Number of local and foreign visitors from 2013 to 2018

2.4 Discussion and Further Implications

The elephant is an example of a species that is highly social, long-lived, and characterized by extended parental care and investment (Lynch *et al.*, 2019). The maternal bond of elephants is very strong, and the care provided by the mother is essential for the survival of elephant calves. During the first years of life, calves depend on their mothers and other family members for social support, survival, and learning (Sukumar *et al.*, 1997; de Silva, Ranjeewa and Kryazhimskiy, 2011). In the wild, the loss of their mother inevitably leads to the death of young orphaned calves.

According to the International Wildlife Rehabilitation Council, wildlife rehabilitation encompasses the provision of temporary care for injured, sick, or orphaned wild animals, with the ultimate aim of reintroducing them into their natural habitat. Hand-raising a wild orphan is one of the most challenging and specialized aspects of wildlife rehabilitation (Karen, 2005). Experience in rehabilitating other wild animals suggests that strict criteria based on age, physical and psychological health, and behavioral characteristics should be used to select animals for rehabilitation.

Wildlife rescue, rehabilitation, and release are playing an increasingly important role in conservation efforts over time (Saran *et al.*, 2011; Lunney *et al.*, 2004; Dickman *et al.*, 2020). The number of threatened animal species housed in rescue centers around the world is on the rise (Cheyne, 2006; Nijman, 2009). Depending on the availability of space, suitable housing, and funding in such centers, animals may face euthanasia, a lifetime in captivity, or reintroduction to the wild (Harcourt, 1987; Cooper and Cooper, 2006). Although there is limited evidence of the fate and contribution of released animals to population or species conservation (Pyke and Szabo, 2018; Hernandez, 2019), there are other reasons why rehabilitation can be valuable or valued. For example, releasing rehabilitated animals may help supplement and maintain existing populations (Pyke and Szabo, 2018; Mullineaux, 2014; Saran *et al.*, 2011; Monadjem *et al.*, 2014; Ridgeway, 2018). When conserving endangered species, it is crucial to supplement and maintain a healthy and stable population. Presently, Sri Lanka hosts a stable population of wild elephants, and some experts speculate that their numbers are increasing. In light of these circumstances, questions arise about the feasibility of releasing rehabilitated elephants back into the wild. However, free-ranging elephants in Sri Lanka face anthropogenic threats, habitat loss, and disease threats, and these issues are intensifying. Therefore, the rehabilitation

program becomes imperative to address potential catastrophes in the future and to accumulate knowledge about this species.

Rehabilitation can also be supported for ethical, legal, and welfare concerns in certain situations, varying by country (Cooper and Cooper, 2006). The ETH can be identified as a place adopting compassionate conservation, as it aims to bridge the division between species conservation and individual animal welfare (Ramp, 2013). The knowledge and experience gained from rehabilitating elephant calves can also support the care of them and other threatened species when they are critically endangered. Over 200 adult elephants die annually in Sri Lanka due to anthropogenic causes making the survival of orphans even more important during periods of high adult mortality rates that affect population growth (DWC, 2022).

As the ETH is the only facility in Sri Lanka responsible for the care and rehabilitation of orphaned wild elephant calves, it is not possible to select animals for rehabilitation based on age and health criteria. Euthanasia involves humanely terminating the life of an animal for its own benefit (Broom, 2007). Although there are no legal restrictions on animal euthanasia in Sri Lanka (FERCSL, 2009), it is rare to find veterinary professionals willing to practice euthanasia. Therefore, animals with little or no chance of survival are transported to the ETH.

The calves admitted to the ETH for care exhibit a diverse range of ages, spanning from a few hours old to four years old, and their health statuses vary from critically ill to healthy. Unfortunately, a significant number of calves (175 out of 427 elephants) did not survive to begin the rehabilitation process. These deaths account for 41% of the total number of elephants received. All of these deaths occurred within six months of arrival and were unavoidable, especially in cases of fatal injuries caused by gunshots, explosive devices, or accidents involving railways and vehicles.

When the ETH receives critically ill elephant calves that are suffering from exhaustion, malnutrition, diseases, or mental distress, their chances of survival are also low, and a majority of these deaths (93%) occur within six months of their arrival. However, the death rate among calves that are able to enter the rehabilitation program is comparatively low (5.5%) and favorable when compared to the mortality rates of captive elephant calves in zoos in Europe and the USA, as well as those in facilities managed by the Tamil Nadu Forest Department and the Myanmar timber enterprises (Sukumar *et al.*, 1997; Taylor and Poole, 1998; Clubb, 2008; Mar, Lahdenperä, and Lummaa, 2012). After receiving any necessary veterinary treatments, a healthy calf or

a recovered animal that joins the rehabilitation program has a very promising chance (94.5%) of successfully returning to the wild.

The calves that are brought to the ETH vary in age, ranging from a few hours old to four or five years old. To ensure the well-being of each calf, the feeding practices at the ETH are tailored to meet the specific nutritional needs of each age group. The youngest calves, require frequent milk feedings to provide them with essential nutrients. These calves are fed milk every three hours to support their growth and development. As the calves mature and grow older, they gradually start to transition to grazing on vegetation. At this stage, their reliance on milk feedings decreases.

The ETH operates on the principle that all elephants should live together as a single herd, regardless of age or health status. This ensures that elephants have opportunities to share information, develop skills, and learn from one another. Moreover, residing within a social group confers advantages to individuals by facilitating resource acquisition and enhancing their awareness of potential hazards in the vicinity (McComb, 2001; Thornton and Clutton-Brock, 2011; de Silva and Wittemyer, 2012). These threats may include jackals, dogs, other potentially dangerous wildlife, or human activities. Living in a social group offers psychological comfort, particularly for younger calves. The presence of companionship and social interactions within the group helps alleviate stress and anxiety, allowing the calves to navigate their environment with greater confidence and ease.

The arrival of elephants with different health statuses poses challenges to disease control and quarantine procedures at the ETH. Limited resources and workforce hinder the implementation of proper quarantine protocols, increasing the risk of disease transmission among the animals. The spread of parasitic and infectious diseases could have serious implications for the health of elephants at the ETH.

Elephants, like humans, exhibit diverse personalities that influence their behavior and interactions. Incorporating new elephants into existing social structures requires close monitoring and intervention to ensure tolerance and cooperation within the herd.

Upon the establishment of the ETH, concerns were raised by certain experts regarding the potential loss of fear towards humans in elephants raised in close association with them. These concerns suggested that if these elephants were reintroduced into the wild, they could become "problem animals" (Fernando, 2000). Nonetheless, the first cohort of elephants was released from the ETH in 1998, and to

date, a total of 162 individuals have been successfully reintegrated into their natural habitat. Extensive long-term monitoring of these released elephants has revealed no instances of significant harm inflicted upon humans either within or outside protected areas.

While a few complaints have been lodged by villagers regarding crop raiding incidents involving released elephants, it is important to note that most of these occurrences transpired in areas where electric fences designed to separate elephants from cultivated lands had collapsed. It is likely that the rehabilitated calves simply exhibited the typical behavior of their wild counterparts in seizing the opportunity to raid crops. Nevertheless, it is crucial to recognize that this situation does not undermine the perceived threat that some individuals may experience when encountering released elephant calves. It emphasizes the ongoing requirement for comprehensive public education programs concerning rehabilitation initiatives, particularly in regions where elephants are released.

2.4.1 Genetic Considerations

In wildlife rehabilitation programs, genetic considerations are often a significant concern when deciding whether to release rehabilitated elephants back into the wild. The main worry is the potential loss of genetic integrity in the recipient elephant population through hybridization (Weeks, 2011). The Sri Lankan population of Asian elephants holds a unique and crucial position in the conservation of the species (Fernando, 2015). Among Asian elephants, the Sri Lankan elephant population is recognized as a distinct subspecies with the highest genetic diversity (Fernando *et al.*, 2000; Vidya and Sukumar, 2005; Vidya *et al.*, 2005; Choudhury, 2008).

In the past, when classification was based on morphological features, specific populations were considered subspecies, such as the elephant population residing in the Mahaweli river basin known as *Elephas maximus vilaliya* (Deraniyagala, 1955; De Alwis, 1982). Recent genetic studies have supported this hypothesis and have shown significant genetic differences between the Indian mainland population and the Sri Lankan population, as well as variations among different regions within Sri Lanka (Fernando *et al.*, 2000). Preserving these genetically unique subpopulations within the country may be beneficial for the survival of the Asian elephant species. However, some mixing of these subpopulations has already occurred due to management strategies involving the translocation of displaced and conflict-affected elephants.

It's important to recognize that Sri Lanka is a relatively small island, and the habitat available for elephant ranging is diminishing rapidly. The country lacks the capacity and resources to maintain the separation of genetically distinct elephant subpopulations. Additionally, only a minority of free-ranging elephants exist in large undisturbed protected areas in Asia (Van Aarde, Jackson and Ferreira, 2006). Intensively managed populations of elephants in small reserves resemble those in zoos, where some elephants are kept in extensive enclosures (Cameron and Ryan, 2016). Such small populations in limited areas raise concerns about inbreeding, which can significantly reduce individual fitness, and the loss of genetic variability from random genetic drift can diminish future adaptability to a changing environment (Lande, 1988). Therefore, when considering the current and future status of the entire elephant population in Sri Lanka, the release of rehabilitated orphaned baby elephants, regardless of their origin, can be viewed as an enrichment of the genetic pool rather than genetic pollution.

2.4.2 Selection of Elephants for Release and Choice of Locations for Release

Released elephants in this study ranged in age from four to seven years. The selection of elephants for release prioritized their abilities and survival skills in the wild. During intervals between scheduled feeds, the elephants roamed in the UNP, engaging in foraging and group interactions, displaying various activities. Two keepers accompanied the group in the forest, observing the behavior of the elephant calves to evaluate their activity budgets and social bonds. These detailed behavioral observations were used to assess the suitability of individual elephants for release. When selecting a group of elephants for release, preference was given to those that had displayed friendly and cooperative behavior towards each other. This ensured that the group would remain together for at least a short period after release into the wild.

Expert opinions on rehabilitation procedures recommend releasing rehabilitated animals, including elephants, within their normal home range or within 10 miles of the capture site. This practice minimizes the spread of parasites, diseases, and genetic material among wild populations while maximizing the animal's chances of survival (Miller, 2012). Additionally, experts emphasize that released animals should be healthy and capable of surviving in the wild, as assessed through behavioral observations (Baker, 2002; Hall, 2005; IUCN/SSC, 2013). The ETH strives to follow this expert guidance whenever possible, but certain practical limitations may arise. For

example, orphaned calves may be received from areas of intense HEC where it is unsafe to release them back into the same locality. In other cases, releasing elephants as small groups, rather than individuals, is necessary to optimize their welfare and chances of survival in the wild. These groups may consist of elephants found at different locations.

The survival of rehabilitated wildlife is influenced by various factors associated with the release environment, such as the timing of release, release method, quality of the release habitat, and the presence of predators. Additionally, for certain species, habitat familiarity and quality play a crucial role in their long-term survival (Anderson, Gress, and Fry, 1996). These factors collectively contribute to the overall success and viability of reintroduced individuals in their natural habitat. Ensuring the safety of released animals and minimizing potential threats to human beings are primary concerns. Ideal release sites should provide an abundance of food resources, ample water sources, and sufficient vegetation cover to support the elephants' needs.

Furthermore, the presence of wild counterparts in the vicinity is beneficial as it allows the released elephants to integrate with or learn from them, thereby enhancing their survival skills. It is important to select release sites that are free from poaching activities and negative human interactions, such as excessive tourist disturbances. Additionally, the release sites should not be overpopulated with elephants or other wildlife species, as this would create intense competition for limited resources. Another crucial consideration is the health aspect, both for the released elephants and the indigenous elephant population. It is essential to avoid releasing elephants carrying harmful pathogens, which could pose a risk to both the released individuals and the existing wild population. Therefore, release should not take place in areas known to have diseased individuals among the wild elephant population.

. Traditional guidelines propose that rehabilitated elephants and other wildlife should ideally be released at or near their original encounter site (Hall, 2005). This approach is particularly suitable for animals that have spent a relatively short duration in captivity. However, the majority of elephant calves rescued by the ETH are discovered outside protected areas, where instances of HEC are prevalent. This makes it impractical to release them individually at their original location or as a group.

The ETH released a total of 162 elephants, with 129 undergoing hard release and the remaining 33 undergoing soft release. Hard release involved transporting elephant calves to a predetermined location and releasing them simultaneously. In the

soft release approach, the calves were separated from the group and kept adjacent to the ETH within an electric fence. soft release methodology was implemented in both 2020 and 2022, involving the release of 20 and 13 elephants, respectively, to the UNP. After separation, the released elephants were given 24 hours of freedom and the opportunity. They were provided with grass and herbivore pellets for a 5-9 months period, gradually reducing the amount and frequency of feeding. The feeding location was continuously adjusted during the soft release process, leading to the elephants being relocated to a site approximately 12 km away from the ETH, close to a river. At the peak of the drought period, the calves were guided to cross the river. However, when the rain began, the river transformed into an obstacle, impeding their return journey to the ETH. Subsequently, the elephant calves became independent, and post-release monitoring efforts have been ongoing to track their progress and ensure their well-being.

The majority of the rehabilitated elephants, totalling 131 individuals, were released into the UNP. Additionally, four elephants each were released at the Lunugamwehera National Park (LNP) and Kumana National Park, while 23 elephants were released at the Maduruoya National Park (MNP). The close proximity of the ETH's location to the UNP contributed to the rapid acclimatization of elephants upon release, thanks to the favourable environmental conditions. However, to ensure the long-term sustainability of the elephant population within the park, it may be necessary to consider reducing the number of elephants released there in the future. According to recent research by de Silva, Ranjeewa, and Weerakoon (2011), the current elephant population in the UNP is estimated to be around one thousand individuals. However, the park is facing significant grazing pressure from domestic cattle. In light of the need to maintain a sustainable elephant population, the ETH is actively exploring alternative suitable parks.

One potential release site that has been identified is the MNP. Situated in the northeastern part of the country, the park spans an area of 58,850 hectares and is home to an estimated elephant population of approximately 700 individuals. The park boasts multiple water bodies, including the larger Maduruoya reservoir when compared to Udawalawe. The presence of similar water levels and surrounding habitats makes the MNP a promising option for releases. Currently, 23 elephants have already been successfully released there. While some elephants were equipped with VHF and GPS collars for monitoring purposes, tracking them in the MNP has proven

challenging due to the limited road network. However, an improved tracking system utilizing GPS collars has been implemented since 2016, facilitating enhanced monitoring of released elephants across the park.

After careful consideration, the LNP was initially identified as a potential release site. However, subsequent experiences revealed that it was not suitable for elephant release due to various challenges. Four released elephants from the park migrated and settled in the Udawalawe-Lunugamwehera corridor/ Watehirakanda Nature Reserve, which significantly increased their exposure to human interaction. Tragically, one released elephant fell victim to trap gunshot wounds over a period of time. Furthermore, another male elephant met a tragic fate by falling to its death from a mountain while roaming with an adult bull, and another elephant was electrocuted when the adult bull pushed a tree onto a live electric cable. These unfortunate incidents prompted the conclusion that the LNP carries significant risks and hazards, making it unsuitable for elephant release.

2.4.3 Improvement of the Rehabilitation Process

The ETH has indeed come a long way since its humble beginnings. Starting with limited resources and a small team lacking experience with elephants, it has evolved into one of the most well-equipped rehabilitation facilities for Asian elephants worldwide. Over the years, the ETH has undergone trial and error to develop effective methods and guidelines for elephant rehabilitation, release, and post-release monitoring.

In the initial years, elephant calves at the ETH were tethered at night in an enclosed paddock and provided with milk and forage. However, this practice was changed in 2012, allowing the calves the freedom to roam in a 10-hectare area bordered by an electric fence. Subsequently, in 2019, another change was made where elephants were not confined at night, and they were given a milk feed only once at midnight. These changes have had a significant positive impact on the development of wild behavior in the elephant calves.

One of the future developments planned at the ETH is the establishment of a quarantine facility for newly arrived elephant calves. This facility is considered a key priority for ETH management.

While the ETH primarily uses the "hard release" technique, it acknowledges that this method may not be optimal for animals that have been hand-reared or have

been in care for an extended period. Soft releases, where elephants are gradually reintroduced to the wild, are preferred but limited in practice due to resource constraints and manpower limitations. There have been two deaths among the elephants released using the soft release technique, one from gunshot wounds and the cause unknown for the other. The current data is insufficient to assess the relationship between soft releasing and survival rates.

The elephants that undergo rehabilitation at the ETH, along with the management experience gained, are considered a valuable scientific resource for the future conservation of the species. The ETH is open to collaborating on research in various fields, such as elephant welfare, infectious diseases, population genetics, anatomy, nutrition, physiology, behavior, parasitic diseases, and radio telemetry. Additionally, the center has the potential to provide training opportunities for elephant keepers, university students, and veterinary professionals.

From a wildlife rehabilitator's perspective, success at the ETH involves the recovery of injured elephants and their long-term survival in the wild, including successful reproduction. At the population level, success is defined as the persistence of populations in areas where rehabilitated elephants are released, with released animals maintaining individual territories, contributing to the reproductive population, and avoiding genetic issues, diseases, and competition beyond the carrying capacity of the habitat.

Since its establishment, the ETH has received 427 orphaned and endangered elephant calves and released 162 elephants back into the wild. The ongoing post-release monitoring program has recorded the first birth from a released elephant in 2008, with 17 additional births documented by September 2022. Although the contribution of released males to reproduction has not been specifically recorded, observations have shown that released bulls are healthy, exhibit normal behavior patterns, grow to their full size, and integrate well into wild herds. The data accumulated since 1995 demonstrate the significant positive impact of the ETH on saving the lives of orphaned elephants, improving their physical and mental welfare, and serving as a successful rehabilitation program globally. Furthermore, as a biodiversity conservation hotspot, the DWC in Sri Lanka has demonstrated the effectiveness of efforts to rehabilitate Asian elephants.

CHAPTER 3

ASSESSMENT OF THE HEALTH COMPLICATIONS AND MORTALITIES OF ELEPHANT CALVES AT THE ELEPHANT TRANSIT HOME, UDAWALAWA, SRI LANKA

3.1 Orphan Elephant Calves in Sri Lanka

Sri Lanka is home to over 200 captive elephants, with approximately 90 elephants residing at the Pinnawala Elephant Orphanage, while others are housed in temples (Pushpakumara *et al.*, 2016). Additionally, the ETH in Udawalawa sees an annual influx of 50-60 elephant calves, depending on the release program.

The survival of an elephant calf greatly depends on the close relationship with its mother. Parental care and supervision extend for several years after weaning (Crandall, 1964). Besides providing milk, elephant mothers play a crucial role in teaching their calves essential skills necessary for survival. They also protect them from predators and other dangers, actively contributing to the education and safeguarding of new calves. In the case of female calves, this bond remains intact throughout the lifetime of the mother (Sukumar 2003). However, for male calves, this bond gradually weakens over time, and the relationship may cease once the male becomes an adult bull (Eisenberg *et al.*, 1971; Douglas-Hamilton, 1973). It has been observed that orphaned elephant calves in the wild, who become separated from their mother and their herd fail to survive (de Silva *et al.*, 2013).

In 1975, the Pinnawala Elephant Orphanage (PEO) was established as a rescue centre and sanctuary for orphaned elephant calves (Pushpakumara *et al.*, 2016). Recognizing the ethical concerns surrounding such facilities and aiming to enhance elephant conservation efforts, the government of Sri Lanka established the ETH in Udawalawa two decades later (Jayewardene *et al.*, 2002). The ETH serves as a rehabilitation centre specifically designed for orphaned elephant calves (Perera *et al.*, 2016).

When orphaned elephant calves arrive at the ETH, they often present with multiple critical health issues. During the initial phase of management at the ETH, these calves undergo intensive treatment to stabilize their health. Once they have recovered from immediate health problems, they are allowed to freely interact with other young elephants in a designated "rehabilitation group." In this group, the

elephants have minimal contact with humans, limited to periods of milk feeding and necessary veterinary interventions for health concerns. They have unrestricted access to water, grasslands, and forests, allowing them to move and explore as they please. They also have the opportunity to interact with wild elephant bulls that roam the area. The calves become accustomed to bottle feeding of milk, which is provided every four hours during the day and at midnight. Younger and smaller calves may receive milk more frequently, such as every three hours, based on their specific needs. Regardless, all roaming calves are closely monitored throughout the 24-hour period.

The orphaned elephants at the ETH are housed together as a cohesive group, consisting of individuals spanning a range of ages from a few weeks to seven years old. Within this rehabilitation group, social interaction among the elephants is extensive, mirroring the dynamics observed in wild elephant herds. This socialization process is crucial for the development of vital social and behavioral skills necessary for their eventual integration into wild elephant populations.

Research emphasizes the significance of prolonged maternal care in the well-being of social animals, including elephants (Clutton-Brock, 1991). Studies conducted on orphaned elephants in the wild have demonstrated that early weaning and separation from their mothers can have adverse social and physiological effects, resulting in reduced survival rates (Andres *et al.*, 2013; Goldenberg and Wittemyer, 2018; Parker *et al.*, 2021).

The Asian elephant (*Elephas maximus*) represents one of the most seriously endangered species of large mammals in the world (Ceballos *et al.*, 2015). One-quarter (24–29%) of all remaining Asian elephants currently live in captivity in range countries mainly in India, Myanmar, and Thailand in Asia, and a further 1000 in zoos around the world (Sukumar, 2003; Kurt *et al.*, 2008; Menon and Tiwari, 2019). It is important to maintain a viable self-sustaining captive population that could reintroduce and restock the wild population when necessary (Keulartz, 2015; Jackson *et al.*, 2019). Juvenile mortality has been identified as a key factor influencing captive population growth rate both in semi-captive and captive elephants in ranging countries and in worldwide zoos (Mar *et al.*, 2012).

For a young calf that is still dependent on its mother's milk, the absence of regular suckling can have dire consequences. Without proper nourishment, the calf can quickly become exhausted, dehydrated, starved, and may succumb to death within a few days. If the calf is slightly older and able to consume solid food, the onset

of exhaustion and starvation is more gradual. However, many orphaned calves arriving at the ETH exhibit various health complications such as diarrhea or constipation, lethargy, weakness, reduced appetite, colic, sunburn, dry skin, umbilical infections, and wounds including abrasions, lacerations, bruising, puncture wounds, fractures, trauma to internal organs, and both internal and external parasitic infestations. Additionally, metabolic diseases can also be present.

The management of elephants undergoing rehabilitation at the ETH involves human intervention until they are eventually released back into the wild. This captive population of elephants, all under the age of seven, represents a unique group that is not found elsewhere in the world for direct comparison. However, there is limited information available regarding calf mortalities in select facilities in Asia that can be used as a basis for comparison with the ETH. This study aims to investigate health complications and mortalities among elephant calves during their stay at the ETH, to gain valuable insights into the challenges faced and potential areas for improvement in terms of medical care and overall well-being

3.2 Materials and Methods

Comprehensive health records for each calf entering the ETH are diligently maintained both in paper format and digitally. These records include vital information such as the calf's name, place of origin, date of arrival, weight and height at arrival, as well as an overview of the animal's health status history.

To conduct this study, relevant data were extracted from these health records and compiled in Excel spreadsheets for analysis. The data extracted from the records served as the primary source for evaluating the health complications and mortalities of elephant calves at the ETH.

3.2.1 Health Stabilization and Rehabilitation Phases

Upon arrival at the ETH, elephant calves undergo two distinct phases: the health stabilization phase and the rehabilitation phase.

3.2.1.1 Health stabilization phase

During the health stabilization phase, newly arrived calves are thoroughly examined to assess their physiological and psychological well-being, ensuring they are ready for the subsequent rehabilitation process. This phase also includes

quarantine procedures to prevent the potential spread of diseases. Upon arrival, these calves often exhibit critical health issues such as dehydration, malnutrition, infectious diseases, infected wounds, parasite infestations, fractures, and psychological disorders associated with stress. While the rescue operations are carried out with good intentions, the handling and transportation process can induce significant stress on the calves. The duration of this first phase of health stabilization typically ranges from a few weeks to six months.

3.2.1.2 Rehabilitation phase

Once the newly arrived elephant calves have undergone health stabilization (phase 1), they are gradually introduced to the rehabilitating group. During the rehabilitation phase, these calves are given the opportunity to roam freely for 24 hours, with access to water sources, grasslands, forests, and opportunities for interaction with both wild elephants and other wildlife. Human interaction with these calves is limited, primarily occurring during feeding sessions for milk and other food supplements, as well as during necessary veterinary interventions.

3.3 Results

3.3.1 The Locations Where Orphans Were Found

During the 27-year study period (September 1995 - September 2022), a total of 427 orphaned elephant calves were received by the ETH. Among these calves, 89% (n=382) were found outside wildlife National Parks, indicating that they were discovered in areas beyond protected regions. Furthermore, 9% (n=38) were found within wildlife National Parks, suggesting that they were orphaned within these protected areas. Additionally, 2% (n=7) of the calves were confiscated as a result of court orders, as they had been illegally captured by individuals who were managing them.

3.3.2 Age of Elephant Calves at Arrival

The annual number of calves received varied between 9 and 25, with an average of 15.69 calves per year. The age of the received calves ranged from one day old to eight years. Among the calves, 20 animals (4%) were less than one week old upon arrival, while 84 calves (19.7%) were between one week and one month old. The

majority of the calves, 295 (69%), were between one month and one year old. Additionally, 61 calves (14%) were over two years old (**Figure 3.1**).

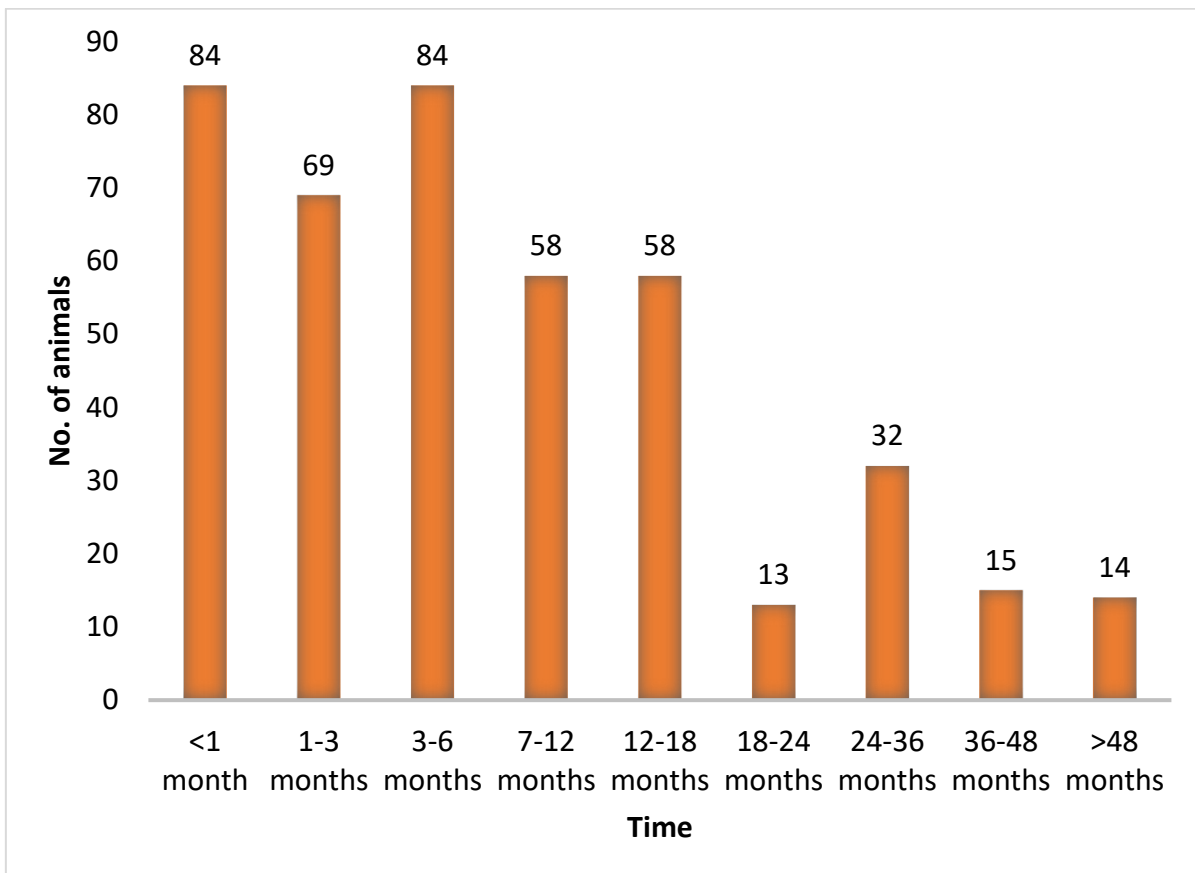


Figure 3. 1 Age of elephant calves at arrival

3.3.3 Mortalities of Elephant Calves at the ETH

The age range of young orphan elephants received at the ETH varies from day 1 to six months. Among the different age groups, the most vulnerable calves are those who did not survive the health stabilization phase.

Among the calves that were less than 1 week old upon arrival, a mortality rate of 13 out of 20 calves (65%) was observed. For calves below 3 months of age upon arrival, the mortality rate was 87 out of 153 calves (57%). Interestingly, the highest survival rate of 52 out of 72 calves (73%) was recorded in the age group of 12-24 months upon arrival (**Figure 3.2**).

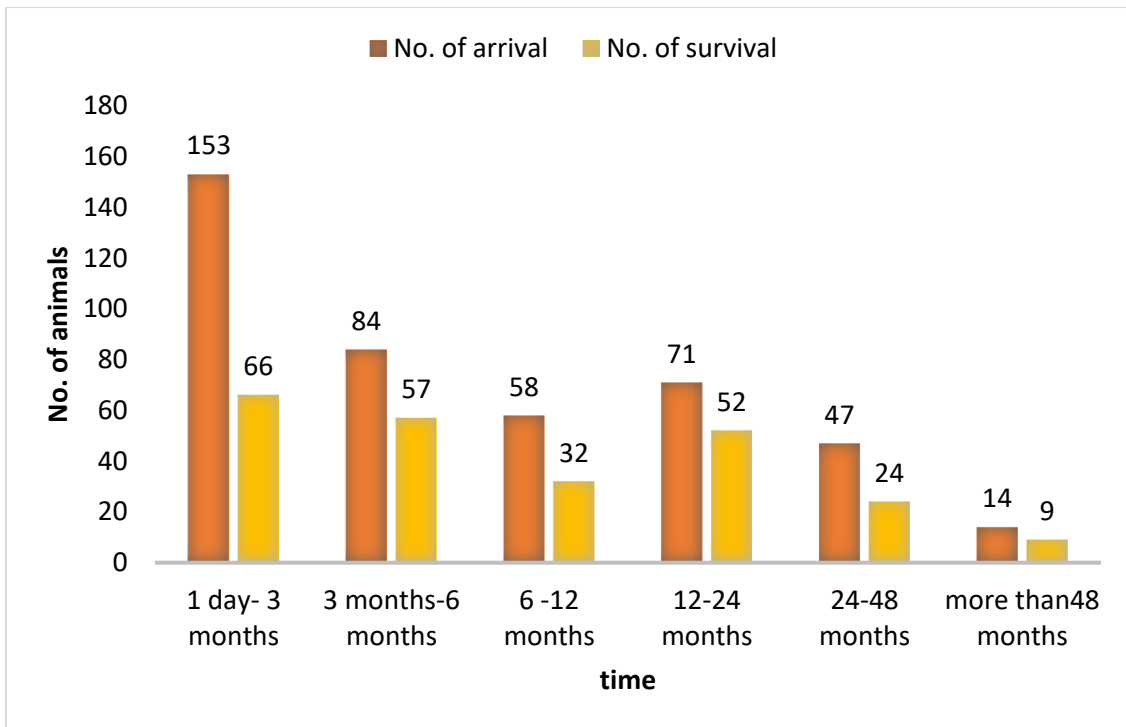


Figure 3. 2 Relationship between age of arrival and survival rate of elephant calves at the ETH

The orphan elephant calves arriving at the ETH often suffer from critical health problems, and unfortunately, some animals (n=5) have died during transportation. The majority of mortalities occur immediately after arrival during the treatment phase. However, the data presented in **Figure 3.3** demonstrates a positive trend in the survival rate over time. Notably, the most critical period is within the first six months after arrival, during which 175 out of 189 calves (93.5%) experienced mortality. After the six-month rehabilitation phase, only 14 deaths occurred (14 out of 252, accounting for 5.5%).

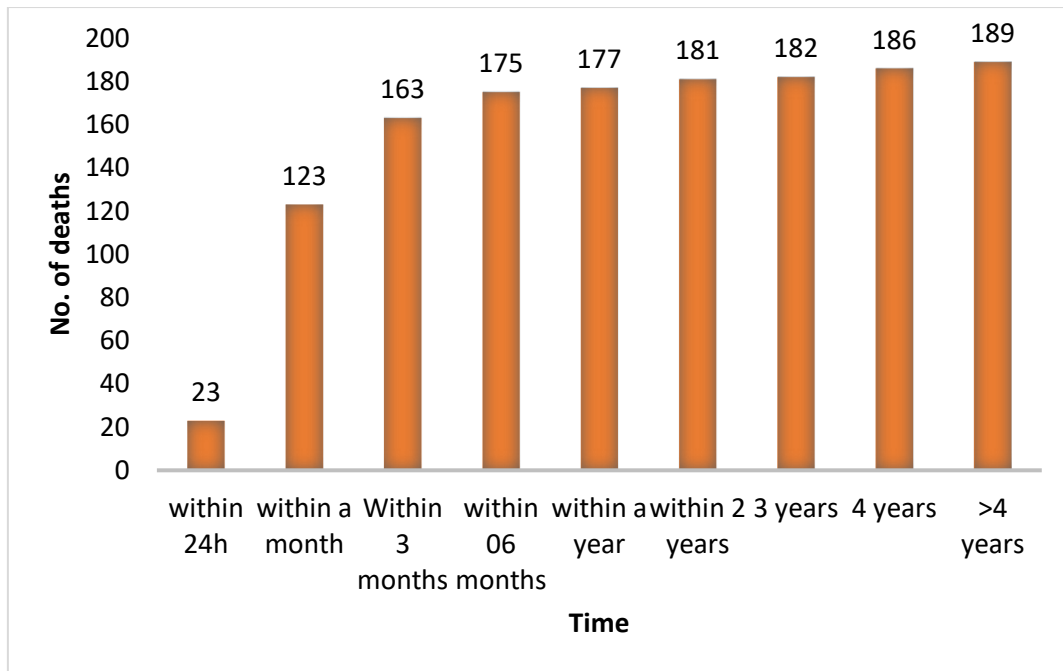


Figure 3. 3 Temporal distribution of mortality among orphan elephant calves after arrival at the Elephant Transit Home.

3.3.4 Causes for mortalities of elephant calves

Out of the total 189 deaths recorded at the ETH, the most probable cause of death was ascertained for 153 cases (**Table 3.1**). Gastrointestinal abnormalities accounted for the highest number of deaths, with 72 out of 189 (38%) cases attributed to this cause. These gastrointestinal abnormalities encompassed a range of conditions, including bacterial and viral infections, worm infestations, milk intolerance or milk allergy, nutritional deficiencies, torsions, and intussusceptions.

Table 3. 1 Causes for mortalities of elephant calves after arrival at the ETH

| Cause of death | Number |
|--|--------|
| GI tract associated complications | 72 |
| Infected wounds | 29 |
| Parasite infestation | 22 |
| Respiratory tract infections | 9 |
| Diseases with hemorrhagic lesions | 7 |
| Congenital abnormalities | 5 |
| Accidents at the ETH | 5 |
| Extreme weather conditions | 3 |
| Allergic reaction | 1 |
| Number of deaths due to multifactorial reasons/ exact cause couldn't ascertain | 36 |
| Total | 189 |

3.3.5 Parasite associated mortalities

Among the recorded deaths at the ETH, 12% (22 out of 189) were attributed to parasitic infestations. These mortalities were caused by various parasite species, including nematodes (*Parabronima smithi*: n=6), liver flukes (*Fasciola jacksoni*: n=5), tapeworms (*Anocephala manubriata*: n=2), hookworms (*Bathmostpmum sangeri*: n=3), and mixed species of parasites (n=6). **Figure 3.4** visually depicts the distribution of these parasite-associated deaths. These findings highlight the significance of parasitic infestations as a contributing factor to the mortalities of elephant calves at the ETH.

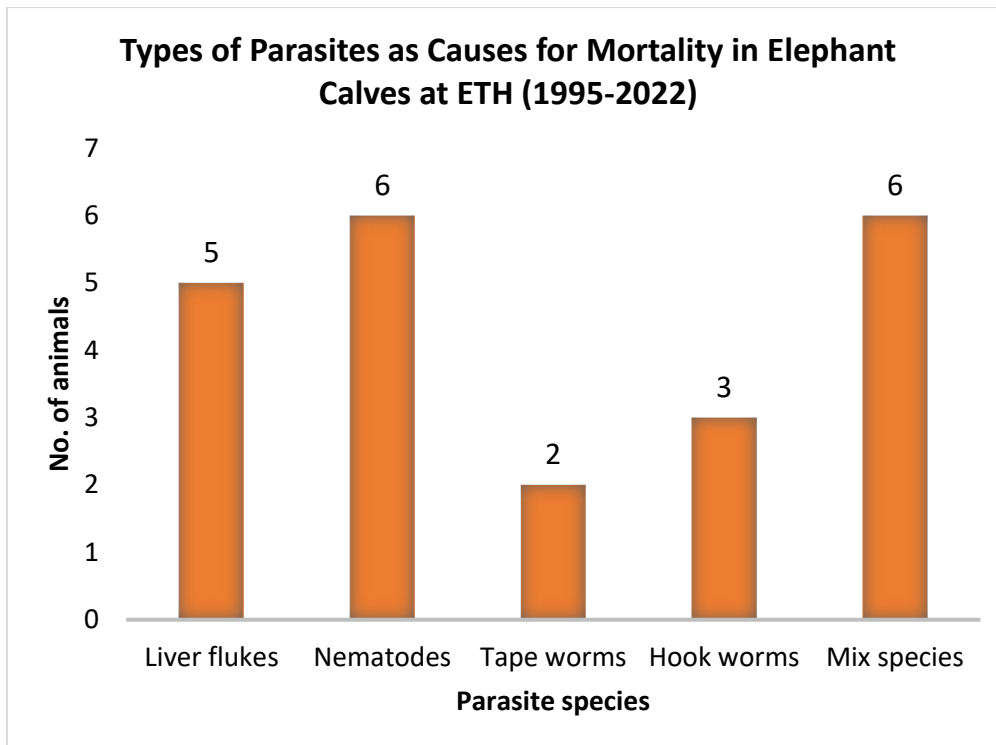


Figure 3. 4 Types of parasites as causes for mortality in elephant calves at ETH

3.3.6 Mortality due to wounds

Out of the recorded deaths at the ETH, a total of 29 cases were attributed to wounds and associated infections (**Figure 3.5**). The majority of these deaths were caused by specific types of wounds, with gunshot wounds and jaw bomb wounds accounting for the highest number of mortalities, both contributing to 10 deaths each. Additionally, deaths were also reported due to railway and vehicular accidents (6) and snare wounds (3). These calves, when affected by vehicular or train traffic injuries, often present with hind quarter paralysis. This paralysis can be associated with various injuries, such as fractured vertebral columns and/or spine (n=3), fractured pelvic bones (n=1), or fractures to the forelimbs (n=2). Unfortunately, none of these calves were able to survive despite efforts to provide medical treatment and care.

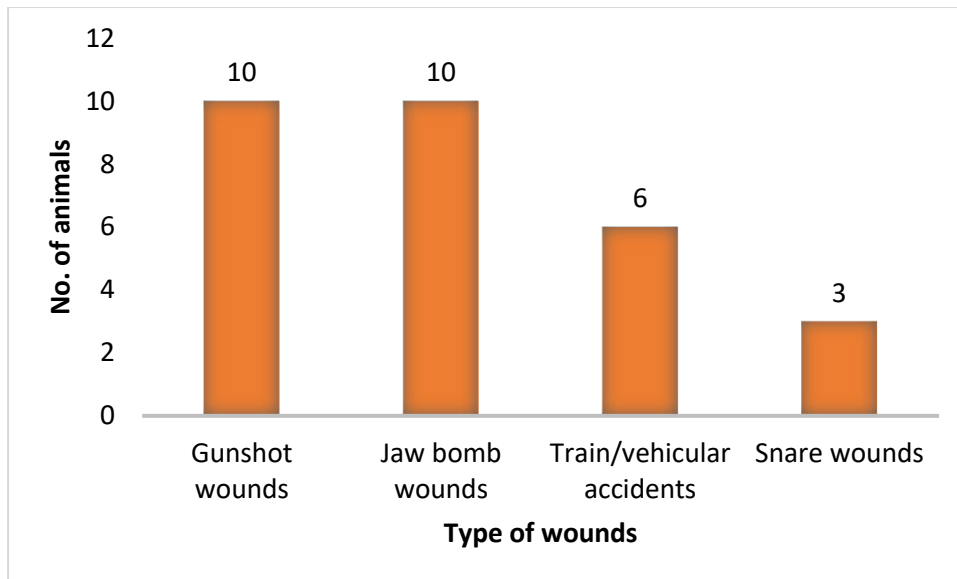


Figure 3. 5 Causes of injury leading to mortalities among elephant calves at the ETH

Eight deaths of orphan calves reported at the ETH were attributed to respiratory tract infections, with pneumonia being the most prominent clinical manifestation. In two out of the eight cases, granulomas were found in their lungs, while lung swabs for tuberculosis yielded negative results. Additionally, two deaths were a result of cold weather, occurring at dawn, the coldest part of the day. These deaths involved calves less than one month old. Furthermore, a weak calf died from heat shock after being exposed to the hot sun for several hours in the grassland.

Accidental deaths accounted for five reported cases. One calf died from a venomous snakebite, while two calves suffered from constriction around the neck region due to tethering with ropes. In another incident, a 5-year-old male calf engaged in a fight with a larger male and subsequently drowned in the reservoir while swimming with the herd. Moreover, a female calf drowned after falling into the irrigated well located within the electric-fenced pastureland of the ETH.

In addition to the previously mentioned deaths, there was a case involving a 5-year-old female calf that exhibited nervous symptoms suspected to be rabies. However, the laboratory report on this particular case was inconclusive, making it difficult to definitively determine the cause of death.

Furthermore, there were five deaths attributed to congenital abnormalities among the orphaned calves. One calf had atresia ani, a condition characterized by the absence or closure of the anal opening, and unfortunately, it died due to post-surgical complications. The remaining three calves also had congenital abnormalities,

manifesting as deformed limbs. Despite their specific abnormalities, all three calves ultimately succumbed to gastrointestinal tract infections.

3.4 Discussion

The survival of a new elephant calf is influenced by various factors, including the calf's health, the health and caretaking abilities of the mother, the care provided by other herd members, the calf's susceptibility to disease, and environmental conditions. In the wild, calf survival relies on the mother's milk, as well as the care and protection provided by the mother and the herd to some extent. However, when elephant calves are raised by humans in artificial settings, it is challenging to replicate all aspects of maternal care and herd dynamics.

It is important to recognize that the orphaned elephants at the ETH can be considered a temporary semi-captive population. While they have access to a natural environment and engage in free-roaming behavior, they are still under the care and supervision of the ETH staff to ensure their health, well-being, and successful rehabilitation.

Orphaned elephant calves inherently harbour a fear of humans, and their immediate instinct upon encountering people is to flee or seek cover. Consequently, during rescue operations, these calves are often discovered lying down, displaying signs of exhaustion, and grappling with life-threatening health complications. The stress experienced by rescued calves, stemming from exhaustion, fear of humans, and the unfamiliarity of their surroundings, can further compromise their immune system's efficacy. Orphaned calves are dispersed throughout Sri Lanka and are subsequently transported to the ETH facility, which itself represents a stressful event. Unfortunately, given these circumstances, mortality becomes an inevitable outcome, with the chances of survival for newly arrived orphaned elephant calves standing at approximately 59% (252 out of 427 cases). However, if the health of these calves can be effectively stabilized and they can progress to the rehabilitation phase, their prospects for survival and successful reintroduction into the wild are significantly heightened (238 out of 252 cases equating to a 94.5% success rate).

In captive situations, elephants are prone to various health problems, including both infectious and non-infectious diseases. These health issues encompass gastrointestinal disorders, malnutrition, weakness-related problems, musculoskeletal problems, ocular diseases, tusk/tushes problems, obstetric problems, foot problems,

parasitic diseases, and miscellaneous conditions such as poisoning. Several studies have documented these health concerns in captive elephants (Gamage *et al.*, 1999) Dangolla *et al.*, 2004; Dangolla, Edirisinghe and Silva, 2005; Fowler and Mikota, 2006; Thitaram, 2006; Dangolla *et al.*, 2006; Stremme, Lubis and Wahyu, 2007; Wijesekara *et al.*, 2007; Kumara., 2007; Wiedner *et al.*, 2008; Alex, 2009; Angkawanish *et al.*, 2009; Chakraborty, 2009; Chandrashekar *et al.*, 2009; Sarma, 2009, Riddle, 2011; Mar *et al.*, 2012; Kumara *et al.*, 2015; Suranga *et al.*, 2016; Athapattu *et al.*, 2018; Jayasumana *et al.*, 2018). In Myanmar, a study on calf mortality reported that accidents accounted for 42.4% of deaths in calves below 5 years, while factors such as agalactic mothers (lack of milk) and general weakness of newborns contributed to 26.6% of mortality cases. Gastrointestinal complications were the main cause of various diseases, accounting for 22.8% of deaths, and taming-related injuries accounted for 4.5% of cases (Lahdenperä *et al.*, 2016).

Out of 427 calves, a total of 175 (41%) died within six months of their arrival at the ETH. The causes of death were complex and multifactorial, involving various stresses related to environmental changes, weather fluctuations, handling and transportation, dietary changes, infectious agents, nutritional problems, dehydration, parasite infestations, and wounds. It is important to note that the calves arriving at the ETH often have pre-existing health issues upon rescue. Many of them are in critical condition, suffering from severe parasite infestations, jaw bomb wounds, gunshot wounds, snare wounds, and injuries from railway or road accidents. These underlying health problems contribute to the mortality rate among the calves at the ETH.

The age group of 12-24 months upon arrival recorded the highest survival rate, with 52 out of 72 calves (73%) surviving. This indicates that calves within this age range have a better chance of survival at the ETH. However, it is noteworthy that the expected higher survival rate for calves above 2 years of age has not been observed, which can be attributed to the critical health conditions of the calves upon arrival. The majority of wounds observed in rescued calves were attributed to gunshot injuries. Although elephant calves are not intentionally targeted, they often fall victim to shootings when villagers attempt to repel elephant herds engaged in crop raiding. Generally, if gunshot wounds are not excessively deep, they have a higher likelihood of successful treatment and subsequent calf survival. However, when wounds penetrate bones and joints, the healing process becomes exceptionally challenging. Another significant type of injury observed in rescued calves is damage to the oral

cavity, including the teeth, jaws, palate, and tongue, resulting from the explosion of improvised explosive devices known as "jaw bombs." These devices are commonly employed by poachers to eliminate wild boars. Unfortunately, when elephant calves encounter these devices in their natural habitat, they may inadvertently bite them, triggering an explosion. The damage inflicted by jaw bombs is severe, and wild boars typically succumb to immediate fatality. In contrast, if an elephant calf triggers a jaw bomb, it may endure prolonged suffering and eventually succumb to dehydration, starvation, or septicaemia. Thus far, the ETH has managed to successfully treat and save only three out of thirteen injured calves affected by jaw bombs (Perera, 2021).

Many calves at the ETH have unfortunately died shortly after their arrival, and determining the precise cause of death has proven challenging for most cases. Typically, these deaths are the result of a combination of physiological and psychological factors, including dehydration, starvation, impaired thermoregulation, pain, stress related to transportation and handling, diarrhea, respiratory difficulties, bacterial and viral infections, parasitic infestations, and infected wounds.

The capacity to conduct comprehensive investigations into the cause of death for orphaned calves at the ETH is currently limited. However, efforts are underway to enhance this capacity. Currently, the island wide veterinary investigation centers (VIC) operated by the Department of Animal Production and Health are fully engaged in handling cases involving domestic animals, which means that investigations into elephant and other wildlife health issues receive lower priority at the VICs. Nonetheless, specific bacterial diseases such as salmonellosis, colibacillosis, and clostridium toxicosis have been confirmed and recorded at the ETH.

Screening of the elephants at the ETH for tuberculosis using the Elephant TB STAT-PACK Assay (Perera *et al.*, 2011) and DPP® (Dual Path Platform) Assay (Perera *et al.*, 2015) identified some seropositive animals. Nevertheless, no calves displaying clinical signs related to tuberculosis have been reported thus far. Additionally, culturing trunk wash samples from selected animals did not reveal the presence of the pathogenic agent.

Common viral infections observed in captive elephant populations include rotaviruses associated with diarrhea, rabies, elephant pox, foot and mouth disease, encephalomyocarditis virus, and elephant endotheliotropic herpes virus (Fowler and Mikota, 2006; Stremme, Lubis and Wahyu, 2007; Riddle and Stremme, 2011). Although access to viral testing at the ETH is limited, it is suspected that viral infections

contribute to the diseases and mortality of elephant calves. Seven deaths characterized by hemorrhagic lesions are suspected to be of viral origin, but the specific pathogenic agent could not be identified.

Elephant endotheliotropic herpesvirus (EEHV) is an acute and highly lethal disease primarily affecting young elephants, typically between 1 and 10 years of age. The disease has been recorded in captive, semi-captive, and free-ranging elephants (Zachariah *et al.*, 2018; Oo *et al.*, 2020; Prompiram *et al.*, 2021). It is recognized as the leading cause of mortality among young Asian elephants, responsible for 50%-60% of deaths in Western zoos over the past 35 years (Howard and Schaftenaar, 2018; Jesus *et al.*, 2021; Perrin *et al.*, 2021). While no confirmed cases of EEHV have been reported at the ETH, the first case of EEHV-associated hemorrhagic disease was documented in the UNP (Perera *et al.*, 2018). There is interaction between the elephant calves at the ETH and free-ranging elephants at the UNP. A recent study found that all of the elephant calves at the ETH tested seropositive for EEHV, with significantly higher antibody levels than elephants in European zoos (Hoorweg *et al.*, 2022). The large herd size of elephant calves, their interactions with each other, and frequent exposure to the virus in the wild may explain these findings.

In the wild, elephant calves typically nurse from their mothers for a period of 2 to 8 years, and natural weaning occurs when the mother gives birth to another calf (Ochs *et al.*, 2001). The composition of elephant milk in the wilderness of Myanmar has been reported to consist of approximately 82.44% water, 17.56% total solids, 5.23% protein, 15.10% fat, 0.87% ash, and 0.18 µg/mL vitamin E (Dierenfeld *et al.*, 2020). In Sri Lanka, specific milk formulas or suitable replacements for elephant calves are not available. However, through trial and error, several commercial human infant milk powder formulas have been identified as suitable substitutes. The percentages of total solids, protein, and fat in elephant milk have been found to vary throughout lactation, generally increasing over time (McCullagh and Widdowson, 1970; Peters *et al.*, 1972; Osthoff *et al.*, 2007; Abbondanza *et al.*, 2013; Kobeni *et al.*, 2020). For example, the total protein content of Asian elephant milk ranges between 3.4% and 6.5%, while the fat content ranges between 0.63% and 19%, depending on the stage of lactation (Rietkerk, Hiddingh and Dijk, 1993; Osthoff, 2012; Abbondanza *et al.*, 2013).

Although these natural variations in milk composition are expected to be beneficial for the calf, adjustments to the composition of the commercial human infant

formulas used at the ETH are not made. Observations have shown that individual elephant calves have highly variable responses to the infant milk formula. Some calves initially exhibit temporary intolerance to the formula, but they eventually adjust and are successfully fed. Certain individuals may be intolerant to formulas derived from cow's milk, and in such cases, calves are provided with alternatives formulated with a soya protein base. Calves experiencing milk indigestion, intolerance, or allergy that leads to diarrhoea may benefit from a combination of supportive measures. Along with rehydration fluids, incorporating rice broth with kithul jaggery (a sweet syrup made from fishtail palm sap) and juices from watermelon or pumpkin can aid in rehydration and provide essential energy. The rice broth, being easily digestible, can provide a gentle source of carbohydrates while the kithul jaggery offers additional sweetness and energy. Rehydration fluids play a crucial role in replenishing electrolytes and maintaining hydration levels, while the juices from watermelon or pumpkin contribute valuable nutrients and further aid in rehydration.

In instances where calves refuse oral fluids entirely or suffer from severe diarrhea, intravenous fluids containing supportive nutrients such as amino acids, vitamins, glucose, and minerals are administered. Calves with serious and life-threatening gastrointestinal infections also receive intravenous fluids. In summary, when calves are unable to obtain sufficient water and nutrients from formula milk and solid foods, a series of measures may be taken, including diet changes, probiotic administration, temporary fasting, rectal fluid administration, provision of intravenous fluids and nutrients, and, if necessary, oral or systemic antibiotic administration.

It is widely recognized that fully grown elephants and their calves in the wild harbour and coexist with parasites. Parasitism is considered an inevitable aspect of nature, and it can have negative impacts on the health and fitness of hosts, posing a conservation threat to endangered species (Watson, 2013). At the ETH, parasite management practices acknowledge the presence of parasites as a natural occurrence. Elephants are dewormed infrequently unless visible health problems in calves are attributed to the parasites they may carry. However, newly arrived calves are consistently dewormed as a quarantine measure to improve and stabilize their health. Routine screening of elephant dung reveals the presence of nematode eggs and adult worms. Cestodes and trematodes are also sporadically detected in faecal samples, and measures are taken to control them. Clinical manifestations of gastrointestinal parasite infections include diarrhoea, colic, dependent oedema, and

anaemia accompanied by weakness. Four parasite species have been identified as the cause of death in 18 elephant calves at the ETH. These parasitic species have also been documented in the wild and are likely responsible for some mortality in wild elephant herds (Perera *et al.*, 2009; Perera *et al.*, 2015; Perera *et al.*, 2017). In addition to direct deaths caused by parasites, various other deaths related to general body weakness and infections are attributed to single or mixed species of parasites. Gastrointestinal parasites have also been reported to cause mortality in captive elephant populations, such as elephants employed in the Myanmar timber industry and captive elephants in India (Sukumar, *et al.*, 1997; Saseendran *et al.*, 2004, Chandrasekharan *et al.*, 200; Mar, 2002; Athapattu, 2018). A retrospective study conducted on Myanmar timber elephants demonstrated that over 60% of recorded deaths in elephants younger than 10 years were attributed to parasitism (Lynsdale *et al.*, 2017). The high mortality rate may be attributed to increased stress levels associated with heavy parasite burdens (Hing *et al.*, 2014).

In the Myanmar timber industry, where elephants are used for work, 10% of calves died before reaching one year of age, and 25.6% died before reaching five years out of 975 births (Lahdenperä *et al.*, 2016; Mar, 2002). In the South Indian timber industry between 1995 and 2005, the mortality rate of elephant calves below one year old was 31% (Vanitha, Thiyagesan and Baskaran 2010). At the Pinnawala Elephant Orphanage in Sri Lanka, five calf deaths out of 65 births (7.6%) were recorded from 1984 to 2016, despite calves being fed by their mothers and having access to veterinary facilities (Pushpakumara *et al.*, 2016).

Captive African and Asian elephants in North America and Europe have also faced challenges in sustaining their populations due to poor breeding success (Clubb and Mason, 2002; Weise and Willis, 2006; Thitaram, 2012). Evidence shows difficulties in conceiving, stillbirths, and early calf mortality among these populations (Hermes *et al.*, 2008; Saragusty *et al.*, 2009; Hartley, 2016). In western zoos, where every birth of an elephant calf is highly valued, significant efforts are made to ensure calf survival. However, calf mortality remains a major cause of declining captive elephant populations in the western world (Hildebrandt *et al.*, 2006; Faust *et al.*, 2011). The recorded infant mortality rate of elephants born in European zoos from 1902 to 1992 was 36.4% (Kurt and Mar, 1996), and approximately 30% of elephant calves die among zoo elephants in North America (Weise, 2000). Among the 14 member zoos of the European Endangered Species Programme (EEP) and the 178 member zoos

and circuses of the Species Survival Plan (SSP) in North America, the mortality rate of young elephants below five years of age (excluding stillbirths) was 23% (16/69; Taylor *et al.*, 1998). In contrast, a study of an Asian elephant population in a facility in North America recorded a 93% calf survival rate out of 28 pregnancies (Kiso *et al.*, 2017).

In the North Western Wildlife Region of Sri Lanka, the death proportion of wild elephant calves below five years of age was 11.4% (57/498) during the period 2009-2018 (LaDue *et al.*, 2021). It is important to note that the actual death rate among wild elephants may be higher, but due to potential inefficiencies in observations and reporting, the figure may not be fully accurate.

The studies mentioned previously indicate that in certain regions such as South India and Myanmar, there is a higher mortality risk for male elephant calves compared to females. However, the gender-specific mortality rates observed at the ETH do not follow the same pattern. In the case of the ETH, the sex-specific mortality rate for male calves was 105 out of 241 (44%), while for female calves it was 84 out of 186 (45%). These figures show that the mortality rates for male and female calves at the ETH are almost equal, indicating that gender does not seem to be a significant factor in the survival of calves in this particular population. It's worth noting that factors influencing calf mortality can vary between different populations and locations, and there may be specific factors at play in the ETH that contribute to the observed mortality rates.

It is interesting to note that in Myanmar, the presence of a grandmother with the mother increased the survival rate of calves by eight folds (Landenberg *et al.*, 2016), highlighting the significance of social factors in the elephant community. This is further substantiated by observations that possibly rejected calves by mothers in captivity may get injured by herd mates (Olson, 2002). However, the same fact remains in captive elephant facilities, namely poor survival rates of calves being observed despite the availability of better veterinary care (Mar *et al.*, 2012), when senior females are not around.

The elephant calves received by the ETH are typically orphaned, resulting from the separation from their mothers and herds. The process of capturing these orphans for rehabilitation involves unfamiliar handling by humans and transportation, which further adds to their distress. However, after stabilizing their health during the health stabilization phase, the calf mortality rate among rehabilitating elephants at the ETH is remarkably low, standing at 5.5%. This low mortality rate contrasts starkly with the

recorded mortalities of calves in Myanmar, western zoos, and the wild African elephant population in Amboseli National Park (Mar *et al.*, 2012; Taylor *et al.*, 1998; Moss, 2001; Clubb *et al.*, 2008; Moss *et al.*, 2011).

The exceptional success in calf survival at the ETH can be attributed to the provision of a natural environment that closely mimics the elephants' native habitat, thereby enhancing their chances of survival. This environment, combined with a comprehensive care program including proper nutrition and veterinary support, contributes to the well-being and thriving of the calves during rehabilitation. Moreover, the presence of experienced caregivers and handlers who possess a deep understanding of the behavioral and social dynamics of elephants plays a crucial role in minimizing stress and fostering the well-being of the calves.

CHAPTER 4

DIURNAL PATTERN OF SALIVARY CORTISOL AND ITS VARIATION FOLLOWING EXOGENOUS ADRENOCORTICOTROPIC HORMONE (ACTH) STIMULATION IN ELEPHANT CALVES

4.1 Introduction

Elephant calves receive maternal care supplemented by caretakers, known as allomothers, as well as other members within their familial unit. The maternal bond in elephants is exceptionally strong and serves as a primary determinant of the overall welfare of elephant calves, extending beyond the weaning period and into young adulthood (Lee, 1987; Goldenberg and Wittemyer, 2017; Goldenberg and Wittemyer, 2018; Parker, 2021). Female calves tend to remain in close proximity to a small group of closely related individuals throughout their lives, while male calves disperse during adolescence (Mellen and Keele, 1994; Sukumar, 2006).

In instances where an elephant calf becomes orphaned, it is deprived of the care provided by its mother and the family unit, leading to significant distress. Therefore, the rehabilitation program at the ETH places utmost importance on the well-being of elephant calves, recognizing the critical need to address their specific requirements.

Animal welfare is a multifaceted topic encompassing various scientific, ethical, economic, cultural, social, religious, and political dimensions. The OIE Terrestrial Code defines animal welfare as the physical and mental well-being of an animal in relation to its living and dying conditions. A state of good welfare is characterized by optimal health, comfort, adequate nutrition, safety, absence of unpleasant experiences such as pain, fear, and distress, and the ability to express natural behaviours that are essential for its physical and mental state (OIE, 2019).

Presently, there is considerable interest among conservationists and the general public in maintaining high animal welfare standards while implementing wildlife conservation practices (Mellor *et al.*, 2015). At the ETH, the management of elephant calves ensures their welfare by adhering to the principles of the 'Five Freedoms' (Council, F.A.W., 2009; Hemsworth *et al.*, 2015). This approach involves providing intense veterinary care to ensure 1) freedom from injury and disease, as well as 2) freedom from hunger, thirst, and malnutrition. To promote their well-being, the

elephants are allowed to live in a natural, wild environment with minimal human interference, granting them 3) freedom from thermal or physical distress, 4) freedom to engage in most 'normal' behaviors, and 5) freedom from fear.

Furthermore, the welfare of elephants within the ETH is also addressed through the comprehensive consideration of the "five domains" concept, encompassing nutrition, physical environment, health, behavioral interactions, and mental state (Mellor *et al.*, 2015; Descovich *et al.*, 2017; Mellor *et al.*, 2020). Nevertheless, it is crucial to subject the entire operation to rigorous scientific evaluation to assess the welfare of elephant calves effectively.

Animal welfare assessment plays a crucial role in ex-situ animal conservation programs (Mellor *et al.*, 2015). The evaluation of welfare status relies on both behavioural and physiological indicators. Animals interact with their internal and external environment through various senses such as sight, hearing, touch, smell, and taste. These sensory stimuli are processed in the central nervous system. When a stimulus, whether physical or physiological, poses a threat to an individual's well-being, it triggers an integrated 'stress response.' This stress response encompasses three primary components: behavioural changes, adjustments in autonomic function, and the secretion of various hormones, all aimed at restoring the body to a state of homeostasis (Carrasco, 2003; Chrousos, 2009).

Stress can be defined as a state where there is a real or perceived threat to homeostasis. The factors that elicit stress are known as stressors (Smith and Vale, 2022). Animals respond to both external and internal stressors by activating a range of behavioral and physiological responses collectively referred to as the stress response. Hormones such as adrenocorticotrophic hormone (ACTH), glucocorticoids (GC), catecholamines, and prolactin play a role in this stress response. When animals experience stress, a cascade of events occurs, ultimately leading to the release of GC. Glucocorticoids, such as cortisol and corticosterone, act as systemic effectors of the hypothalamic-pituitary-adrenal (HPA) axis (Spencer and Deak, 2017).

The HPA axis comprises three components: the hypothalamus in the brain, the anterior pituitary gland, and the adrenal cortex. During stress, the paraventricular nucleus of the hypothalamus secretes corticotrophin-releasing hormone (CRH), which stimulates the corticotroph cells in the anterior pituitary gland to release adrenocorticotrophic hormone (ACTH) (Kalsbeek, 2012; Lightman, 2020). ACTH then stimulates the zona fasciculata cells in the adrenal cortex to release GC into the

bloodstream, eventually appearing in saliva (Korte, 2001; Tilbrook, 2007; Gaffey *et al.*, 2016; Vinson, 2016). GC exerts negative feedback on the secretion of ACTH and CRH (Gupta, 2007; Papadimitriou and Priftis, 2009).

Stimulation tests for ACTH are commonly employed in both human and animal research to induce the activation of the classical hypothalamic-pituitary-adrenal (HPA) axis (Bolaños *et al.*, 1997; Tsuma *et al.*, 1998; Otten *et al.*, 2004). These tests have also been conducted in elephants in specific studies (Brown *et al.*, 1995; Stead, Meltzer and Palme, 2000; Wasser *et al.*, 2000).

Glucocorticoids play a crucial role in regulating various physiological systems in mammals and are responsible for coordinating behavioural, neuroendocrine, autonomic, and immune responses to disruptions in homeostasis (Möstl and Palme, 2002; Joëls and Baram, 2009; Palme, 2012). While glucocorticoid hormones are secreted by the adrenal cortex, the adrenal medulla releases catecholamines. These two hormone types are rapidly released within seconds to minutes after exposure to a stressor. They facilitate an organism's ability to cope with the situation by inducing physiological changes in the body, preparing animals for a response commonly known as "fight or flight." This response is vital for survival in the face of short-term stressors, such as predator attacks (Sapolsky, Romero and Munck, 2000; Sheriff *et al.*, 2011; Romero and Wingfield, 2015).

Glucocorticoids serve as primary hormones in dealing with stressful situations. Assessing the physiological levels of GC in blood, faeces, saliva, and hair is considered reliable for evaluating stress levels in animals (Palme *et al.*, 2005). Following their release into the bloodstream, GC hormones are rapidly metabolized and excreted through urine and faeces (El-Bahr *et al.*, 2005; Lepschy *et al.*, 2008). GC are the most commonly used physiological indicators for assessing animal welfare, including in the case of elephants (Menargues *et al.*, 2012; Bansiddhi *et al.*, 2019; Brown *et al.*, 2019; Kosaruk, 2020; Plangsangmas *et al.*, 2020).

Traditionally, GC are measured in blood; however, the act of blood sampling itself can induce stress, resulting in elevated GC levels. Salivary cortisol concentrations have shown a positive correlation with plasma concentrations, as the lipid-soluble steroids readily and quickly diffuse from the blood to saliva (Kirschbaum and Hellhammer, 1989; Negrao *et al.*, 2004; Wood, 2009). It is important to note that only the biologically active, unbound (free) fraction of GC from the blood is diffused into saliva (Palme, 2012). Therefore, collecting salivary hormone samples allows for

short-term and frequent assessments of the endocrine status, including diurnal variations in hormone levels (Cross and Rogers, 2004; Heintz *et al.*, 2011) and short-term physiological responses to social interactions (Horváth *et al.*, 2008; Wobber *et al.*, 2010).

The use of saliva for measuring cortisol levels has been reported in various species, including Asian elephants (*Elephas maximus*; Menargues *et al.*, 2012), horses (*Equus ferus*; Kolk *et al.*, 2001; Hughes *et al.*, 2010; Schmidt *et al.*, 2010; Peeters *et al.*, 2011), bonobos (*Pan paniscus*), western lowland gorillas (*Gorilla gorilla*), and Sumatran orangutans (*Pongo abelii*; Staley and Miller, 2020; Behringer, Stevens, and Sonnweber, 2022), chimpanzees (*Pan troglodytes*; Heintz *et al.*, 2011), spotted hyenas (*Crocuta crocuta*; Montgomery *et al.*, 2022), grey seals (*Halichoerus grypus*; Surviliené *et al.*, 2022), bottlenose dolphins (*Tursiops truncatus*; Rickert *et al.*, 2021), rhesus macaques (*Macaca mulatta*; Pfefferle *et al.*, 2018), common marmosets (*Callithrix jacchus*; Ash *et al.*, 2018), and donkey stallions (Bonelli *et al.*, 2019).

In elephants, cortisol or its metabolites have been successfully measured and validated using serum (Brown and Lehnhardt, 1995; Brown *et al.*, 1995), urine (Brown and Lehnhardt, 1995; Brown *et al.*, 1995), faeces (Foley *et al.*, 2001; Ganswindt *et al.*, 2003), and saliva (Dathe, Kuckelkorn and Minnemann, 1992; Menargues *et al.*, 2008). While blood samples can be collected from trained elephants in captive facilities for studying stress, this method may induce additional stress in the animals. Therefore, non-invasive approaches for assessing GC levels or their metabolites are essential when studying stress in elephants.

Studies have shown that many mammalian species, including humans, pigs, chimpanzees, cetaceans, bonobos, horses, and elephants, exhibit circadian patterns in GC secretion, with higher concentrations in the morning and lower concentrations around midnight (Takatsuji, 2008; Muneta, 2010; Heintz *et al.*, 2011; Suzuki *et al.*, 2003; Verspeek *et al.*, 2021; Bohak *et al.*, 2013; *et al.*, 2010; Menargues *et al.*, 2012; Casares *et al.*, 2016).

The measurement of salivary GC levels, which reflect the free GC concentration in the blood, is gaining popularity in captive animals due to the ease of saliva sampling and the non-invasive nature of the collection method (Kirschbaum and Hellhammer, 1994; Gozansky *et al.*, 2005; Gröschl, 2008; Levine *et al.*, 2007; Hellhammer *et al.*, 2009; Wood, 2009). The high correlation between salivary GC levels and free-unbound serum GC levels has been demonstrated in ACTH stimulation and

dexamethasone suppression tests (Dorn *et al.*, 2007; Hellhammer *et al.*, 2009). However, there are challenges in using this technique in free-ranging animals (Sheriff *et al.*, 2011).

Several studies have utilized salivary cortisol measurement to assess the welfare of elephants (Dathe, Kuckelkorn and Minnemann, 1992; Menargues, 2012; Plangsangmas *et al.*, 2020; Kosaruk *et al.*, 2020; Hambrecht *et al.*, 2020). Compared to blood, faeces, or hair sampling, salivary GC measurement offers two advantages: it allows for the collection of a controlled number of samples over relatively short time intervals, and salivary GC are relatively stable and can be kept at room temperature for several days (Lutz *et al.*, 2000; Chen, Cintrón and Whitson, 1992).

At the ETH, elephant calves are allowed to live freely with minimal human interactions. These animals are exposed to various stressors such as conspecifics, predators, weather, climate change, relocation, reintroduction, and habitat disturbances, which can impact their survival and reproduction (Creel, 2001; Cyr and Romero, 2007; Thiel *et al.*, 2008; Monclús *et al.*, 2009). Measurement of GC provides valuable insights into an animal's well-being and contributes to our understanding of ecological, evolutionary, conservation, and management processes (Sheriff *et al.*, 2011).

Salivary cortisol measurements have been employed in ex-situ animal conservation facilities as an indicator of stressful events in elephants (Casares *et al.*, 2016). The non-invasive nature of salivary cortisol sampling makes it a practical tool for assessing stress in these animals. By measuring cortisol levels, we can gain insights into the welfare of elephant calves at the ETH and understand the impacts of various stressors they encounter.

The objective of this study was to validate salivary cortisol metabolites for evaluating adrenocortical activity and determining potential stress responses in elephant calves, while also establishing baseline cortisol values and examining their diurnal patterns. To comprehend their biological responses to stressful stimuli, we induced adrenal cortex stimulation in four calves by administering adrenocorticotrophic hormone (ACTH). This study was conducted with the hypothesis that there are measurable levels of salivary cortisol in elephant calves and that the calves exhibit a predictable circadian pattern of salivary cortisol.

The second objective of the study was to conduct the ACTH stimulation test, providing insights into the HPA axis mechanism in elephant calves.

4.2 Methodology

Four clinically healthy elephant calves (2 males and 2 females) between 2-3 years of age and weighing 305-335 kg (**Table 4.1**) were selected as subjects for this experiment.

Table 4. 1 Information on the four elephant calves (2 males and 2 females) from ETH used in the experiment.

| Name | Sex | Place of origin | Date of receiving | Age at arrival | Age at time of ACTH injection (2017-09-17) | Weight at time of ACTH injection |
|----------------|--------|-------------------------|-------------------|----------------|--|----------------------------------|
| Kathari | Female | Kataragama | 06.01.2015 | 2 months | 3 years | 335 kg |
| Kumari | Female | Udawalawe National Park | 29.10.2016 | 1 year | 2 years | 305 kg |
| KK | Male | Udawalawe National Park | 25.01.2016 | 06 months | 2 years and 3 months | 325 kg |
| Wije | Male | Bundala National Park | 17.04.2017 | 1½ years | 2 years | 320 kg |

4.2.1 Collection of Saliva

Saliva samples were collected using the Salivette kit® (Sarstedt, AG & Co., Numbrecht, Germany). A modified feeding tube, similar to the one utilized for milk feeding, was affixed to the filter of the Salivette kit. Prior to sample collection, a one-week training period was conducted with the selected elephant calves to familiarize them with the tube attachment procedure. During milk feeding sessions, the new tube with the attached absorbent filter was gently inserted into the calf's mouth to simulate the process of milk intake. After 1-4 minutes, the tube was replaced with the regular feeding tube, and the filter containing saliva was separated from the tube and transferred into the Salivette tube. Subsequently, the Salivette tube was sealed.

4.2.1.1 Saliva Sample Processing

To process the saliva samples, the filters with collected saliva were centrifuged at 5,000 rpm for 5 minutes at room temperature. The resulting saliva was meticulously transferred into 2ml Eppendorf test tubes and stored at -20°C until further analysis.

4.2.1.2 Sampling Schedule and Success Rate

Saliva samples were opportunistically collected during feeding hours at specific time points: 0200, 0600, 0900, 1200, 1500, 1800, and 2200 hours. This sampling schedule was maintained for 16 consecutive days, commencing from day 0, which also included the day of ACTH injection.

4.2.2 Administration of ACTH

Three doses of 1.25 mg of synthetic ACTH (Cortrosyn, Organon Inc., Thailand) were administered intramuscularly at 2-hour intervals (0600, 0800, and 1000), following the protocol established in a prior ACTH stimulation study (Brown *et al.*, 1995). The total administered dose was calculated as 5 µg/kg body weight * 300 kg, resulting in a total of 1500 µg. The injections were performed manually using a 5ml disposable syringe with an 18G needle.

4.2.3 Measuring of cortisol in Saliva

The measurement of salivary cortisol was conducted at the Faculty of Veterinary Medicine, Chiang Mai University, Thailand. Concentrations of salivary cortisol were determined using a double-antibody enzyme immunoassay (EIA) with a polyclonal rabbit anti-cortisol antibody (R4866). Second antibody-coated plates were prepared by adding 150 µL of anti-rabbit IgG (0.01 mg/mL) to each well of a 96-well microtiter plate (Nunc-Immuno maxisorp, Thermo Fisher Scientific, Roskilde, Denmark), followed by incubation at room temperature (RT) for 15–24 hours.

After incubation, the wells were emptied, blotted dry, and then filled with 250 µL of blocking solution (100 mM phosphate, 150 mM sodium chloride, 1% Tween 20, 0.09% sodium azide, 10% sucrose, pH 7.5). The plates were incubated again at RT for 15–24 hours. Subsequently, the wells were emptied, blotted, and dried at RT in a desiccating cabinet (Sanpla Dry Keeper, Sanplatec Corp., Auto A-3, Japan) with loose desiccant at the bottom. Once dried (humidity < 20%), the plates were heat-sealed in a foil bag with a 1g desiccant packet and stored at 4°C until use.

For the assay, neat samples (50 µL) or cortisol standards (50 µL) were added to appropriate wells. Cortisol-horseradish peroxidase (HRP) (25 µL) was immediately added to each well, followed by 25 µL of anti-cortisol antibody (except for non-specific

binding wells). The plates were then incubated at RT for 1 hour on a plate shaker set to 150 rpm. After incubation, the plates were washed four times with wash buffer (1:20 dilution, 20x Wash Buffer Part No. X007; Arbor Assays, Ann Arbor, MI, USA).

Next, 100 μ L of TMB dihydrochloride dissolved in phosphate-citrate buffer with sodium perborate (Sigma Aldrich, St. Louis, MO, USA) was added to each well, followed by incubation for 10 minutes at RT without shaking. The reaction was stopped by adding 50 μ L of stop solution (1N HCl), and the absorbance was measured at 450 nm using a microplate reader (TECAN Sunrise, Salzburg, Austria). The assay sensitivity, based on 90% binding, was determined to be 0.084 ng/mL.

The cortisol EIA was validated for elephant saliva by demonstrating parallelism between serial dilutions of saliva and the cortisol standards ($y = -10.946x + 99.705$, $R^2 = 0.996$), as well as significant recovery of cortisol added to low-concentration saliva before analysis ($y = 0.7935x + 0.0743$, $R^2 = 0.9987$). Samples were analyzed in duplicate, and the inter-assay and intra-assay coefficients of variation (CVs) were 5.48% ($n = 4$) and 1.46%, respectively.

4.2.4 Weather Parameters and Their Potential Influences on Stress Levels

Throughout the study period, comprehensive weather parameters, including temperature, humidity, and precipitation, were meticulously collected to assess their potential impacts on stress levels.

4.2.5 Data analysis

It was conducted a paired t-test to investigate significant differences in the average mean salivary cortisol levels between males and females, as well as the average mean salivary cortisol level of each individual before and after ACTH stimulation.

4.3 Results

A total of 71 saliva samples were collected from male calves, while 73 samples were collected from female calves. The success rate of saliva collection was determined to be $34 \pm 4.1\%$ (range: 27-41% per elephant). In total, 144 saliva samples larger than 0.4 ml were successfully collected over the 16-day period, with an average volume of 0.7 ± 0.29 ml per sample. Baseline mean salivary cortisol levels were compared at each time point, excluding the day of ACTH injection (**Table 4.2**). It was conducted a comparison of mean salivary cortisol levels between male and female calves at each sampling time point over a 16-day period, excluding the day of ACTH injection. The results of the paired t-test revealed a non-significant difference between the two groups. The t-value was -0.50612, with a degree of freedom (df) of 5, and the associated p-value was 0.6351. These findings indicate that there is no significant difference in salivary cortisol levels between male and female calves at each time point based on the data analysed.

Table 4. 2 Comparison of mean salivary cortisol levels between male and female calves at each time point

| Salivary cortisol (ng/ml) Mean \pm SE | Time | | | | | | |
|---|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|
| | 0200 | 0600 | 0900 | 1200 | 1500 | 1800 | 2200 |
| Male | 0.33 \pm 0.06 | 0.93 \pm 0.15 | 0.97 \pm 0.15 | 0.78 \pm 0.05 | 0.46 \pm 0.18 | 0.29 \pm 0.10 | 0.32 \pm 0.01 |
| Female | 0.38 \pm 0.18 | 1.10 \pm 0.18 | 1.01 \pm 0.03 | 0.66 \pm 0.15 | 0.67 \pm 0.17 | 0.39 \pm 0.05 | 0.48 \pm 0.24 |

The mean salivary cortisol levels of four calves were assessed five days prior to and nine days after ACTH stimulation. **Figure 4.1** illustrates a box plot representing the mean cortisol levels before and after the ACTH stimulation. The study employed paired t-tests to examine significant differences between the average mean values before and after injecting at each time point. The results indicated no statistically significant differences in the average mean values of each individual before and after

injecting at any of the time points, as supported by the corresponding p-values ranging from 0.1339 to 0.8229.

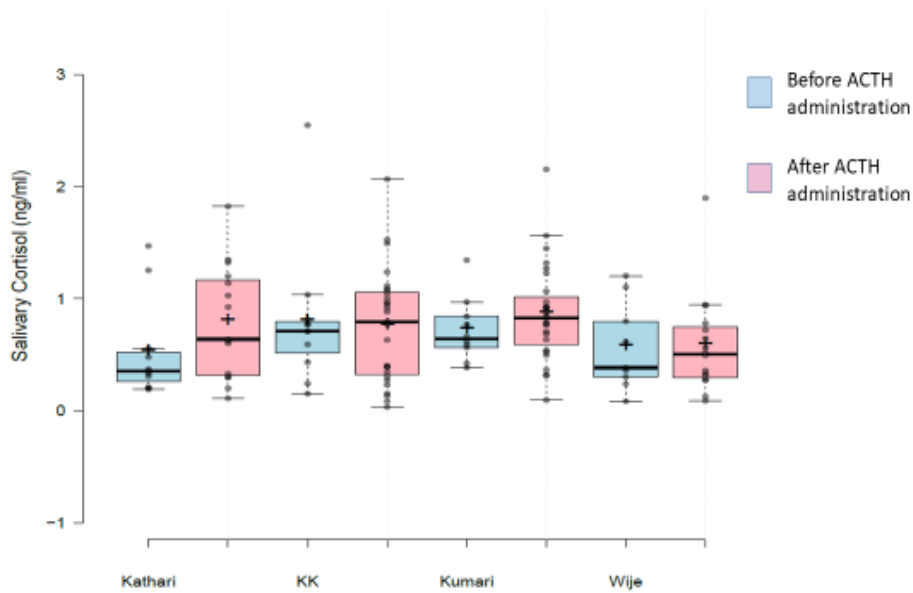


Figure 4. 1 Box plot comparing mean cortisol values of individual calves five days before and nine days after ACTH stimulation.

A circadian pattern of salivary cortisol secretion was observed in all four animals (**Figure 4.2**). The mean values indicated that the highest cortisol levels were observed at 0600 hours, while the lowest levels were recorded at 1800 hours (**Figure 4.3**).

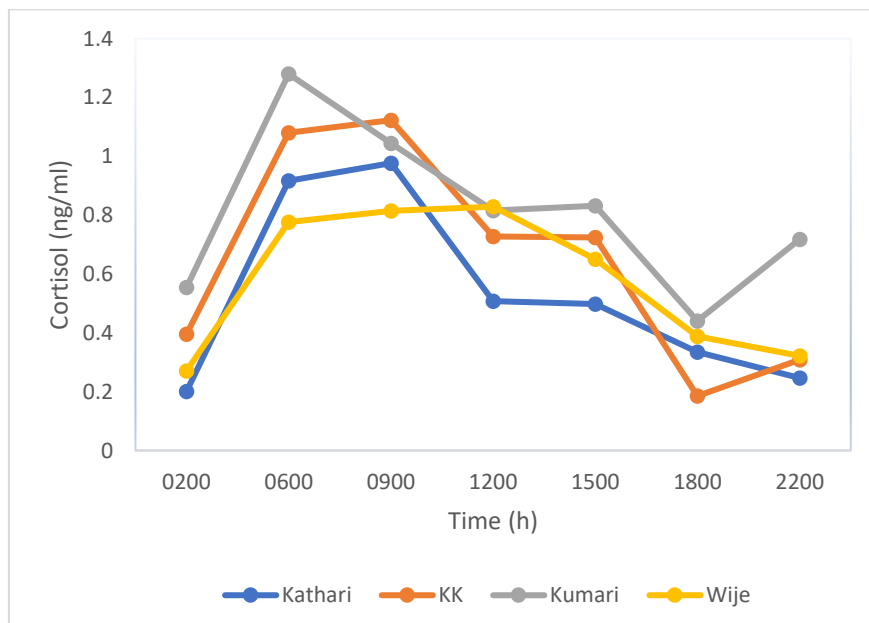


Figure 4. 2 Salivary cortisol levels in four elephant calves at different sampling times.

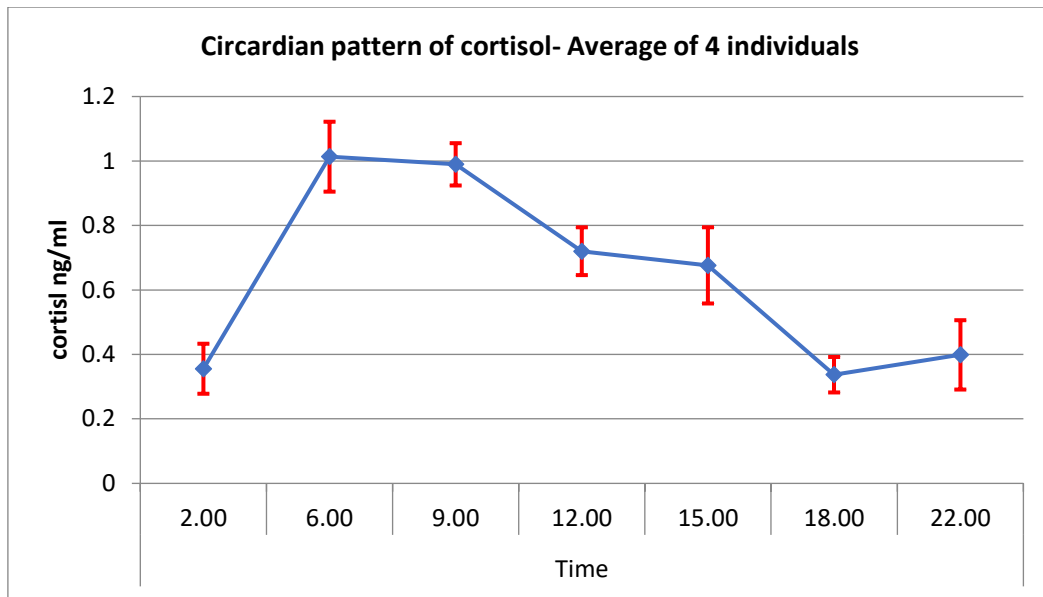


Figure 4. 3 Pattern of average salivary cortisol secretion.

At the day of ACTH stimulation, there was drastic increase of salivary cortisol levels. The mean average values of time points after the ACTH administrations were higher than the mean baseline values and it comes to baseline level at 0200. The highest value was 16.837 ng/ml at 1200 after administering the three doses. (**Figure 4.4**: The baseline means cortisol values and values after ACTH stimulation).

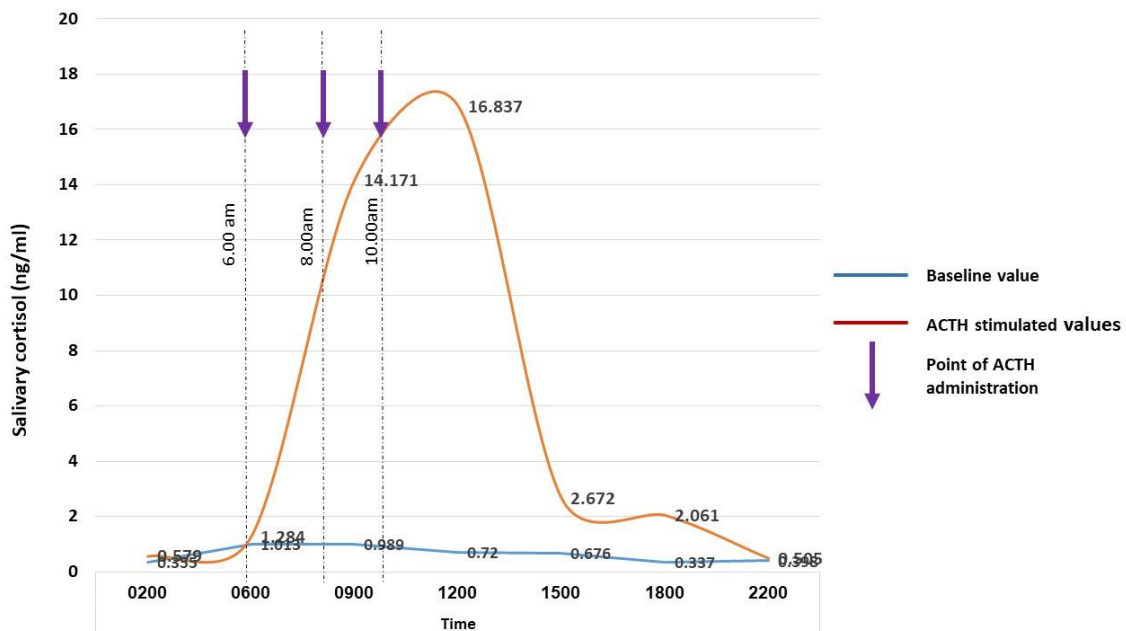


Figure 4. 4 Mean baseline salivary cortisol values and such values after ACTH stimulation (ACTH injection times (3) are indicated by vertical arrows).

During the study period, weather parameters such as temperature, humidity, and precipitation were measured. It is worth noting that no rainfall occurred during this

period. Notably, the highest average temperature and lowest humidity levels were observed at 1200 and 1500. The average temperature ranged between 26°C and 32°C, as illustrated in **Figure 4.5**.

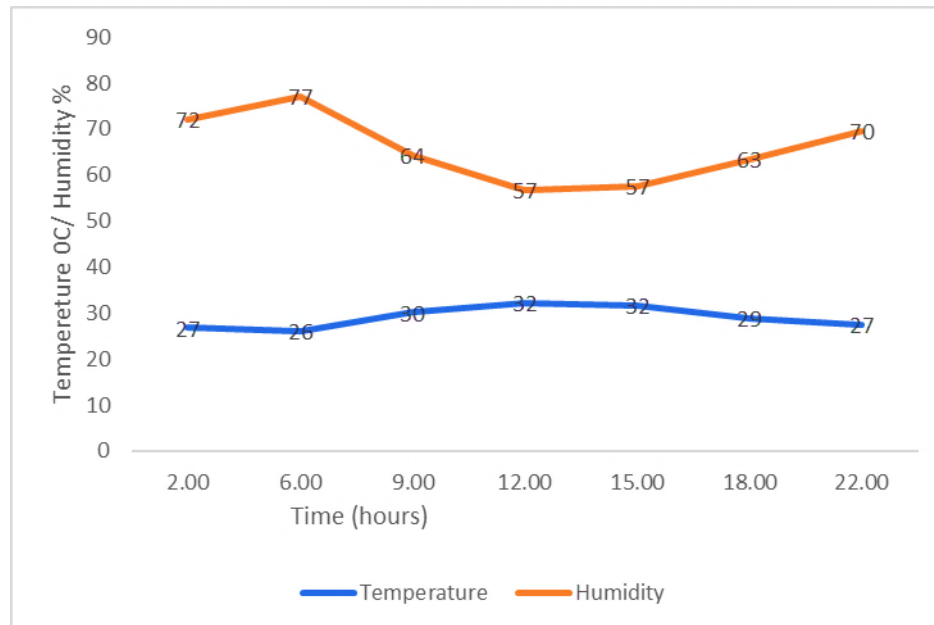


Figure 4. 5 The fluctuations of average temperature and humidity throughout the study period.

4.4 Discussion

The present study provides significant baseline data for assessing the welfare of elephant calves in a non-invasive manner by measuring salivary cortisol levels. A unique and distinctive approach was utilized by the researchers to collect saliva samples. The success rate of saliva collection was determined to be $34 \pm 4.1\%$. It is important to note that several factors influenced the failure of sample collection within this methodology. These factors primarily included uncooperative behaviour exhibited by the animals, insufficient saliva volume obtained, and the contamination of saliva samples with food particles and soil.

To the best of our knowledge, this is the first study on circadian pattern of salivary cortisol and its variation on ACTH stimulation in Asian elephant calves. This was the first study in which sampling was performed at 7 different times during a day. The results presented here show that salivary cortisol is a measurable physiological indicator in elephant calves. If salivary cortisol is to be used as a welfare assessment

in elephant calves, it is very important to have a clear data on fluctuations on the basal levels of cortisol related to the time of collection. While HPA axis modulate the stress response secreting the GC, under normal, non-stressed, conditions, in diurnal species of animals, GC are secreted cyclically (influenced by the sleep–wake cycle), with a peak upon waking and lowest levels during sleep (Takahashi, Kipnis and Daughaday, 1968; Czeisler and Klerman, 1999; Luboshitzky, 2000; Herman *et al.*, 2003; Brown *et al.*, 2010; Kutsukake *et al.*, 2009; Menargues *et al.*, 2012; Aurich *et al.*, 2015). A study conducted by Grand *et al.*, 2012 has established a positive relationship between serum and salivary cortisol in African elephants and demonstrated a normal decline towards afternoon in both salivary and serum cortisol. The data on 15 days, clearly revealed that elephant calves exhibit circadian pattern of secretion of cortisol in saliva.

A study done with elephants by Brown *et al.*, (2010), found that urinary cortisol excretion showed high levels in the morning, which decreased during the evening. Some other studies done on elephants had reported the diurnal pattern of urinary cortisol excretion as well as circadian pattern of salivary cortisol (Menargues *et al.*, 2012; Casares *et al.*, 2016; Plangsangmas *et al.*, 2020; Kosaruk *et al.*, 2020; Hambrecht *et al.*, 2020). In this study the highest concentration of baseline cortisol level was observed in the morning hours with the peak at 0600 (1.015 ng/ml), the lowest concentration was seen during the night with the lowest at 1800 (337 ng/ml). Some previous studies on African and Asian elephants had demonstrated a diurnal rhythm for salivary cortisol with peak concentrations in the morning that gradually decreased throughout the day. Salivary cortisol was highest at 0800 and lowest at 2000 h in African elephants (Casares *et al.*, 2016) and was the highest at 0730 and lowest around 1930 h for Asian elephants (Menargues *et al.*,2012). All of these studies were done with elephants living in the zoos. The reasons for the observed diurnal variation in cortisol have not been explained. Elephants did not eat during the 8 hours at night, and this prolonged period of fasting may stimulate lipid metabolism. Another assumption is it relies on the connections of the biological clock, via its projections to the pre-autonomic neurons, with the autonomic nervous system, and not so much on the suprachiasmatic nucleus of hypothalamus connections with the HPA-axis (Kalsbeek, 2012). Some studies explained GC concentrations tend to be highest at the beginning of the active phase of the day (Romero and Wingfield, 2016).

Some studies suggested that diurnal GC play an important part in regulating energy homeostasis in order to perform daily activities (Leal and Moreira, 1997; Le

Minh *et al.*, 2001; Dallman *et al.*, 2003). Horses too exhibit the circadian pattern of cortisol secretion but the real reason for the maximum and minimum period of cortisol secretion remains unclear (Bohák *et al.*, 2013). Thus, the reason for circadian pattern of cortisol secretion in free ranging elephant calves with *ad libitum* access to food and water too remains unclear.

Though the circadian pattern of salivary cortisol in studied animals exists, random fluctuations in individuals both during the day and night time, were seen. Stress is a subjective experience, and thus the extent to which individuals are 'stressed' is difficult to quantify (Dawkins, 1980). The studied animals are free ranging with 50+ calves, therefore many internal and external stressors could cause these fluctuations. These includes social disputes such as fights, physical accidents and external factors such as veterinary interventions, presence of wild elephants and other wildlife, dogs etc. (Behringer *et al.*, 2009; Casares *et al.*, 2016; Palme, 2019). A low level of cortisol indicates a relaxed, healthy individual. However, acute increase in cortisol levels reflects a threat to homeostasis that can be elicited by all factors that signal the need to mobilize energy and it does not necessarily denote an individual in distress (Romero and Beattie, 2022; Behringer Stevens, and Sonnweber, 2022). In some occasions cortisol levels also increase as a response to pleasurable experiences in natural activities such as mating and exercise, termed positive valence arousal (Rushen and de Passillé, 1992; Ralph and Tilbrook, 2016). Therefore, in animal welfare assessment with cortisol alone, or single event sampling, overall conclusions on animals' stress levels or welfare need to be interpreted with caution (Ross *et al.*, 2014; Ralph and Tilbrook, 2016).

Time course of GC response (stress response) to an acute stressor is highly conserved across all vertebrate taxa (Sapolsky, 1992; de Kloet *et al.*, 2005). When there is stressor, serum GC concentrations usually reach peak levels 15–30 min after a stressor and return to basal levels within 60–90 min (Sire *et al.*, 1995; De Kloet *et al.*, 2005; Hernandez *et al.*, 2014). The presence of short-term elevated GC concentrations facilitates the escape from life-threatening situations (Wingfield *et al.*, 1998).

The stress-response can vary due to many extrinsic and intrinsic factors (e.g., extrinsic: time of day, seasonal variation, food availability, predation, disease, social status, intra-group competition, translocation, habitat; intrinsic: species, body condition, reproductive status, age, sex, sexual state); if there is a greater response it

is indicative of the animal being under greater stress (Sapolsky, 1992; De Nys *et al.*, 2010). The GC levels in blood can be detectable after 3 min of exposure to an acute stressor, and maximum GC levels are reached within 15–30 min. Salivary cortisol concentrations reliably reflect circulating cortisol in the blood (Peeters *et al.*, 2011). The transfer of cortisol from plasma to the saliva occurs within few minutes and therefore, salivary cortisol level too is detectable parallel to cortisol level of blood. (Grand *et al.*, 2012; Hernandez *et al.*, 2014). There are studies that proved salivary and plasma cortisol correlates relatively well in different species including cattle (Negrao *et al.*, 2004), sheep (Fell, Shutt and Bentley, 1985), goats (Greenwood and Shutt, 1992), pigs (Bushong, Friend and Knabe, 2000), dogs (Beerda *et al.*, 1996), bonobos and orangutans (Behringer *et al.*, 2014), and horses (Pell and McGreevy, 1999), elephants (Grand *et al.*, 2012). If the animal is normal GC level begin to decline soon after peak levels have been reached, after exposure to acute stress. GC reach pre-stressor levels approximately 60–90 min later. However, with animals in stressful situations GC levels may remain elevated for a prolonged period (De Kloet *et al.*, 2005).

In this ACTH stimulation study, 4 calves showed the significant elevation of salivary cortisol. After injecting three doses of ACTH in two hours interval (0600, 0800 and 1000) the mean salivary cortisol level increase from 0.72 ng/ml to 16.83ng/ml (23-fold increase). This drastic increase is far beyond the level of 04 juvenile African elephants those were stimulated by single dose of ACTH. In that study serum cortisol concentrations increased by 4–7 fold reaching highest values after 2 h. (Stead, Meltzer and Palme, 2000). In other ACTH stimulation study with Asian bull elephants, after injecting three doses of ACTH in two hours interval, cortisol increased dramatically (3- to 10-fold) in all bulls in the study with highest peak of serum cortisol value 140ng/ml (Yon *et al.*, 2007). The study done by Brown *et al.*, 1995 with one African and one Asian elephant were given three intravenous injections of ACTH at 2 h intervals reported that serum cortisol increased four- to eightfold within 30 min after the first injection and peaked (nine- to twelvefold increase) after the second injection.

The welfare, particularly on animals under human care is becoming an increasingly important topic for both science and society along with the current numerous ethical debates. Monitoring animal welfare is critically important and an effective animal management tool in ex-situ conservation facilities (Mellor, Hunt and Gusset, 2015). The stress physiology has a great deal to contribute to behavioural,

population, and community ecology. When GC is considered as a stress indicator, it is clear that the release of GC, cortisol or corticosterone, is species- and context-specific. Further, it has become increasingly clear that the GC responses of wild free-living animals do not always match the predictions of the traditional model (Romero and Beattie, 2022). Activation of the hypothalamic-pituitary-adrenal (HPA) axis and the subsequent release of GC are integral components of the stress response, but the HPA axis also plays crucial non-stress-related roles. It is involved in various physiological functions, including metabolism regulation, immune system modulation, circadian rhythm regulation, cognitive function and memory, and blood pressure regulation (Sapolsky, Romero and Munck, 2000; McEwen, 2007; MacDougall-Shackleton, 2019). This study could suggest detailed and further studies via non-invasive sampling on elephant calves on the subject, and to examine its influence on behaviour, weight gain or loss and fitness changes.

CHAPTER 5

EVALUATION OF THE WELFARE STATUS OF REHABILITATED AND RELEASED ORPHAN ELEPHANT CALVES USING FAECAL GLUCOCORTICOID METABOLITES

5.1 Introduction

The objective of the Elephant Transit Home (ETH) is to reintroduce orphaned elephants, which have been under temporary human care, back into their natural habitat. The calves at ETH are kept with minimal human contact until they reach the age of six to eight years, after which they are formed into groups and released into the wild. Evaluating the outcomes of the rehabilitation program for orphaned elephant calves in Sri Lanka is crucial for its improvement. However, traditional assessment methods like long-term survival and reproductive success are not suitable for assessing rehabilitation outcomes due to elephants' long lifespan and slow reproduction rates. Additionally, these indicators do not provide direct information about animal welfare, which is a major concern in both scientific and public discussions. Several methods exist for measuring the welfare of mammals, with hormones and stereotypies being the most validated and cross-correlated tools for inferring elephant welfare in captive settings (Rees, 2004; Laws *et al.*, 2007; Mason and Veasey, 2010).

Over the past 27 years, the ETH has received an average of 15.7 orphaned elephant calves annually for rehabilitation. Out of these, a total of 162 elephants were successfully rehabilitated and released back into the wild (Perera, 2018). It is important to monitor these rehabilitated calves after their release to continue the learning process, introduce better welfare measures if necessary, and make relevant changes to the rehabilitation programs. Therefore, this study aims to assess the welfare status of elephants before and after their release from the ETH in Udawalawe.

Animal welfare is concerned with the emotional states of animals, such as "suffering" or "contentment," which cannot be directly measured but can be inferred from behavioral and cognitive responses, physiological responses, and their effects on reproduction and health (Mason and Veasey, 2010). Stress responses are considered a "gold standard" in welfare assessment, and stress hormones serve as

physiological markers to measure and monitor individual responses to stressors (Gibson *et al.*, 1986; 2007; Menargues *et al.*, 2008; Ali and Nater, 2020). The amplitude and duration of stress response often correlate with the overall health of an animal (Sapolsky, 1993; Boonstra *et al.*, 1998). Both ethology and physiology can provide insights into stress conditions in wild animals during handling (Taraborelli *et al.*, 2011).

Stress in wild animals can be caused by natural processes such as climate, social and interspecific interactions (Sapolsky, 1992; Creel, 2001; Boonstra, 2004; Van Dyck, 2012; Creel *et al.*, 2013), as well as human-associated processes including cattle grazing, energy extraction, hunting, tourism activities, and logging (Baltic *et al.*, 2005; Millspaugh *et al.*, 2001; Thiel *et al.*, 2008; Wasser and Hunt, 2005). Animal capture and handling can also induce severe stress (Carmanchahi *et al.*, 2011; Dembiec, Snider and Zanella, 2004; Dickens, Delehanty and Romero, 2010). The effects of stress on wild animals include changes in behavior, such as disruptions in social hierarchies and alterations in territorial behavior (Tarlow and Blumstein, 2007), as well as changes in physiology, such as alterations in hormone levels in the blood (Creel, 2005). Prolonged stress can suppress immune function, increase disease susceptibility, lead to abnormal behavior, and have deleterious effects on fitness (Selye and Fortier, 1950; Moberg, 1985, 1990, 2000; Blas *et al.*, 2007; Sheriff *et al.*, 2009).

Currently, there is a growing focus among conservationists on the relationship between stress and disease in wildlife populations, and glucocorticoid (GC) indices are used to investigate stress and disease in wildlife (Lafferty and Kuris, 1999; Aguirre and Tabor 2008; Van Bresseem *et al.*, 2009; Blaustein *et al.*, 2012; Cooke *et al.*, 2013). Stress refers to disruptions in homeostasis and involves a wide range of physiological responses, including endocrine responses that aim to ensure normal bodily function (Tilbrook and Clarke, 2006). Among the various hormonal responses during stress, the hypothalamic-pituitary-adrenal (HPA) axis is almost always activated (Tilbrook, 2007; Tilbrook and Ralph, 2016). When a stressor is perceived by the anterior pituitary of the brain, it triggers the release of adrenocorticotrophic hormone (ACTH) into the systemic circulation (Reeder and Kramer, 2005; Verspeek *et al.*, 2021). ACTH causes the secretion of glucocorticoids (GC) from the adrenal cortex, which act on multiple organ systems to redirect energy resources to meet real or anticipated demands (Herman *et al.*, 2016). The HPA axis can respond to a wide range of psychological

and physiological stimuli, and its activation is tightly controlled by various neuronal and endocrine systems, including GC feedback at different levels of the HPA axis (Keller and Dallman, 1984; Sean *et al.*, 2006; Mormède *et al.*, 2007; Myers *et al.*, 2012).

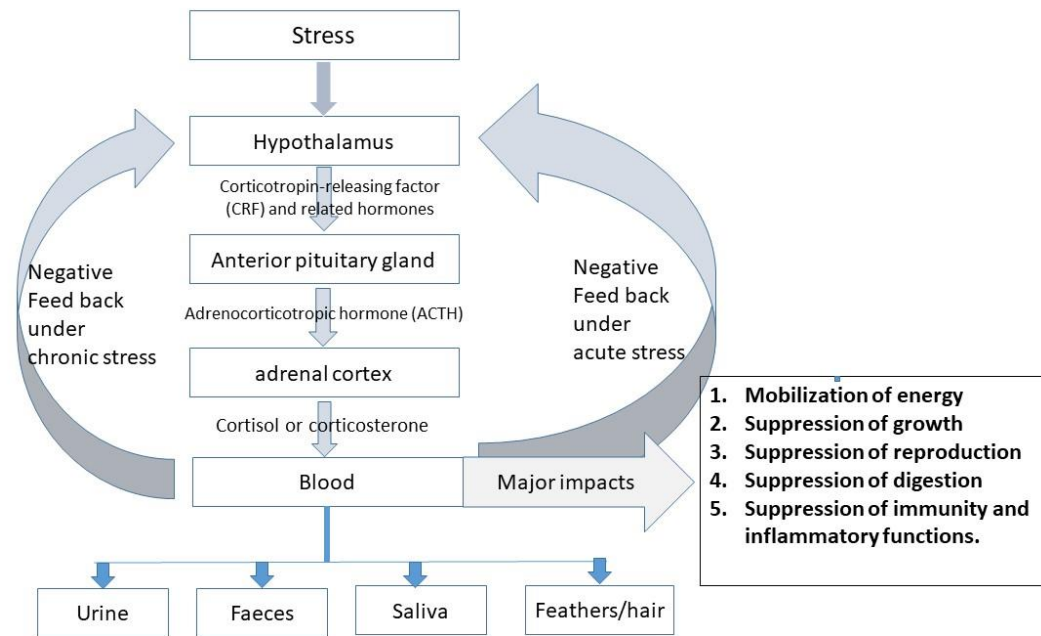


Figure 5. 1 Schematic representation of the hypothalamic–pituitary–adrenal (HPA) axis

(Serum cortisol levels provide feedback to the hypothalamus and pituitary, resulting in the inhibition of corticotropin-releasing factor (CRF) release (Boonstra, 2004; Sean *et al.*, 2006; Boonstra *et al.*, 2013; Herman *et al.*, 2016). When the stressor is acute, the feedback mechanism operates efficiently, allowing the system to rapidly return to normal and affecting only short-term bodily processes. However, under chronic stress conditions, the feedback signals are weakened, resulting in prolonged activation of the system and effects on long-term bodily processes, which can be detrimental.)

The stress response consists of three main components: behavioural changes, adjustments in autonomic function, and secretion of various hormones that enhance an individual's chances of survival when faced with homeostatic challenges (Carrasco and Van de Kar, 2003). Activation of the stress response triggers behavioural and physiological changes. Behavioural effects include increased awareness, improved cognition, euphoria, and enhanced analgesia (Chrousos and Gold, 1992; Charmandri *et al.*, 2005). Physiological adaptations initiated by the stress response include increased cardiovascular output and respiration, redirection of blood and energy to

cerebral tissues and muscles, intense focus on the stressor, decreased appetite, suppression of reproductive activity, and immune system modifications inhibiting general vegetative functions such as feeding, digestion, growth, reproduction, and immunity (Habib *et al.*, 2001; Carrasco and Van de Kar, 2003). Although the term "stress" is typically associated with negative experiences and an animal's inability to cope with environmental factors (Norcross and Newman, 1999; Cross, Pines, and Rogers, 2004; Dehnhard, 2007), not all stressors have negative impacts. Stress is necessary for reproduction, survival, and adaptation to environmental changes (Moodie and Chamove, 1990; Wielebnowski *et al.*, 2002; Crespi *et al.*, 2013). However, chronic stress resulting from prolonged periods of elevated glucocorticoid levels has negative effects on health, weight, behaviour, reproductive efficacy, and immune function (Buckingham, 2010). Prolonged stress can inhibit protein synthesis, increase energy mobilization, and decrease fitness by causing immunosuppression, tissue atrophy, poor population performance, and disruption of reproductive hormone secretion (Foley *et al.*, 2001; Robertshaw, 2006; Mason and Veasey, 2010).

Various methods are available for measuring glucocorticoid concentrations or their metabolites in four main biological matrices: blood (Möstl and Palme, 2002; De Mel *et al.*, 2012), saliva (Dathe *et al.*, 1992; Ekkel *et al.*, 1996; Behringer *et al.*, 2022), faeces (Whitten *et al.*, 1998; Mormede *et al.*, 2007; Sheriff *et al.*, 2011), urine (Rukstalis and French, 2005; Laws *et al.*, 2007), and hair (Koren *et al.*, 2002), which are used in studies on wild animals. Although blood sampling has traditionally been the most common method for measuring glucocorticoid concentrations, recent years have seen the establishment of numerous reliable non-invasive methods for assessing adrenocortical activity in various mammalian species (Ganswindt *et al.*, 2003; Schwarzenberger, 2007). These methods have proven practical and enabled long-term monitoring of environmental and social factors that impact adrenocortical activity in African elephants in both zoo and wild settings (Ganswindt *et al.*, 2005; Rasmussen *et al.*, 2008; Ganswindt *et al.*, 2010). Assays for measuring cortisol or its metabolites in elephants have been validated for serum (Brown and Lehnhardt, 1995; Brown *et al.*, 1995), urine (Brown, Wemmer, and Lehnhardt, 1995; Brown and Lehnhardt, 1995), faeces (Foley, Papageorge, and Wasser, 2001; Ganswindt *et al.*, 2003), and saliva (Dathe, Kuckelkorn and Minnemann, 1992; Menargues *et al.*, 2008). Glucocorticoids in plasma are extensively metabolized by the liver and excreted into the urine via the kidneys or into the gut via the bile ducts (Taylor, 1971; Palme *et al.*, 2005).

The measurement of stress hormones can help us understand how stressors affect the survival and reproductive success of free-living animals, as well as how natural environmental challenges (e.g., conspecifics, predators, weather), climate change, relocation or reintroduction, and habitat disturbance impact populations (Wasser *et al.*, 1997; Creel *et al.*, 2002; Cyr and Romero, 2007; Thiel *et al.*, 2008; Cresswell, 2008; Sheriff, Krebs and Boonstra 2009; Leroux and Schmitz, 2015; Moll, 2017).

To optimize the welfare of elephant calves at ETH and after their release, this study was conducted using faecal glucocorticoid metabolites (fGCM) as a physiological indicator of stress. fGCM was monitored for 23 consecutive months in 10 rehabilitated elephants. The initial hypothesis of the study suggested that calves undergoing rehabilitation at ETH experience a positive welfare status compared to their life in the wild after release. The second hypothesis is that the hard release method currently used at ETH can be a stressful event for the calves, leading to chronic stress until they are properly acclimatized.

5.2 Materials and Methods

5.2.1 Study Animals and Study Locations

The study population consisted of 10 orphan elephants at ETH, including 6 males and 4 females, all ranging in age from 6 to 8 years (**Table 5.1**). These elephants were originally from the low country dry zone of Sri Lanka (**Figure 5.2**) and were brought to ETH when they were below one year old. They had been at ETH for a minimum of 6 years prior to the study. In March 2015, all 10 elephants were released into the Udawalawe National Park (UNP) (**Figure 5.3**). Six of the elephants were equipped with standard VHF collars, while the other four were fitted with plain collars solely for identification purposes. Post-release monitoring was conducted through direct and indirect observations, with tracking facilitated by the use of VHF collars.

Table 5. 1 Information on 10 elephants used in the study

| Name | Sex | Rescue site | Date of arrival | Age at arrival | Age at release |
|-----------|--------|---------------|-----------------|----------------|----------------|
| Samari | Female | Hambantota | 23 May 2008 | 2 months | 8 years |
| Amber | Female | Vauniya | 9 Sep 2008 | 3 months | 8 years |
| Morisha | Female | Horowpathana | 6 Jun 2009 | 1 year | 8 years |
| Srimali | Female | Sigiriya | 24 Jul 2010 | 10 months | 6 years |
| Buwaneja | Male | Mahaoya | 28 Sep 2008 | 4 months | 8 years |
| Kane | Male | Madawachchiya | 3 Sep 2009 | 2 months | 7 years |
| Balangoda | Male | Balangoda | 5 Apr 2010 | 4 months | 6 years |
| Vakarei | Male | Vakarei | 2 Apr 2009 | 1 year | 8 years |
| Matthala | Male | Lunugamwehera | 4 Jun 2008 | 1 week | 8 years |

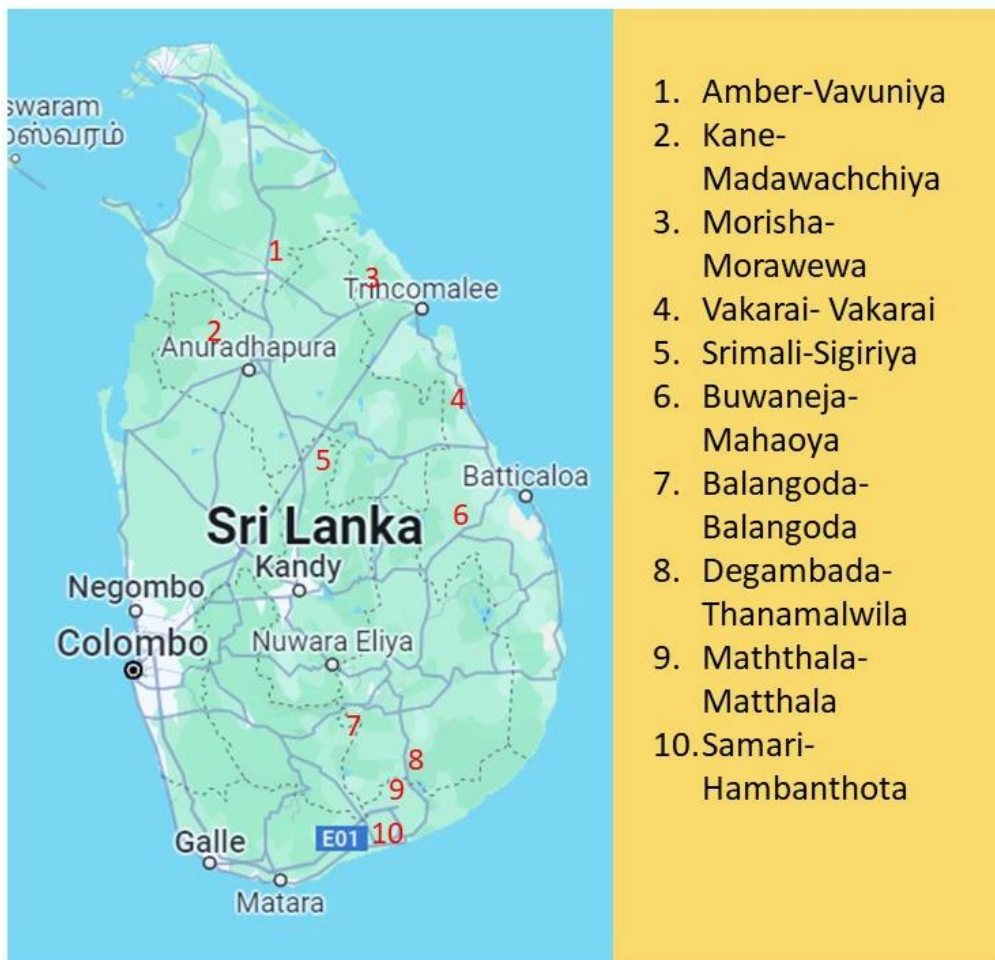


Figure 5. 2 Origin of Studied Elephant Calves

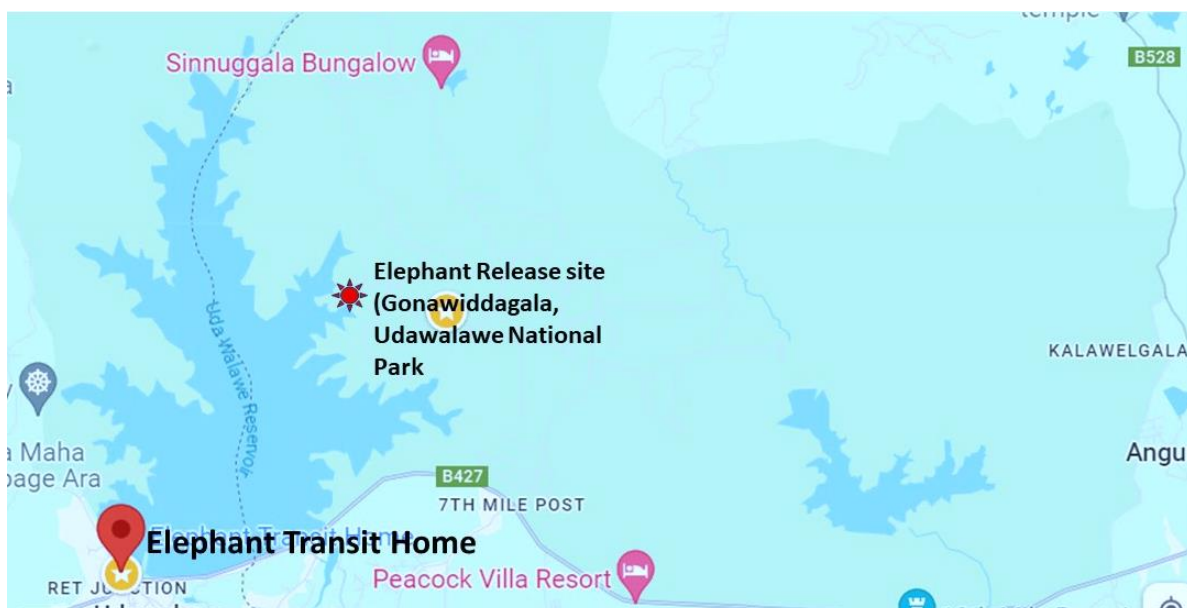


Figure 5. 3 Location of ETH and releasing site at the Udawalawe National Park

5.2.4 Faecal Extraction for fGCM Analysis

Faecal extracts were assayed for fGCM using a validated immunoassay at the endocrine laboratory at the Veterinary Faculty of Chiang Mai University, Thailand. The extraction procedure followed the method of Bansiddhi *et al.*, (2018). Approximately 0.1 g of powdered faeces was mixed with 4.5 mL of EtOH and 0.5 mL of distilled water in glass tubes. The samples were extracted twice, boiled in a water bath (90°C) for 20 minutes, and then centrifuged. The supernatant was decanted into labeled tubes, and additional ethanol was added to the pellet, followed by centrifugation. The faecal extracts were combined, dried, and re-suspended in ethanol and methanol. The samples were stored at -20°C until analysis.

fGCM concentrations were measured in diluted faecal extracts using a double-antibody EIA with a polyclonal rabbit anti-corticosterone antibody. Corticosterone standards and samples were added to wells, followed by incubation and the addition of TMB solution. The absorbance was measured, and the concentrations were determined using a microplate reader. The assay sensitivity was 0.099 ng/mL, with low intra- and inter-assay coefficients of variation.

5.2.5 Statistical analyses

Pre-release samples (74 samples) represented 8.3 months of collections, while post-release samples were categorized as early post-release (first 17 days; n=36) and late post-release (14.4 months; n=108). The fGCM concentrations during the pre-release period were compared between males (n=6) and females (n=4) using a pooled t-test. Data were further analyzed using R statistical software version 4.1.0 without transforming the data. Normality and variance were examined by using QQ plots, and descriptive statistics were computed. Repeated measure data were analyzed using the Generalized Least Square method (GLS, R package: linear and non-linear model 3.1-164) to determine the effect of release times (before release, early post-release, and post post-release) and dates on fGCM concentrations. Additionally, Tukey post-hoc tests were further applied to examine differences in mean fGCM concentrations among different release times and dates.

5.3 Results

In the study, the mean fGCM values before releasing, during the first 17 days post-release, and the later post-release period are summarized in **Table 5.2**. The mean fGCM levels decreased below the pre-release levels after 17 days of acclimatization. As expected, the highest mean fGCM values were observed during the 17 days post-release period.

The fGCM values between males and females are presented in **Figure 5.4**. The mean fGCM concentration for males was 51.166 ng/g, while for females it was 52.118 ng/ml. These values were not significantly different from each other at a 5% significance level.

The mean fGCM concentrations of the pre-release, early post-release, and late post-release periods were 51.54 ng/g, 90.09 ng/g, and 39.26 ng/g, respectively. These concentrations were significantly different from each other, with an F-value of 81.26 and a p-value of 0.0001.

Table 5. 2 Mean fGCM values pre-release, early post release, and late post release, with standard errors, standard deviations, error, minimum and maximum fGCM (ng/g) values, and 95% confidence level

| | Number of samples | Mean fGCM | Standard error | Median | Standard deviation | Minimum | Maximum | Confidence level (95%) | |
|--------------------|-------------------|-----------|----------------|--------|--------------------|---------|---------|------------------------|-------------|
| | | | | | | | | Lower bound | Upper bound |
| Pre release | 74 | 51.54 | 2.01 | 51.77 | 17.29 | 20.94 | 98.71 | 47.53 | 55.54 |
| Early post release | 36 | 90.1 | 6.38 | 89.03 | 38.32 | 31.31 | 182.02 | 77.12 | 103.06 |
| Late post release | 108 | 39.25 | 1.09 | 38.24 | 11.34 | 20.96 | 95.8 | 37.09 | 41.42 |

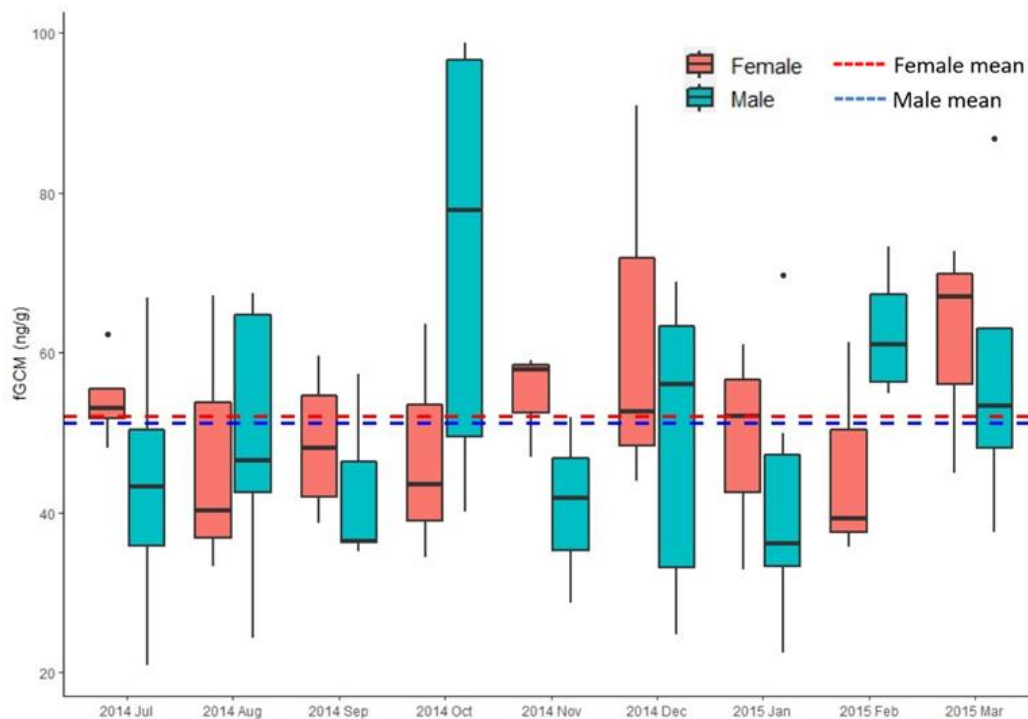


Figure 5. 4 Monthly mean fGCM concentrations of male (n=6) and female (n=4) elephants while at the ETH (Whiskers represent median, quartiles, and the 25th/75th percentiles)

According to **Figure 5.5**, the mean fGCM levels of the released elephants (n=10) were found to be highest immediately after their release and continued to remain high for a period of 17 days post-release. These fGCM levels were compared with the fGCM levels observed within the ETH as well as the fGCM levels observed at a later stage post-release.

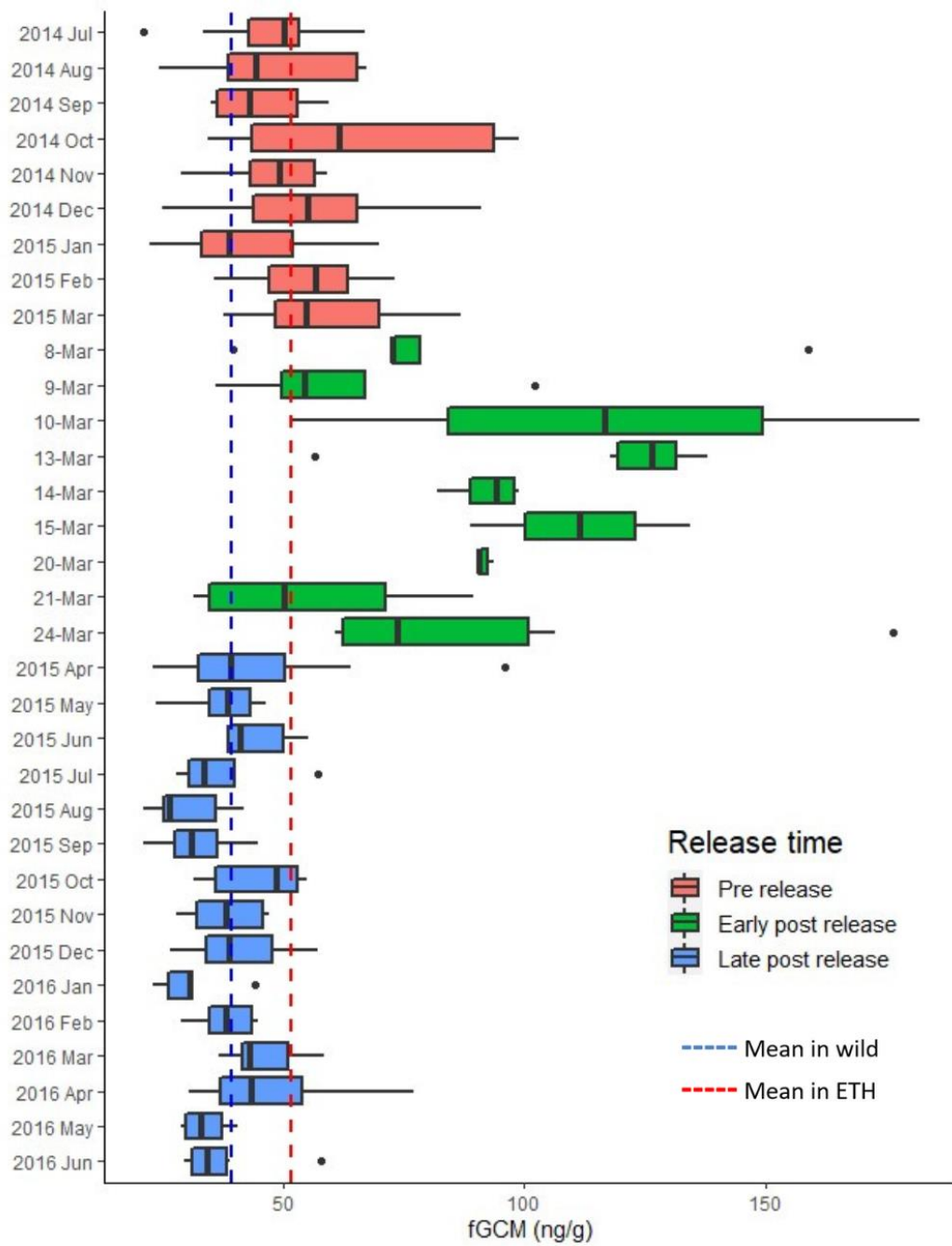


Figure 5. 5 Box plot of mean fGCM levels of pre-release, early post release and late post release periods

5.4 Discussion

The use of faecal glucocorticoids as an indicator of stress is advantageous since faecal sampling is non-invasive, practical for free-ranging elephants, and independent of short-term fluctuations (Brown *et al.*, 1995; Palme *et al.*, 1999). Touma and Palme (2005) recommend faecal corticosteroids as a reliable measure of overall stress levels and in recognizing chronic stress, while Fanson *et al.*, (2013) recommend fGCM as the most useful measure of broad-scale changes in adrenocortical activity in Asian elephants.

fGCM testing has additional advantages, including being unaffected by researcher-induced biases introduced by restraint/handling and reflecting both true baseline GC levels and an animal's stress response (Goymann, 2005; Sheriff, Krebs and Boonstra, 2010). However, it is important to note that the delay between defecation, sample collection, and processing can influence steroid concentrations due to faecal bacterial enzymes altering steroid composition post-defecation (Webber *et al.*, 2018). fGCM concentrations can be influenced by various factors, including the water content in food and the frequency of defecation. Additionally, gut bacteria can modify glucocorticoid metabolites over extended periods, resulting in changes in the observed levels of fGCM (Goymann, 1999). Additionally, fGCM does not provide real-time or short-term variation in endocrine physiology, such as circadian rhythms or the effects of behaviour on hormone concentrations, as excreted metabolites represent concentrations averaged over hours or days (Behringer and Deschner, 2017; Behringer, Stevens and Sonnweber, 2022; Montgomery *et al.*, 2022).

In this study, elephants were reintroduced to the wild on March 8th, and the peak fGCM level was recorded 2 days later on March 10th, indicating a 48-hour lag after the stressor. There is a considerable delay between the occurrence of a stressor and the detection of fGCM in the faeces (Ganswindt *et al.*, 2003). This delay varies across species, and it takes a specific amount of time before increased levels of GC in the bloodstream become evident in the faecal samples. Research has identified lag times of up to 38 hours in African elephants (Ganswindt *et al.*, 2003), while a study conducted with juvenile elephants in South Africa found that peak fGCM levels were reached between 22 and 25.5 hours after the injection of ACTH (Santymire *et al.*, 2012). However, another study revealed that the mean fGCM level of a translocated

African elephant herd reached a maximum the day after the translocation and remained elevated for five days (Viljoen *et al.*, 2008a).

The elevated fGCM levels remained for a 17-day pre post released period. The subsequent decrease in fGCM levels after the 17th day is in accordance with a study conducted in South Africa, which translocated elephants and showed that fGCM remained high for 23 days post-release (Viljoen *et al.*, 2008a; 2008b). Fanson *et al.*, (2013) suggested that selecting strong social units could minimize relocation stress because social bonds become stronger and develop more rapidly. Therefore, the finding reported herein on fGCM levels reaching significantly lower levels earlier than previously reported aligns with existing knowledge on the subject.

Studies on the response of elephants to specific management practices are limited (Dathe *et al.*, 1992; Schmid *et al.*, 2001; Laws *et al.*, 2007). More research is needed to understand the impact of different management practices on elephant stress levels and welfare. This study demonstrates that the stress levels of elephant calves are highest immediately post-release, but they decrease below the pre-release levels within ETH after adequate acclimatization. It is worth noting that stress levels can vary based on individual characteristics, such as age, sex, social status, and previous experiences. In this study, the elephant calves showed higher stress levels immediately after release, which could be attributed to the stress of the translocation process and the unfamiliar environment. However, over time, their stress levels decreased and eventually fell below the pre-release levels, indicating successful acclimatization to their new surroundings.

The findings of this study have important implications for the conservation and management of elephant populations. Translocations and reintroductions are common strategies employed to establish or augment elephant populations in suitable habitats. Understanding the stress response of elephants during and after such events is crucial to ensuring their well-being and successful integration into the wild.

Efforts should be made to minimize stress during translocations by implementing appropriate protocols and techniques. For example, the selection of strong social units and maintaining social cohesion during the translocation process can help reduce stress levels. Providing adequate time for acclimatization and monitoring stress indicators, such as faecal glucocorticoids, can help assess the effectiveness of the translocation and ensure the well-being of the elephants.

Long-term monitoring of translocated elephants is also essential to assess their overall adaptation, survival, and reproductive success. This can provide valuable insights into the long-term effects of translocations on elephant populations and guide future conservation efforts.

In conclusion, this study highlights the initial stress response of elephant calves post-release during a translocation event and demonstrates their subsequent acclimatization and reduction in stress levels. Faecal glucocorticoid measurements serve as a useful tool to assess stress in elephants, although they have some limitations. Continued research on elephant stress responses and the refinement of translocation protocols are necessary to ensure the welfare and success of translocated individuals and contribute to the conservation of these magnificent animals.

CHAPTER 6

GROWTH PATTERNS OF ELEPHANT CALVES AT THE ELEPHANT TRANSIT HOME, SRI LANKA AND A COMPARATIVE ANALYSIS OF BODY CONDITION SCORES WITH WILD ELEPHANT CALVES

6.1 Introduction

Effective nutritional management is vital for the successful rehabilitation of elephant calves at the Elephant Transit Home (ETH) in Sri Lanka. It plays a critical role in preparing them to overcome challenges they may encounter after being released into the wild. Additionally, it helps identify any potential health issues or abnormalities, enabling necessary adjustments to be made to their diet and care.

The primary objective of ETH is to rehabilitate and reintegrate orphaned elephant calves into their natural habitats. Hence, it is essential to compare the weight gain of rehabilitating elephant calves with their wild counterparts. However, monitoring the body weight of individual elephants in captivity poses challenges (Wijeyamohan, Read and Santiapillai, 2010; Miller and Andrews, 2013), and this task becomes even more difficult in the wild.

In captivity, it is customary to measure the birthweight of animals and subsequently track their weight over the course of weeks and months (Miller and Andrews, 2013). However, weighing a large wild animal presents practical challenges due to the unsuitability of field equipment (Bell, 1997). Consequently, alternative techniques have been developed to assess the growth rates of elephants without relying on scales. These methods utilize geometric measures such as body length, shoulder height, and chest girth (Kurt and Nettasinghe, 1968; Sreekumar and Nirmalan, 1989; Hile, Hintz, and Erb, 1997). These techniques are primarily intended for use with captive or partially domesticated elephants. However, when it comes to semi-captive elephants in ETH with minimal human contact, as well as wild elephants with no human contact, the applicability of these geometric measurements is indeed limited. It is crucial to acknowledge the potential adverse effects on the well-being of animals when they are frequently immobilized solely for the purpose of weighing (Alibhai, Jewell and Towindo, 2001).

An alternative approach, which does not require weighing, is the estimation of body condition (Mumby *et al.*, 2015). Visual body condition scoring (BCS) is a noninvasive monitoring method used to assess the nutritional status of animals, providing an index of energy stored as fat and muscle tissues (Burkholder, 2000; Alapati *et al.*, 2010). It has proven to be an effective and inexpensive tool in veterinary practice for evaluating body fat, particularly in cases of obesity (Henneke *et al.*, 1983). Visual scoring systems specific to certain species have already been developed for domesticated animals, including cattle (Wildman *et al.*, 1982), horses (Kienzle and Schramme, 2004), sheep (Russel, 1984), dogs (Laflamme, 1997), buffaloes (Alapati *et al.*, 2010), and goats (Vieira *et al.*, 2015). Ecologists also employ BCS systems to investigate body condition in various wild populations (Lane *et al.*, 2014; Carpio *et al.*, 2015; McWilliams and Wilson, 2015). For instance, BCS protocols have been developed for rhinos (Keep, 1971; Reuter and Adcock, 1998; Heidegger *et al.*, 2016) and tapirs (Clauss *et al.*, 2009).

The development of a BCS system relies on the visibility of specific body areas, and thus, major indicators are often the anatomical characteristics of the hind quarters, such as the tail head, backbone, pelvic bone, and ribs. Consequently, BCS is unique to each species, although similarities and differences may exist. For instance, in Polar bears (*Ursus maritimus*), the vertebrae, ribs, and hip bones are used, whereas in African buffaloes (*Syncerus caffer caffer*), the ribs, spine, hips, tail, and coat are considered (Stirling, Thiemann and Richardson, 2008; Ezenwa *et al.*, 2009).

However, BCS can be misleading in cases where animals have thick and dense hair that covers the critical anatomical benchmarks, or when factors such as intestinal tract filling, hydration status, or the reproductive stage in females come into play (Reuter and Adcock, 1998; Dierenfeld *et al.*, 2007; Ezenwa *et al.*, 2009; Reppert, Treiber and Ward, 2011; Schiffmann *et al.*, 2017). Another constraint is the inter-observer variability resulting from the subjective nature of BCS assessment. Therefore, it is essential for any BCS system designed for a specific species to undergo a validation process to ensure reliable and consistent results (Cook *et al.*, 2001; Barthelmess *et al.*, 2006; Pitt, Larivière and Messier, 2006; Peig *et al.*, 2009). Animals with short or no hair are naturally well-suited for visual-based assessments, making them particularly suitable for BCS evaluation, as observed in elephants (Schiffmann *et al.*, 2017).

In BCS protocols for free-ranging, semi-captive, and captive populations of both Asian and African elephants, specific body areas including the head, scapula, ribs, flank, lumbar vertebrae, and pelvic bone are considered, and these can be estimated from a safe distance (Albl, 1971; Poole, 1989; Wemmer *et al.*, 2006; Fernando *et al.*, 2009; Treiber, Reppert and Ward, 2012; Morfeld *et al.*, 2014a; Wijeyamohan *et al.*, 2015; Morfeld *et al.*, 2016). Typically, BCS assessments for elephants are based on an ordinal 5- or 9-point scale (Schröder, 2006), where higher numerical values indicate better body condition and lower scores indicate lower body fat levels (refer to **Table 6.1**). These BCS evaluation systems have been validated to varying degrees (Chapman *et al.*, 2016; Schiffmann *et al.*, 2017).

The objectives of this study were to gain a comprehensive understanding of the growth patterns of elephant calves at the ETH through weight measurements and to investigate the influence of age, sex, and season of the year on their growth rates. Furthermore, the study aimed to compare the BCS of elephant calves at the ETH with their counterparts in the wild, with the goal of evaluating similarities and differences. This study, which includes assessing weight gain and comparing BCS, will provide valuable insights into the nutritional management of elephants at the ETH and contribute to their preparation for eventual release into the wild.

Table 6. 1 Overview of specific body condition score protocols for elephants

| Protocol | Critical body areas | Defined categories |
|------------------------------------|---|--------------------|
| Wemmer <i>et al.</i> , (2006) | head, scapula, ribs, flank, lumbar vertebrae, pelvic bone | 12 (0–11) |
| Fernando <i>et al.</i> , (2009) | ribs, shoulder and pelvic girdle, backbone, neck | 11 (0–10) |
| Wijeyamohan <i>et al.</i> , (2015) | ribs, scapula, pelvic bone, vertebral column | 10 (1–10) |
| Morfeld <i>et al.</i> , (2016) | backbone, pelvic bone, ribs | 5 (1–5) |
| Schiffmann <i>et al.</i> , (2017) | ribs, scapula, pelvic bone, vertebral column | 11 (0-10) |

6.2 Materials and Methods

6.2.1 Monitoring Bodyweight Gain in Elephant Calves

At the ETH, elephant calves underwent regular weighing to monitor their bodyweight gain. A walk-on Avery® weighing scale (H400 flatfoam, digital scale) was used for this purpose. The weighing took place once a week for a total of 133 consecutive weeks. To ensure the well-being of the calves and minimize any potential stress, the scale was strategically installed at their feeding place. This placement aimed to create a familiar and comfortable environment for the elephants during the weighing process. Before recording the actual measurements between October 2015 and May 2018 (133 weeks), the calves underwent a habituation process. This training period spanned four weeks and focused on acclimating the elephants to standing on the scale.

6.2.2 Body Condition Scoring of Elephant Calves

The body condition scoring algorithm developed by Schiffmann (2017) is employed to evaluate the body condition of elephant calves. Although originally designed for adult elephants, slight modifications were made to enhance its suitability for assessing elephant calves. The system employs a scoring range from 0 to 10, with specific criteria for each score. For example, a BCS of 0 is designated when all ribs are visible, indicating extreme emaciation. A BCS of 1 is assigned to calves that exhibit all ribs but are not extremely emaciated. A BCS of 2 is recorded when more than three ribs are visible. When only one or two ribs are visible, the BCS is documented as 3.

Moving forward, a BCS of 4 is given when the ribs are not visible, but prominent pelvic and scapular bones are observed along with a depression on the scapular blade. If the depression on the scapular blade is absent but depressions behind the scapula and in front of the ilium are visible, the BCS is scored as 5. A BCS of 6 is assigned when the pelvic and scapular bones are visible with no depressions observed. If the pelvic and scapular bones are not visible but the backbone is visible, the BCS is recorded as 7. BCS 8 is designated when the backbone is not visible but a skin roll under the neck is present. BCS 9 is recorded when the backbone is not visible, but thick skin rolls are visible under the neck. Finally, a BCS of 10 is assigned when the calves are determined to be extremely obese. (**Figure 6.1 and 6.2**).

The body condition scoring of elephant calves was visually conducted between August and November 2019. This assessment took place in various locations, including 8 National Parks, 3 protected areas outside the national parks, outside the protected areas and at the ETH (**Table 6.3**). To ensure consistency and accuracy, the BCS estimates were carried out by the researcher and another veterinarian exclusively. During the process, photographs and videos of the elephant calves were collected to serve as a means of cross-validation for the scores, when necessary. The observations were performed within distances spanning from 1 to 100 meters to provide an optimal viewpoint for assessment.

The nutritional status of elephants was assessed by assigning a body condition score (BCS). BCS scores of 3 and below indicated poor nutrition, while scores between 4 and above denoted good nutrition.

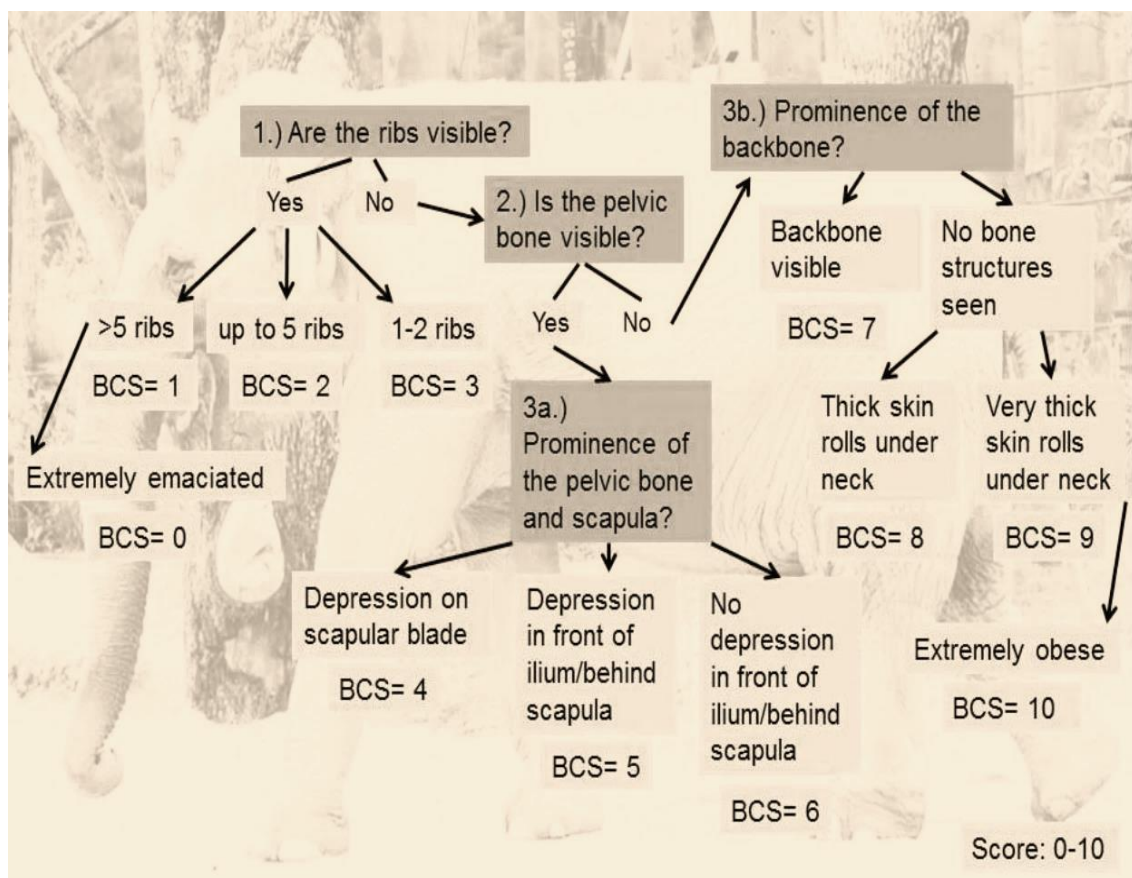


Figure 6. 1 showcases the algorithm for body condition scoring in elephants, as described by Schiffmann *et al.* in 2017.

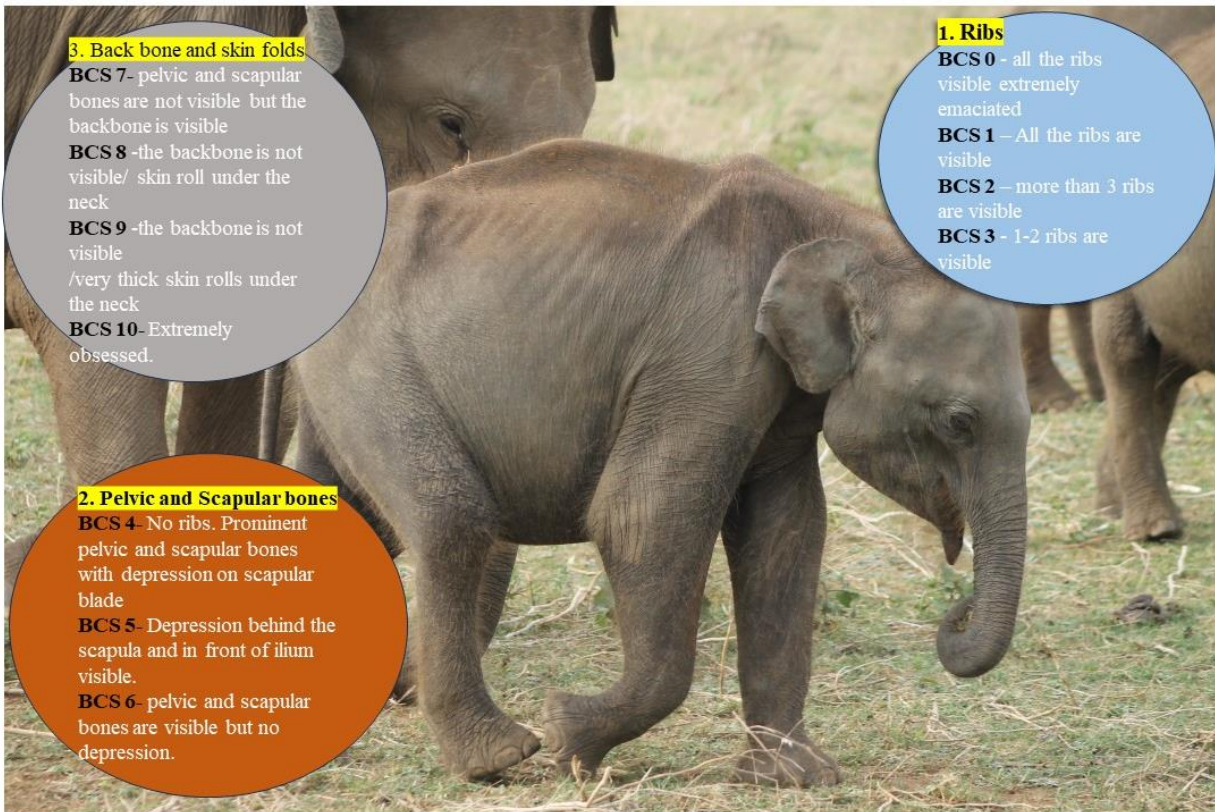


Figure 6. 2 Schematic representation of body condition scoring for an Asian elephant calf.

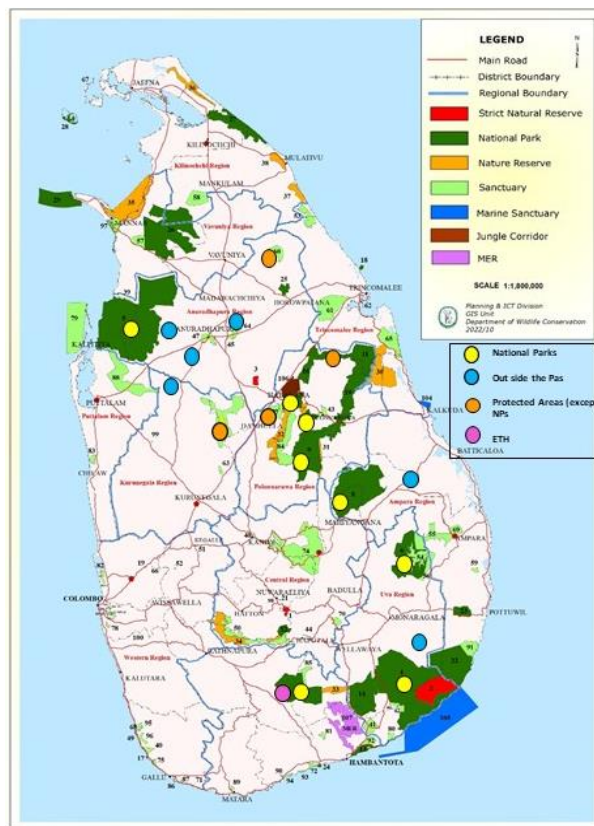


Figure 6. 3 Geographical distribution of study sites for observing wild elephant calves in the BCS (Source: GIS unit, DWC 2022)

The elephants were classified into three distinct age categories: infants (less than 1 year old), calves (1-5 years old), and juveniles (5 to 8 years old). The assessment of appearance, behaviours, and size was utilized for accurate age estimation of the elephants. Due to the impracticality of determining the sex of elephant calves in the wild, the sampled elephants were not grouped based on sex. Number of animals observed for BCS and their locations in **Figure 6.4**

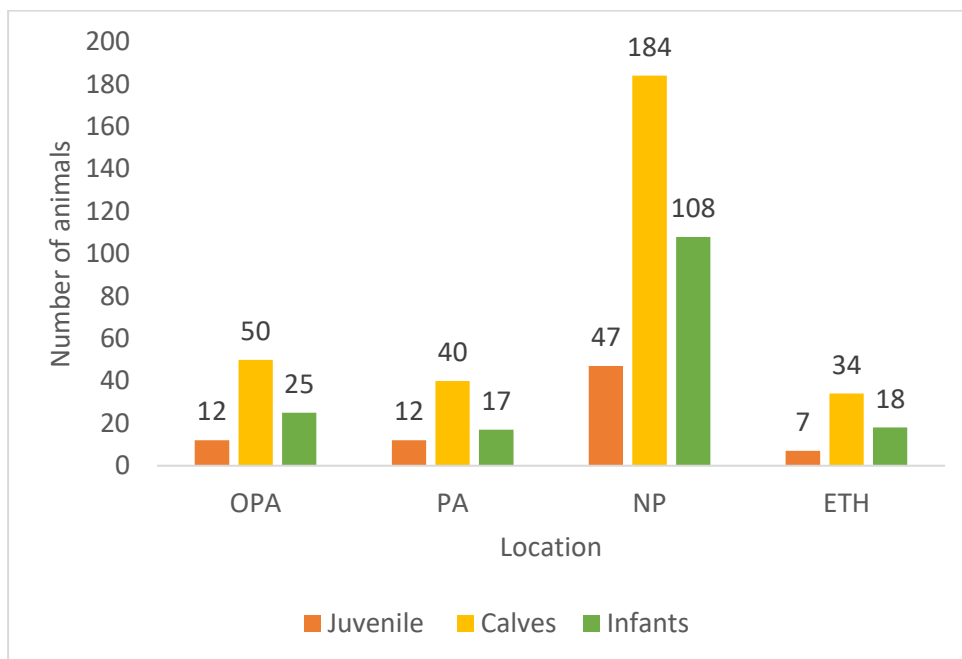


Figure 6. 4 Locations and age categories of observed animals for BCS

Analysis of data

The ANOVA test was used to analyze if there were significant variations in the average weight gain among different age groups of elephant calves at ETH. This test helps determine if there are any statistically significant differences in the means of multiple groups. The t-test was utilized to assess the significance of discrepancies in the average daily weight gain between male and female elephant calves within each age group, as well as for the overall average. Furthermore, a chi-squared test was employed to compare the proportions of BCS between ETH elephants and wild elephants in three age categories. The chi-squared test is used to determine if there is a significant association or difference between categorical variables.

6.3 Results

6.3.1 Weight Gain of Elephants at the ETH

A total of 56 elephant calves were weighed on a weekly basis, and their average daily weight gain ranged from 0.056 to 0.506 kg/day, with an average of 0.253 ± 0.026 kg/day. The calves were categorized into four groups based on their age: less than one year, 1-2 years, 2-4 years, 4-6 years, and over 6 years old. The mean daily weight gain for each group was as follows: 0.280 kg, 0.281 kg, 0.241 kg, 0.228 kg, and 0.223 kg/day, respectively (refer to **Table 6.3** for more details).

Table 6. 2 Daily weight gain of elephants in 5 age groups at ETH

| Age | | Average daily weight gain (kg) |
|-----------------------|--------|--------------------------------|
| less than 1 year n=17 | Mean | 0.280 |
| | Male | 0.278 |
| | Female | 0.296 |
| 1-2 years (n=8) | Mean | 0.281 |
| | Male | 0.258 |
| | Female | 0.351 |
| 2-4 years (n=4) | Mean | 0.241 |
| | Male | 0.239 |
| | Female | 0.243 |
| 4-6 years (n=23) | Mean | 0.228 |
| | Male | 0.237 |
| | Female | 0.210 |
| Over 6 years (n=4) | Mean | 0.233 |
| | Male | 0.294 |
| | Female | 0.172 |

The ANOVA test yielded an F-statistic of 0.449, with a corresponding p-value of 0.770. Since the p-value (0.770) is greater than the conventional significance level of 0.05, there is insufficient evidence to conclude that there are significant differences in the mean weight gain among the five age groups.

The statistical test used to assess the significance of the differences in average daily weight gain between male and female elephant calves within each age group, as well as for the overall average, was the t-test. The results of the t-tests revealed no

significant difference in the average daily weight gain between male and female calves ($p > 0.05$) in all age groups. This indicates that there is no substantial disparity in the average daily weight gain between male and female elephant calves, regardless of the age group. Furthermore, the t-test conducted on the overall average daily weight gain across all age groups also showed no significant difference between male and female calves ($p > 0.05$). These findings suggest that gender does not significantly impact the rate of weight gain in elephant calves, as indicated by the t-test results.

The monthly mean and standard deviation of the mean monthly average weight gain were calculated (refer **Figure 6.5**). Here we remove the extreme positive and negative values from the data set using the statistical method the interquartile range (IQR) and calculate the mean weight gain for each month using the remaining data points. By removing outliers, we ensure that the analysis focuses on more representative values and provides a clearer understanding of the average monthly weight gain of elephant calves.

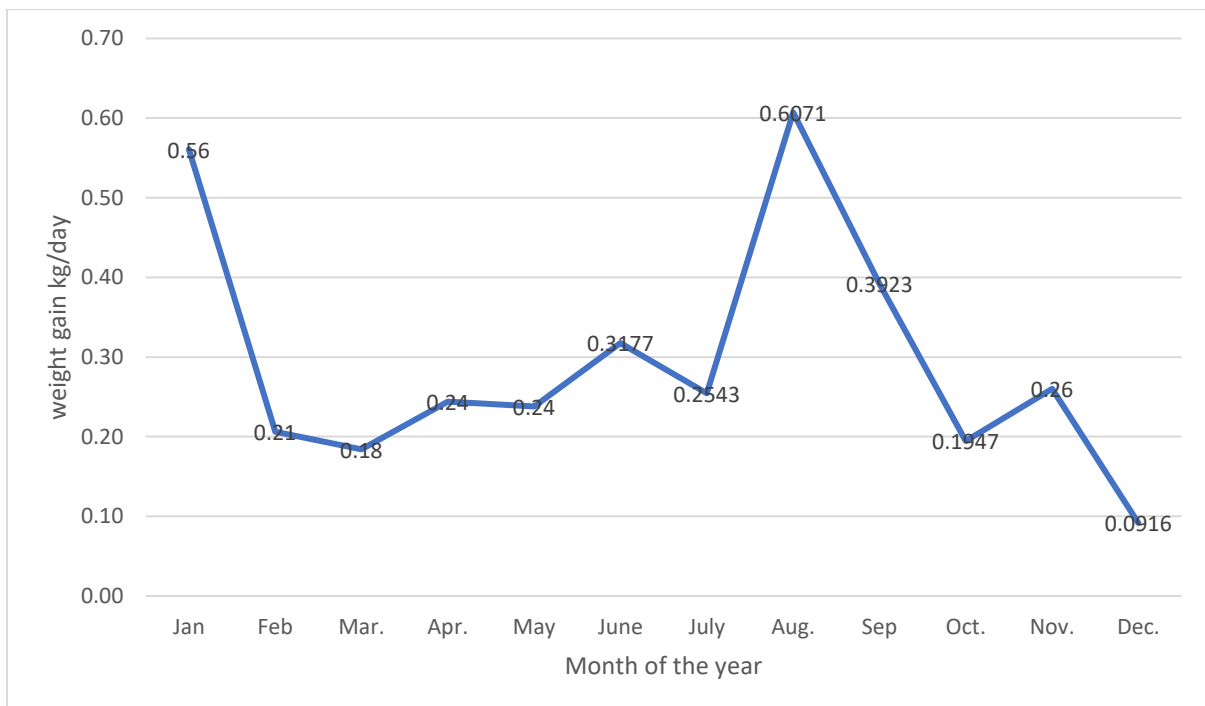


Figure 6. 5 Monthly mean average body weight gain in elephant calves in ETH

6.3.2 Body Condition Scores

The BCS of elephants were collected from both semi-captive elephants at ETH ($n=59$) and free-ranging wild elephants ($n=495$). The free-ranging elephants included those encountered in national parks (NP), protected areas excluding national parks (PA), and areas outside the protected areas (OPA) (**Table 6.3**).

Table 6. 3 Locations, age categories and respective BCS scores of elephants

| Body condition Scores | OPA | | | PA | | | NP | | | ETH | | |
|-----------------------|---------|--------|-----------|---------|--------|-----------|---------|--------|-----------|---------|--------|-----------|
| | infants | Calves | Juveniles | Infants | Calves | Juveniles | Infants | Calves | Juveniles | Infants | Calves | Juveniles |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 1 | 0 | 0 | 0 | 0 | 0 | 0 | 3 | 2 | 4 | 0 | 0 | 0 |
| 2 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 3 | 4 | 3 | 5 | 0 |
| 3 | 1 | 1 | 0 | 0 | 1 | 1 | 4 | 19 | 7 | 4 | 17 | 3 |
| 4 | 8 | 39 | 21 | 6 | 20 | 9 | 25 | 109 | 60 | 0 | 11 | 9 |
| 5 | 3 | 10 | 3 | 6 | 19 | 7 | 13 | 48 | 28 | 0 | 1 | 5 |
| 6 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 1 | 5 | 0 | 0 | 1 |
| 7 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 0 |
| 8 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 12 | 50 | 25 | 12 | 40 | 17 | 47 | 184 | 108 | 7 | 34 | 18 |

As The observed elephants only demonstrated BCS scale 1-7, scores between 1 and 3 indicated poor nutrition, while scores between 4 and 7 denoted good nutrition. In the ETH location, infants (7 out of 7, 100%) and calves (22 out of 34, 35%) exhibited poor nutrition, reflecting a concerning state of nutritional health among the younger elephants. Only juveniles demonstrated good nutrition, with 15 out of 18 individuals (83%) falling into this category.

In comparison, the OPA, NP, and PA locations showed that the majority of infants, calves, and juveniles exhibited a relatively high prevalence of good nutrition across all age groups. (**Table 6.5** Comparison of nutritional status of elephant calves 04 different locations).

Table 6. 4 Comparison of nutritional status of elephant calves 04 different locations

| Body condition Scores | Infants | | | | Calves | | | | Juveniles | | | |
|-----------------------|---------|---------|-----|------|--------|-----|---------|------|-----------|-----|---------|------|
| | OP A | PA | N P | ET H | OP A | P A | NP | ET H | OP A | P A | NP | ET H |
| Poor nutrition | 1 | 0 | 7 | 7 | 1 | 1 | 24 | 22 | 1 | 1 | 15 | 3 |
| Good nutrition | 11 | 12 | 40 | 0 | 49 | 39 | 16 0 | 12 | 24 | 16 | 93 | 15 |
| Total animals | 12 | 12 | 47 | 7 | 50 | 40 | 18 4 | 34 | 25 | 17 | 10 8 | 18 |
| Poor nutrition % | 8 | 0 | 15 | 100 | 2 | 3 | 13 | 65 | 4 | 6 | 14 | 17 |
| Good nutrition % | 92 | 10 0 | 85 | 0 | 98 | 98 | 87 | 35 | 96 | 94 | 86 | 83 |

6.4 Discussion

The core of elephant society revolves around a closely-knit family unit, which is led by an older matriarch. This family unit consists of female matrilineal relatives, dependent offspring, and other family members who exhibit remarkable cooperation in their movement, foraging, and decision-making processes (Lynch *et al.*, 2019). In the wild, the presence of close female kin, such as mothers and sisters, has been shown to increase the level of care provided to dependent young and significantly enhance the survival and reproductive success of elephants (Moss *et al.*, 2011).

Only a few reports on body weight development in elephants exist and these are often with small sample sizes. Majority of these studies including few studies with free ranging African elephants have provided data restricted to morphometric (shoulder height, thorax circumference, foot length and/or circumference) or indirect (foot print length, dung bolus size) measurements. (Fischer *et al.*, 1993; Lee & Moss, 1995; Miller & Andrews, 2013; Schwimmer, Hildebrandt and Goritz, 2001; Sukumar *et al.*, 1988; Walker, Schlegel and Pas, 2013). Between birth to 5 years of life, elephant calves significantly grow in height and weight (Kurt and Kumarasinghe, 1998; Kurt and Nettasinghe, 1968; Lee and Moss, 1995; Shrader *et al.*, 2006; Weihs *et al.*, 2001). European zoo elephants demonstrated a nearly linear body mass growth until 150 months of life independent of sex and species (Schiffmann *et al.*, 2019). In a study

with African elephants (n=11) born in captivity they gained on average 0.59 kg/day in the first 75 days of life regardless of sex (Miller and Andrews, 2013). In another study with African elephants, they gained 0.385 kg/day (Andrews, Mecklenborg and Bercovitch, 2005) throughout the first 90 days. The book 'Elephant Husbandry Resource Guide' indicates that a hand-raised calf should gain between 0.5-1.4 kg/day, averaging 0.9 kg/day (Olson, 2002).

In a study of Asian elephant calves imported (n=4) into the USA or calves born in US zoos and reared by their mothers (n=6) the weight gain of both groups was approximately 31 kg/month (1 kg/day) for the first 12 months of the life (Reuther, 1969). A mean weight gain of one hand reared Asian male calf was 0.18 kg/day, (range of 0-3.75 kg/day) during the first six months (Rietkerk, Hiddingh and Dijk, 1993). Daily gains in body weight of 4 Asian elephant calves born at Ichihara Elephant Kingdom Zoological Park, Japan during the first 12 months of the life were 1.16, 0.96, 1.41, and 1.39 kg, respectively. Here first male calf was hand reared (Takehana *et al.*, 2020).

When comparing the available data for captive Asian and African elephant calves in the USA and Europe, it is evident that the growth rate of elephants at ETH was lower, with an average of 0.253 kg/day. This lower growth rate may be attributed to several factors, including the impact of being orphaned. Studies conducted on humans, chimpanzees, and African elephant calves have shown that orphans tend to exhibit a decreased growth rate compared to young individuals who are reared under normal conditions (Finlay *et al.*, 2016; Parker and Wittemyer, 2022). After birth, elephant calves remain in close proximity to their mothers, relying exclusively on lactation for nourishment until around 6 months of age. They continue to suckle until they reach approximately 3 to 5 years of age (Mar *et al.*, 2002). In the wild, it has been observed that calves may continue to suckle even after their mother has given birth to a new calf. When a calf becomes an orphan, it loses valuable social care, maternal milk, protection, and important learning experiences that are crucial for its long-term survival. This suggests that the absence of maternal care and the challenges faced by orphaned elephants, such as malnourishment and low birth weight, can have a negative impact on their overall body weight gain.

The elephants have the longest gestation period of all land animals. A study in San Diego Zoo's wild animal park revealed that the African elephant calves were only 4.7% of maternal mass at birth and grew to 5.5% of maternal mass by 5 weeks of age, and 6.3% of maternal mass at 3 months of age (Andrews, 2005). The birth weight of

elephant calves born in the wild have not been measured, it is not possible to weigh them in a non-invasive manner. In the last 26 years' the ETH has received 427 orphan elephant calves and when rescued, 7 of them were less than one day old. Their weights were between 40-102 kg (mean weight 74kg). The weight range of orphaned calves with an estimated age of less than one month (n= 42) was 65-118kg (mean weight 88kg) (unpublished data- Perera *et al.*, 2022). These data on weight are significantly lower with those reported in elephants born in zoos. A study done by Dale, (2010) mentioned that the average mean birth weight of Asian elephant calves (n= 93) born in Europe and North America was 117.87 ± 3.5 kg for male (n=49) and 118.17 ± 3.1 kg for female (n=44). Average weight at birth of African elephant those born (n=11) at San Diego Zoo Safari Park, USA was 106 kg (Range 98 - 122 kg) for males and 97 kg (Range 87 - 108 kg) for females (Miller and Andrews, 2013). The average mean birthweight of another 6 African elephants from Disney Park, USA was 128kg (range 104-142 kg) as reported by Sullivan *et al.*, (2016). Nineteen Asian elephant births occurred at a private facility in central Florida, USA from 1997-2014 has recorded birth weights between 97.1 and 159.7 kg and averaged 126.2 kg (Wiedner, *et al.*, 2017). The average birth weight of elephant calves born in Pinnawala Elephant Orphanage, Sri Lanka was for male (83.1 ± 4.6 kg; n = 14) and female (82.8 ± 8.4 kg; n = 6) calves (Pushpakumara *et al.*, 2016).

In general, elephants born in zoos tend to experience faster growth rates, and as adults, their body mass significantly exceeds that of their wild counterparts in range countries (Ange *et al.*, 2001; Hatt and Liesegang, 2001). However, these high growth rates can lead to health issues such as musculoskeletal disorders and impaired reproductive success (Hildebrandt and Göritz, 1995; Lee *et al.*, 2013; Morfeld and Brown, 2014b; Nilsson *et al.*, 2014). A recent survey conducted on elephants housed in American zoos revealed that 75% of female Asian elephants and 65% of male Asian elephants were characterized as being overweight or obese (Morfeld *et al.*, 2016). Similarly, Asian elephants housed in European institutions have also faced overweight problems (Schiffmann *et al.*, 2018). This disparity between zoo and free-ranging elephants is primarily attributed to the continuous provision of an unnaturally energy-rich diet and reduced physical activity under zoo conditions (Hatt and Clauss, 2006).

In contrast to the conditions in zoos, the elephant calves at ETH are required to forage for a more natural diet of variable quality, in addition to receiving their daily allowance of formula milk. This distinction is further highlighted by data obtained from

an elephant calf born at a facility dedicated to confiscated elephants at ETH. A female calf, born to a confiscated elephant cow, weighed 72 kg at birth and reached a weight of 300 kg at 1 year of age, exhibiting an average daily weight gain of 0.624 kg/day (Perera, unpublished data). Both the mother and calf were provided with food *ad libitum*, including grasses, branches, and fruits. In another example, a female calf over 5 years old, who had been received at ETH with minor infected wounds caused by a jaw bomb explosion, showed a weight gain of 0.98 kg/day when provided with *ad libitum* grass, branches, and fruits (Perera, unpublished data). These examples demonstrate that the elephant calves at ETH, with their access to a more natural diet and foraging opportunities, exhibit different weight gain patterns compared to their counterparts in captive settings. In the case of elephant calves at ETH, although their growth rate is lower compared to captive-born calves, the rehabilitating elephant calves have shown a high survival rate of 94.5% (as discussed in chapter 03), indicating that they are receiving satisfactory nutrition and care at the ETH. When evaluating the success of wildlife species rehabilitation programs, it is crucial to consider the survival of animals both before and after their release (Cope *et al.*, 2022). Data from the monitoring of released calves demonstrate that high survival rate and performing of satisfactory reproduction after being reintroduced to the wild (Perera *et al.*, 2019).

The average monthly weight gain of elephants at ETH is influenced by various factors. These include the water level of the reservoir, availability of grasslands, moisture content of grasses, provision of cut branches and grasses from outside sources, and health-related issues such as parasite burdens. The elephants at ETH exhibit monthly variations in their average daily weight gain, with the highest weight gain observed in August (0.607 kg/day) and the lowest in December (0.091 kg/day). The mean annual rainfall in the UNP is 1500 mm, with two rainy seasons: an inter-monsoonal spell between March and May, and the northeast monsoon from October to January (DWC, 2008). Similar to other studies, differences in growth rates have been observed between dry and wet seasons, likely due to the better availability of higher quality forage during wetter months (Campos-Arceiz *et al.*, 2008). Seasonal changes in resource availability also impact the body condition scores of wild elephants (Foley *et al.*, 2001; Pokharel, Seshagiri and Sukumar, 2017; Ranjeewa *et al.*, 2018; De Klerk, 2009). A study conducted in the UNP revealed that body condition scores of Asian elephants were higher during the dry season (Ranjeewa *et al.*, 2018).

This could be attributed to the availability of fresh grass in the dry season when reservoir bed grasslands emerge due to water drawdown.

At ETH, the highest mean daily growth rate of elephants (0.607 kg/day) was recorded in August. This coincides with the period when the grasslands start to emerge, typically in June and July. During this time, the grasses are growing in the wet tank bed but are exposed to the hot sun. By August, the grasses have matured, becoming more palatable and readily available *ad libitum* for the elephants. On the other hand, the lower mean daily weight gain was recorded in December (0.091 kg/day). In December, the water level of the reservoir reaches its peak, resulting in the submergence of the reservoir bed grasslands. During the rainy season, which typically starts in October and extends until January, the forest area experiences significant growth of grasses. This new growth of grasses is characterized by low effective fibre, high crude protein, and high moisture content. While these conditions are favourable for grass growth, the high moisture content can sometimes lead to diarrhoea in elephants, similar to the occurrence of "spring diarrhoea" in temperate countries during the spring season. This phenomenon may help explain the lower body weight gain observed in December when the lush grass growth coincides with the rainy season.

Elephants are remarkable creatures with large brains and complex social structures (Lynch *et al.*, 2019). They rely heavily on their memory and engage in various levels of competitive and collaborative relationships due to their fission-fusion system (Wittemyer, Douglas-Hamilton and Getz, 2005). However, when elephant calves undergo a prolonged period of rehabilitation, there is a risk of habituation to humans, which can lead to the loss of natural social behaviours and essential foraging and survival skills in the wild (Saran *et al.*, 2011; Hashem, 2019; Miazga *et al.*, 2020). It is important to carefully manage the rehabilitation process to minimize these risks and ensure that the calves maintain their natural instincts and behaviours necessary for their successful integration back into the wild.

An important measure of the adequacy of the feeding regime at the ETH is how fast calves grow and how this compares with the growth rate of calves in their natural, free-range environment. However, as noted above it is difficult or impossible to measure the birth weights and weight gains of elephant calves in the wild. An alternative method to evaluate nutritional and health status of calves is the BCS. This method may be applied to free ranging, zoo and ETH housed animals. For zoo elephants BCS has been a valuable and simple tool for complementary monitoring of

an elephant's condition, especially in adult and geriatric individuals (Schiffmann *et al.*, 2020). There are many factors that have an effect on BCS: for example age (Chusyd *et al.*, 2018; Somgird *et al.* 2016), sex (Godagama *et al.*, 1998; Morfeld *et al.*, 2016; Pinter-Wollman, Isbell, and Hart, 2009a; Ramesh *et al.*, 2011), living conditions (Morfeld *et al.*, 2014a; Wijeyamohan *et al.*, 2015), season (Albl 1971; De Klerk 2009; Foley *et al.*, 2001; Pinter-Wollman, Isbell, and Hart, 2009b; Pokharel, Seshagiri and Sukumar, 2017; Ramesh *et al.*, 2011; Ranjeewa *et al.*, 2018), husbandry parameters (Harris *et al.*, 2008a; Morfeld *et al.*, 2016), reproductive status such as lactation (De Klerk, 2009), faecal glucocorticoid metabolites (Pokharel, Seshagiri and Sukumar, 2017), history of translocation (Pinter-Wollman, Isbell, and Hart, 2009b) and duration of musth (Poole, 1989; Somgird *et al.*, 2016).

After an extensive literature search, we could not find standardized techniques designed for visual body condition scoring of young elephant calves. The challenge of using BCS for elephant calves was noted by Schiffmann *et al.* (2018). After assessing available techniques designed for adult elephants, we used the methodology described by Schiffmann *et al.*, 2017, but adapted by modification of the algorithm for BCS scoring for Asian elephants (Fernando *et al.*, 2009, Wijeyamohan *et al.*, 2015, Morfeld *et al.*, 2016). The dichotomous key use in this technique was adapted to describe and score body condition of free ranging elephant calves by observing ribs, scapular bone, pelvic bone, back bone and skin rolls under neck. BCS was estimated in the dry season as elephants gather at water sources and associated open grasslands. Though the original scale of this technique had 0-10 points, our adapted BCS range was limited to 1-7 points. We have never come across elephant calves exhibiting skin rolls under the neck, which was a criterion for achieving the highest scores in the original system.

Previous studies have shown that BCS varies with the availability of water and food (either in terms of quality or quantity), with stress and with overall health (Sukumar 2003; Bonier *et al.*, 2009; Muehlenbein *et al.*, 2012; Pokharel, Seshagiri and Sukumar, 2017). Some studies reveal that body condition is inversely associated with markers of stress in some mammals, such as badgers (*Meles meles*; George *et al.*, 2014) and Weddell seals (*Leptonychotes weddellii*; Bartsh *et al.*, 1992). Calves at the ETH receive formula milk rather than maternal milk, they lack care from mothers and adult elephants and they experience stress from contact with unrelated elephants and from interactions with humans. Further, in the time interval between being orphaned and

rescue, calves may become weaker both physically and psychologically. Even after arrival at the ETH, some animals suffer badly with immune related and other chronic health complications. These factors may combine to reduce the rate of growth, resulting in stunting and cause a reduced BCS. However, it should be noted that when ETH calves grew older (juveniles) their mean BCSs scores were not very different to their wild counterparts. The feeding and management protocols at the ETH allow calves to show catch-up growth after the stress and trauma of their early years. It seems that after weaning older calves (the juvenile group) at the ETH overcome the challenges of foraging and meeting their nutritional requirements to the same degree as free living elephants of the same age.

Generally, zoo elephants have significantly higher BCSs compared to free-ranging elephants. The BCS of European adult zoo elephants was in the range 7–10 (Schiffmann *et al.*, 2018). In elephant calves (Between birth and 5 years of life) in European zoos BCS remained stable at a score 7–8/10 (Schiffmann *et al.*, 2019). When using the BCS scale of 0 to 10 points, between 4 and 6 could be considered ideal for the zoo animals. These definitions are only based on the assumption that the middle range of an index represents a preferable condition (Schiffmann *et al.*, 2018).

The probable reason for higher BCS in zoo elephants is the quantity and quality of their diets that usually not season-dependent and are more energy-rich compared to natural foods (Hatt and Clauss, 2006). In addition, poor habitat quality and competition for resources are considered as major influencing factors that may cause poor body condition (Janson, 1988; Fernando and Lande, 2000). These two reasons may apply for the ETH elephants as the elephants in the ETH have been using the same approximately 50 hectares habitat intensively for over 26 years and in this habitat, they experience intra- and inter-group competition for resources.

In the overall picture the ETH elephants show a low weight gain (mean 0.253 kg/day) compared with zoo standards of 0.9 kg/day. They also have a lower mean BCS compared to their wild counter parts and compared to zoo animals in Europe (Olson, 2002). Generally, it is considered that an increase or decrease in body condition may signify a change in the quality of management or environment in which an animal lives (Wijeyamohan *et al.*, 2015). Growth rate determines adult body size and may influence key life-history traits, including survival, development, and reproduction (Stearns, 1992; Charnov, 1993). It is not possible to define ranges of body mass and BCS for ‘underweight’, “normal weight,” “overweight,” or “obesity” for

free ranging elephants. The growth rate and BCS fluctuations are determined by many physiological and psychological factors, food availability, genetic factors, health factors such as parasitic diseases, metabolic syndromes (such as hypertension, hyperlipidaemia, insulin resistance, and type 2 diabetes), exercise etc.

Body weight and BCS may be the first indicator of a change in the population's health and/or environmental change. These provide an early warning of a change in the environment and/or health of an individual elephant. Elephant body condition is a good measure for detecting resource limitation, both within populations and between seasons, and that elephant body condition respond to relatively small changes in resource conditions (De Klerk, 2009). BCS is recommended as a management tool for zoo elephants, but has never been an important management tool in free ranging Asian elephant management so far. This study which compared BCS demonstrates the possible way to applied it for rehabilitating elephants. As elephants are long lived, long-term monitoring is required to determine optimal weight gain and BCS and ways it can maintain nutritional needs. Therefore, further studies are needed for identify the causative agents and situations for low growth and poor BCS in elephants at the ETH.

A BCS system has been successfully adapted for young elephants, allowing for comparisons between elephants at ETH, those in zoos, and wild elephants. It has been observed that calves at the ETH grow at a slower rate compared to those born in zoos. However, it is important to note that maximum growth rate does not necessarily indicate healthier calves. Zoo elephants are more prone to obesity and related health issues, which can have negative impacts on their reproductive success and overall health. High growth rates in the early years may contribute to these problems.

When comparing the BCS of young elephants at the ETH with those in the wild, interesting patterns emerge. It has been observed that calves at the ETH initially have lower BCS compared to their counterparts in the wild. This difference may be attributed to the calves arriving at the ETH with poorer health and nutritional status, especially when compared to calves born in zoos or in the wild. These calves may face additional stresses during their early years at the ETH, resulting in lower growth rates and BCS, indicating their compromised health. However, as the calves mature into juveniles, their BCS becomes similar to that of wild elephants. This positive trend in BCS can be attributed to the efforts made at the ETH to improve the health and well-being of the calves. By the time the calves are ready to be released from the ETH, they exhibit

signs of a healthy BCS, which not only enhances their chances of survival but also facilitates their ability to adapt to normal behaviours and successfully reproduce. These findings suggest that the interventions and care provided at the ETH have a significant impact on the overall success and prospects of a successful reintroduction of the calves into the wild.

CHAPTER 7

MONITORING ELEPHANTS AFTER RELEASING FROM THE ELEPHANT TRANSIT HOME INTO THE WILD

7.1 Introduction

Rehabilitation programs for displaced, sick, injured, or orphaned animals, such as elephants, aim to provide them with the necessary care to regain their health and develop the skills required to live independently in their natural habitat. The ultimate goal is not just to rescue these animals from immediate danger but also to ensure their long-term survival and flourishing in the wild.

There are three significant advantages to this approach. Firstly, by rehabilitating elephants and preparing them for release, the costs associated with maintaining them in a suitable environment for several decades (given their long lifespan of 40-50 years) can be avoided. This makes rehabilitation a potentially more cost-effective option compared to long-term captive care. Secondly, successful rehabilitation programs have the potential to re-establish elephant populations in regions where they have become endangered or locally extinct. By reintroducing rehabilitated elephants, the genetic diversity and overall population numbers can be increased, contributing to conservation efforts and restoring ecological balance. Thirdly, and perhaps most importantly, the welfare of elephants is best maintained when they are allowed to thrive in their natural habitat. While temporary care may be necessary to nurse them back to health, the ultimate aim is to provide them with the skills and abilities to live self-sufficiently in the wild. Elephants are highly intelligent and social animals, and their physical and psychological well-being is closely tied to their natural environment. By enabling their return to the wild, rehabilitation programs prioritize their long-term welfare and overall quality of life.

The success of a rehabilitation program primarily depends on two factors: the animals' survival ability after release and their potential to integrate into the existing breeding population. Research conducted by Ludwig and Mikolajczak (1985), Porter (1992), and Beringer (2004) has identified these factors as key indicators of the program's effectiveness. Monitoring the survival rates of released individuals and their

ability to reproduce successfully in the wild is essential for evaluating the overall success and impact of rehabilitation efforts.

After the establishment of the ETH in 1995, the first batch of rehabilitated elephant calves was released in 1998. This initial group comprised three females and one male. Over the years, from 1998 to 2022, the ETH successfully rescued, rehabilitated, and released a total of 162 elephants. These elephants were released in 15 different groups, with each group consisting of 4 to 20 individuals. The released elephants were reintroduced into four distinct locations: Udawalawe National Park (131 elephants), Lunugamwehera National Park (4 elephants), Kumana National Park (4 elephants), and Maduruoya National Park (23 elephants).

Each year, wildlife rehabilitators rescue and rehabilitate millions of native animals worldwide. However, the release of these animals back into the wild raises scientific and ethical considerations, as highlighted by Saran *et al.*, (2011), Guy, Curnoe and Banks, (2013), and Cope *et al.* (2022). Releasing rehabilitated animals into their natural habitat can provide welfare benefits to individuals, as they are freed from unnatural and potentially stressful conditions (Guy, Curnoe and Banks, 2013; Mullineaux, 2014). Furthermore, if the rehabilitated species is endangered and faces a declining population at risk of genetic impoverishment, releasing individuals can contribute to conservation efforts by enhancing genetic diversity within the local population. Additionally, the release of rehabilitated animals can facilitate scientific advancements through post-release behavior monitoring and survival pattern studies. It also serves as a means to educate the public and raise funds for conservation initiatives, as emphasized by Moore *et al.* (2007) and Saran *et al.* (2011).

However, the release of rehabilitated animals comes with risks at the individual and population levels. Individual animals may have a low probability of survival due to factors such as insufficient foraging skills and inadequate predator avoidance abilities. They may also struggle to integrate and socialize with local counterparts, especially if they were habituated to human contact during captivity (Moore *et al.*, 2007; Schultz *et al.*, 2007). Such habituation can lead to human-wildlife conflicts. Most importantly, the release of rehabilitated animals can pose population-level risks, including the potential spread of diseases (Goodrich and Miquelle, 2005; Mullineaux, 2014). These risks need to be carefully evaluated and managed to ensure the overall success and sustainability of rehabilitation and release programs.

When making decisions regarding the release of rehabilitated animals, it is crucial to conduct a comprehensive evaluation that takes into account welfare, conservation, and other long-term objectives. The fate of animals after their release into the wild and the subsequent post-release monitoring are integral components of orphan wild elephant calf rehabilitation programs. Monitoring released individuals is considered an essential and inseparable part of the rehabilitation program, rather than an optional addition at a later stage. The purpose of this monitoring is multifaceted. Firstly, it aims to determine the survival of released animals and identify any potential welfare issues they may face. Secondly, it assesses the broader impacts on the existing population, including ecological, social, and economic risks to human livelihoods. Lastly, it helps identify the need for additional management interventions.

The ETH adheres to the IUCN Guidelines for Reintroductions, which provide a framework for monitoring efforts. Six primary forms of monitoring are adopted: demographic performance, behavioral monitoring, ecological monitoring, genetic monitoring, health and mortality monitoring, and social, cultural, and economic monitoring (IUCN/SSC, 2013). By employing these monitoring strategies, the ETH and similar programs can gather vital information to evaluate the success of rehabilitation efforts, ensure the well-being of released animals, and make informed decisions for the conservation and management of elephant populations in the wild.

Post-release monitoring of rehabilitated animals can indeed present challenges, especially in areas with dense vegetation and potential risks from wild elephants and other wildlife. Additionally, observing animals at night can be practically impossible. The close presence of humans during monitoring activities can also influence the behavior of the released animals. In such circumstances, radio telemetry emerges as a reliable and effective method for obtaining data on the movement patterns, resource utilization, and habitat occupancy of Asian elephants (Fernando, 2015). Radio telemetry involves attaching radio transmitters to the animals and using receivers to track their movements and gather data remotely. This technology is particularly useful when collecting data from remote or inaccessible locations or when direct data collection would be dangerous or challenging (Silva-Opps and Opps, 2011).

Until 2016, the post-release monitoring program of the ETH involved fitting VHF (Very High Frequency) collars on the rehabilitated elephant calves. However, starting from 2016, GPS (Global Positioning System) collars were utilized for monitoring the

released elephants. It is important to note that due to financial constraints, out of the total 162 released elephants, only 59 animals were fitted with VHF or GPS collars. For the remaining elephants, canvas collars without radio transmitters were used solely for easy identification of individuals in the field. This approach allowed researchers and rehabilitators to visually recognize and track these elephants without the need for radio telemetry. Typically, released elephants undergo intensive monitoring in the initial months following their release. This close monitoring allows for the collection of detailed data on their behavior, movements, and adaptation to the wild. As the elephants acclimate and demonstrate successful integration into their natural environment, the frequency of monitoring is gradually reduced.

While the use of VHF and GPS collars provides valuable insights into the post-release behavior of monitored individuals, it is important to acknowledge the financial limitations that may restrict the number of animals fitted with such collars. Nonetheless, the monitoring efforts carried out by the ETH contribute to our understanding of the long-term success and outcomes of elephant rehabilitation programs.

The aim of this study was to assess post-release survival rates, including evaluating safety, assessing acclimatization to the new environment, observing behavior related to exploring surroundings, studying interactions within the group, and observing responses to encounters with wild elephants and other wildlife. An additional objective was to calculate the distances traveled by individual elephants.

7.2 Methodology

7.2.1 Studied Animals

In this study, we focused on two groups of released elephants consisting of 10 animals in group one and 9 animals in group two. These elephants were released into the wild in 2015 and 2018, respectively. To monitor their behaviour and movements, a combination of direct observation and telemetry methods, including VHF and GPS tracking, was employed.

Group one, comprising 6 males and 4 females, was released into the UNP on March 8th, 2015. The elephants' ages ranged from 5 to 8 years old at the time of release, with weights varying between 850 and 1040 kilograms, as indicated in **Table 7.1**. Prior to their release, five elephants were fitted with VHF collars. After one year, two of these elephants had their collars replaced with GPS collars. The VHF collars were affixed to the elephants' necks 1 to 2 months prior to the release, while the GPS collars were attached while the elephants were freely roaming in UNP.

Group two, consisting of 5 males and 4 females, was released into the Maduruoya National Park (MNP) on March 30th, 2018, as detailed in **Table 7.2**. Among these elephants, four individuals (two males and two females) were equipped with GPS collars. The GPS collars were attached to the elephants' necks while they were at the ETH.

Table 7. 1 Information of Elephants Released in Group 1 to UNP

| Name | Sex | Location of origin | Date of arrival | Age at arrival | Age at release |
|-----------|--------|--------------------|-----------------|----------------|----------------|
| Samari | Female | Hambantota | 23.05.2008 | 2 months | 8yrs |
| Gagani | Female | Vavuniya | 09.09.2008 | 03 months | 8yrs |
| Morisha | Female | Morawewa | 06.06.2009 | 1 year | 8 yrs |
| Srimali | Female | Sigiriya | 24.07.2010 | 10 months | 6 yrs |
| Buwaneja | Male | Mahaoya | 28.09.2008 | 4 months | 8 yrs |
| Kane | Male | Madawachchiya | 03.09.2009 | 2 months | 7 yrs |
| Balangoda | Male | Balangoda | 05.04.2010 | 4 months | 06 yrs |
| Vakarai | Male | Batticaloa | 02.04.2009 | 1 year | 8 yrs |
| Matthala | Male | Lunugamwehera | 04.06.2008 | 1 week | 8 yrs |
| Degambada | Male | Thanamalwila | 19.02.2008 | 1 month | 8 yrs |

Table 7. 2 Information of Elephants Released in Group 2 to MNP

| Name | Sex | Location of origin | Date of arrival | Age at arrival | Age at release |
|-------------|--------|--------------------|-----------------|----------------|----------------|
| Vibhishana | Male | Anuradhapura | 20.07.2011 | 2 months | 7 yrs |
| Madurajah | Male | Madu road | 12.03.2014 | 2 yrs | 6 yrs |
| Yalapala | Male | Yala NP | 05.07.2014 | 2 ½ yrs | 6 yrs |
| Kalu Putha | Male | Anuradhapura | 01.09.2015 | 2 yrs | 5 yrs |
| Sooriya | Male | Suriyawewa | 04.02.2011 | 3 months | 7 yrs |
| Madumathi | Female | UNP | 15.12.2013 | 1 ½ yrs | 6 yrs |
| Groosha | Female | MNP | 07.03.2010 | 6 months | 7 yrs |
| Deegawapiya | Female | Ampara | 28.11.2011 | 4 months | 7 yrs |
| Ridhma | Female | Anuradhapura | 15.02.2012 | 4 months | 6 yrs |



Figure 7. 1 Released elephants drinking water at the Udawalawe reservoir one day after release.



Figure 7. 2 Released elephants at the Maduruoya reservoir one day after release

7.2.2 Monitoring of Released Elephants

The monitoring activities were conducted by the staff of the ETH and park personnel through a combination of direct observations on foot and in vehicles. On average at least 2-3 personnel were involved in recording the observations.

During the initial four weeks following release, the elephants were observed on a daily basis. Subsequently, for a period of 3-4 months, observations were conducted once a week. After this initial period, observations were carried out once or twice a month. It is important to note that the monitoring and recording of these elephants have been ongoing and up-to-date, with observations made whenever they are encountered. In addition, the location data from the VHF or GPS collars fitted on some of the elephants facilitated indirect monitoring of their movements.

7.2.2.1 *Very high frequency (VHF) and the Global Positioning System (GPS) collars*

The VHF radio telemetry method was employed as the primary real-time monitoring technique to track individual elephants from a distance. For all VHF collared elephants, including five from UNP and an unspecified number from Maduruoya, a directional antenna and receiver were used to track their signals. Triangulation methods based on the emitted signals were employed to determine the location of the elephants, following which the monitoring team approached the location until visual contact was established. Tracking was conducted using a vehicle whenever motorable roads were available, and on foot, when necessary, with precautions taken to minimize disturbances. A minimum distance of approximately 20 meters was maintained between the study animals and monitoring vehicles. For safety purposes, if approaching on foot, a minimum distance of 40 meters was maintained. To avoid habituation of the tracked animals to vehicles, natural hides and tree cover were utilized for observations in certain situations.

The VHF collar model used was the Telonics® MOD-600-2, with dimensions of 7.6 x 6.8 x 4.9 cm and a weight of 5.5 kg. The accompanying receiver model was the RA-2AK, a lightweight handheld directional "H" antenna. The emitted VHF frequency was unique for each individual elephant, ranging from 230.00 to 232.00 MHz, and the VHF signal pulsed at a rate of 60 beats per minute. Triangulation was performed manually using geographical maps of the area. It is important to note that VHF signals

can be affected by topography, water, or dense vegetation, potentially leading to misleading tracking data and requiring additional caution during observations.

The GPS collar model utilized was the Followit® "Tellus Elephant collar." These collars had options for a built-in VHF transmitter, which enabled tracking and locating the elephants. The collar had a belting width of 80 mm and an average belting length of 190-220 cm. The satellite download option utilized the Iridium satellite system. The VHF frequency range for GPS collars was from 230.30 to 231.00 MHz. When fitted with a GPS collar, the geographic coordinates of the collared elephants were directly recorded, and operators could pre-design the signal time interval for location data retrieval via satellites or the mobile telephone network. GPS collars typically included built-in VHF transmitters, allowing for real-time direct observations of the elephants.

7.3 Results

7.3.1 Monitoring of Released Elephants - Group 1

The ten elephants that were released remained together as a cohesive group for the initial four months following their release. During this time, they extensively explored and roamed the UNP. Throughout this period, they interacted with both wild elephant bulls, other elephant herds, and various forms of wildlife. At the end of the fourth month, the group eventually split into two sub-groups.

Sub-group 1, consisting of four elephants (one female and three males) named Gagani, Vakarai, Buwaneja, and Kane, remained near the Mau-ara reservoir. In contrast, Sub-group 2, comprising six elephants (three females and three males) named Samari, Morisha, Srimali, Maththala, Balangoda, and Degambada, ventured towards the eastern border of the UNP, occasionally entering chena cultivation areas outside the park.

As time progressed, eight months after the release, these two subgroups rejoined, except for two females: Morisha and Srimali. They joined a wild elephant herd foraging in the Watehirakanda Nature Reserve, which connects the UNP and Lunugamwehera National Park. Meanwhile, the remaining two females and six males (Gagani, Samari, Vakarai, Buwaneja, Kane, Maththala, Balangoda, and Degambada) continued to range across the Mau-ara reservoir and both the western and eastern

borders of the Udawalawe reservoir, exhibiting the characteristic fission-fusion behavior observed in wild elephant herds.

Eleven months after the release, two males, Degambada and Balangoda, moved far away from their original release site and were found residing in the Dahiyagala sanctuary. In this area, wild elephants frequently ventured outside the park, breaking electric fences. These two collared elephants were spotted several times roaming outside the park alongside other wild adult bulls, resulting in complaints of crop raiding behavior ((**Figure 7.3**. Map of the UNP with Dahaiyagala Sanctuary and Waterhirakanda Nature Reserve).

On 22nd October 2016, a significant period after their release, Degambada sustained a gunshot injury in the village of Hambegamuwa. After being assessed for his health condition, Degambada was captured and brought back to the ETH, where he received treatment for four months with antibiotics and other supportive therapies. During his treatment, Degambada eventually rejoined the rehabilitating elephant calves at ETH but gradually moved away from the premises and reunited with three previously released male elephants (Vakarai, Buwaneja, and Kane), who were roaming at the western border of the Udawalawe reservoir.

In light of these developments, it was decided to replace the VHF collars of two elephants. Vakarai, a male, was re-collared on 14th October 2016, while Gagani, a female, was re-collared on 5th July 2017. The new GPS collars were programmed to send GPS positions every four hours for enhanced monitoring and tracking.

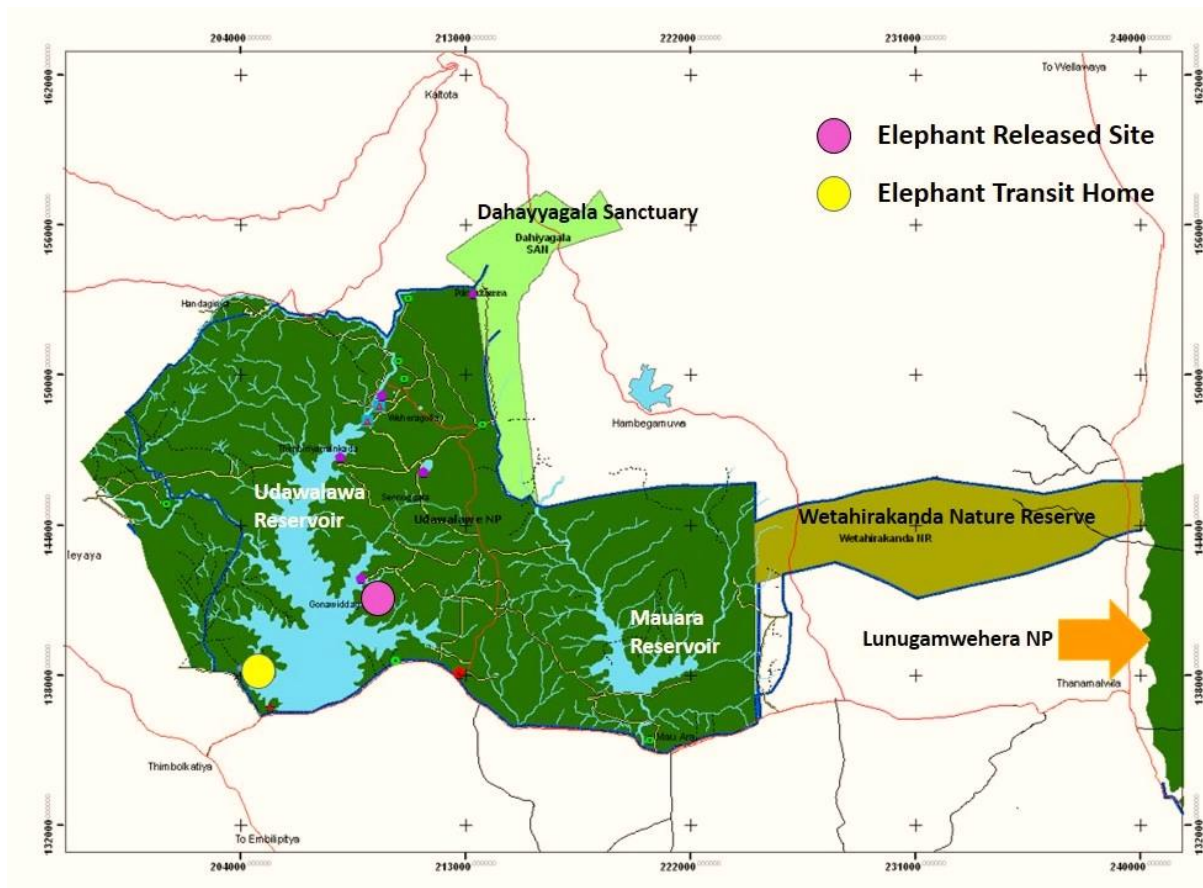


Figure 7. 3 Udawalawe National Park with Dahaiyagala Sanctuary and Waterhirakanda Nature Reserve (Source: GIS unit, DWC 2018)

7.3.1.1 Ranging pattern of male elephant Vakarai

The collar fitted to the Vakarai functioned from the date of fitting (October 14, 2016) to April 30, 2018, spanning a period of 564 days. Over this duration, a total of 1,118 GPS points were received every 4 hours, as depicted in **Figure 7.4**, indicating that the Vakarai moved approximately 1,003 km. The estimated area covered by its movements during this time period was approximately 175 km².

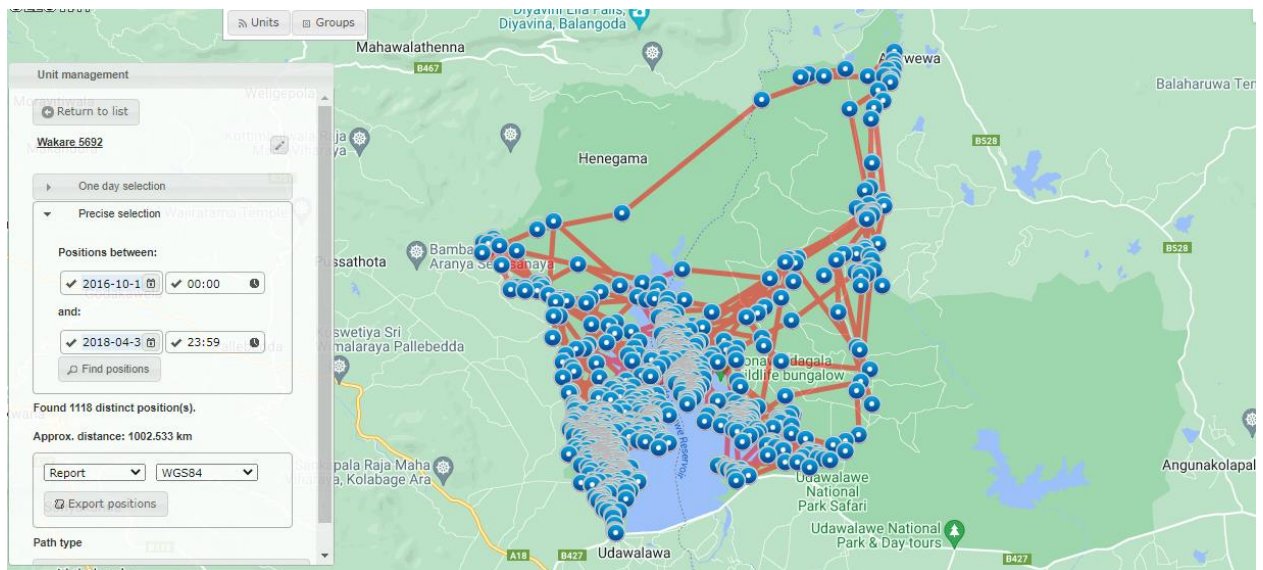


Figure 7. 4 Movement Pattern of Vakarai over 564 Days After Re-collaring

The monthly movement patterns of Vakarai (**Figures 7.5 to 7.22**) indicate a primary concentration within the Udawalawe reservoir, demonstrating an extensive roaming range throughout the year. These movements do not adhere to a specific location within his home range but vary over time. When considering the physical characteristics of the area, several factors influence Vakarai's movements, including water availability, grass presence in the tank beds, and fluctuations in reservoir water levels.

During periods of declining water levels in the reservoir, emergent grass beds attract a gathering of elephants, including Vakarai. However, with the onset of rain in October or November, the grasslands become submerged, reaching their peak water levels in December. Consequently, Vakarai moves away from the reservoir in search of suitable foraging opportunities. The forest encompasses small water holes that adequately fulfill Vakarai's water requirements during this period, enabling him to sustain himself despite the relocation from the reservoir. This rain-dependent movement pattern extends into March and April, coinciding with rainfall in Udawalawe during these months. The increased precipitation prompts animals to move away from the reservoirs once again.

Overall, Vakarai's movement patterns exemplify a rain-dependent behavior, where foraging is influenced by the availability of water and grass, as well as the dynamic water levels within the Udawalawe reservoir.

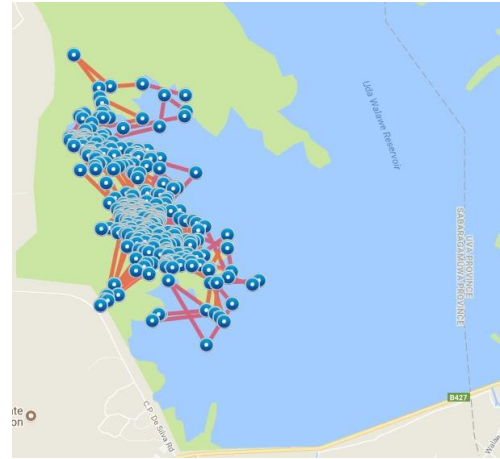
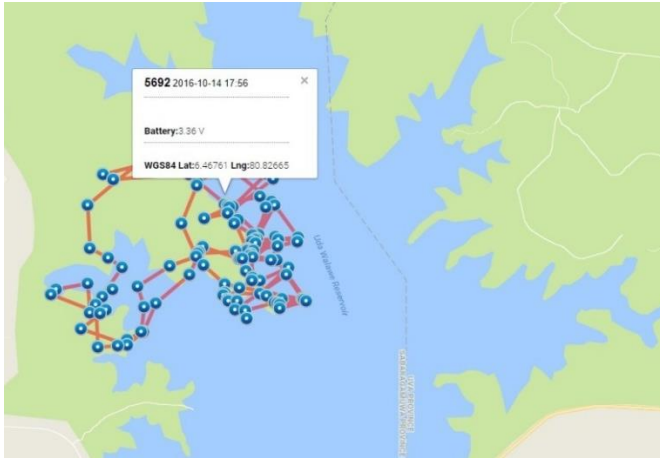


Figure 7. 5 and 7.6. Movement pattern of Vakarai during October and November 2017

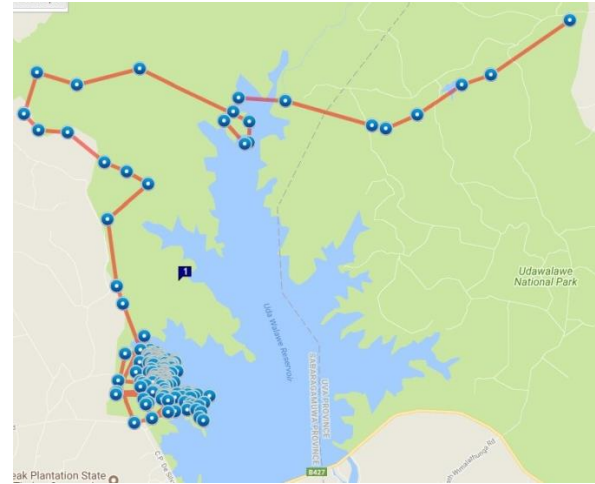
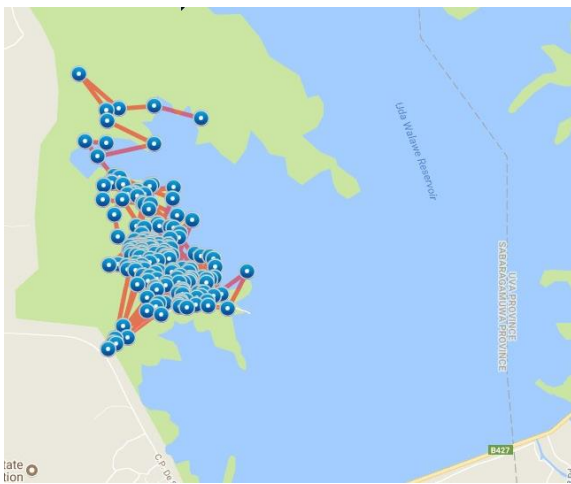


Figure 7.7 and 7.8. Monthly movement pattern of Vakarai during December 2017 and January in 2018

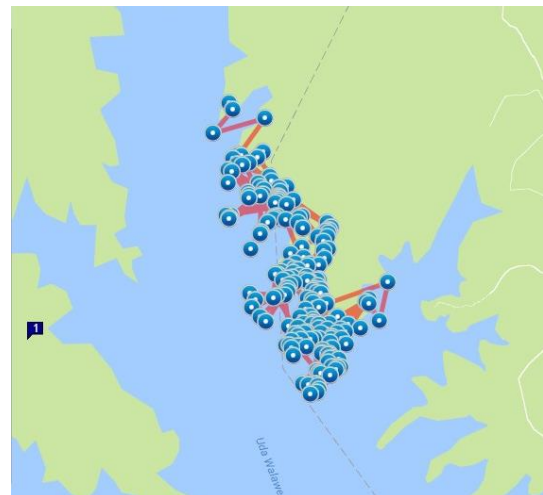
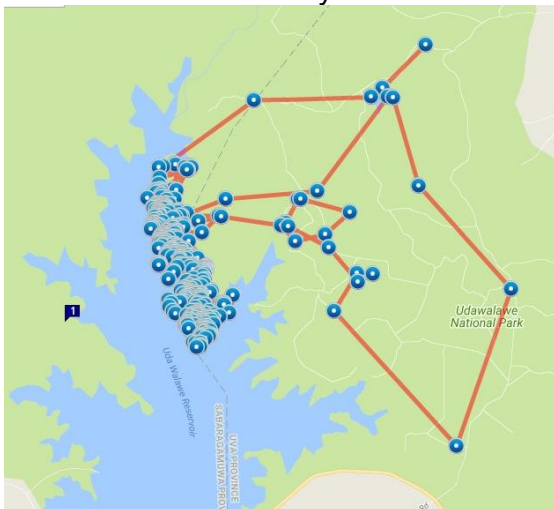


Figure 7.9 and 7.10 Monthly movement pattern of Vakarai during February and March in 2018



Figure 7.11 and 7.12. Monthly movement pattern of Vakarai during April and May in 2018

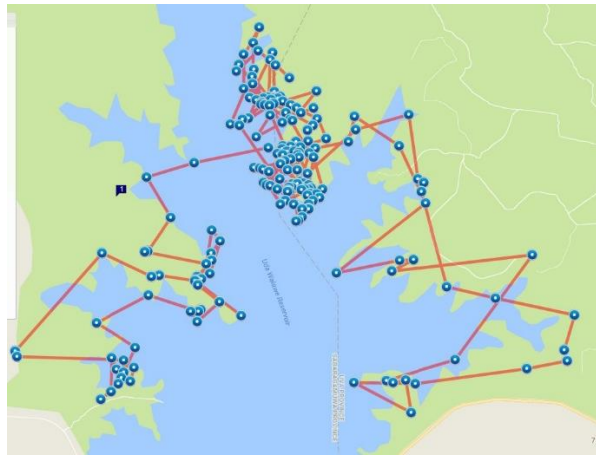


Figure 7.13 and 7.14 Monthly movement pattern of Vakarai June and July 2018

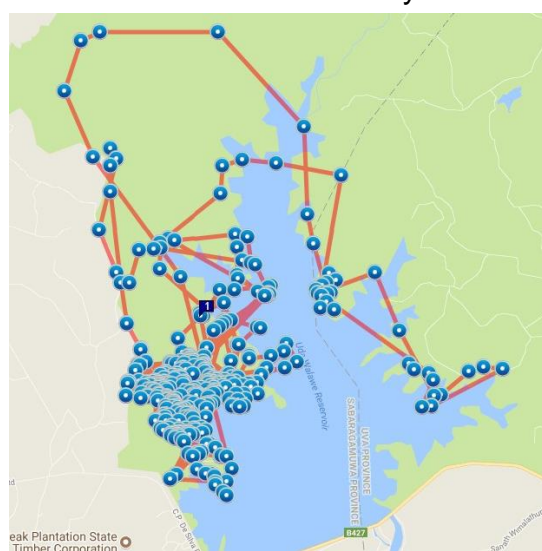


Figure 7.15 and 7.16. Monthly movement pattern of Vakarai during August and September in 2018

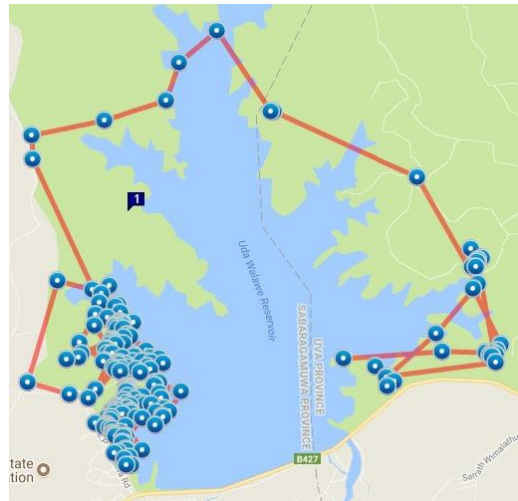
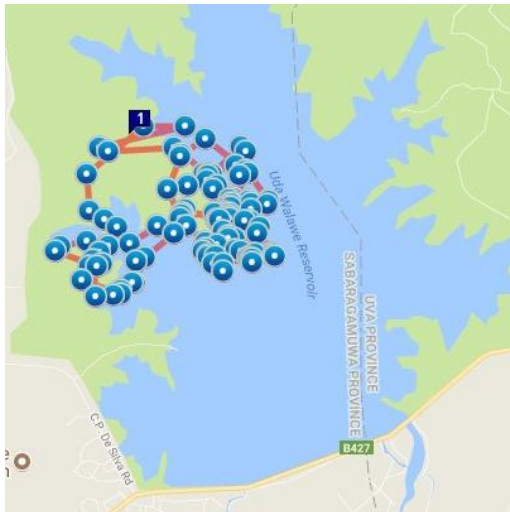


Figure 7.17 and 7.18. Monthly movement pattern of Vakarai during October and November in 2018

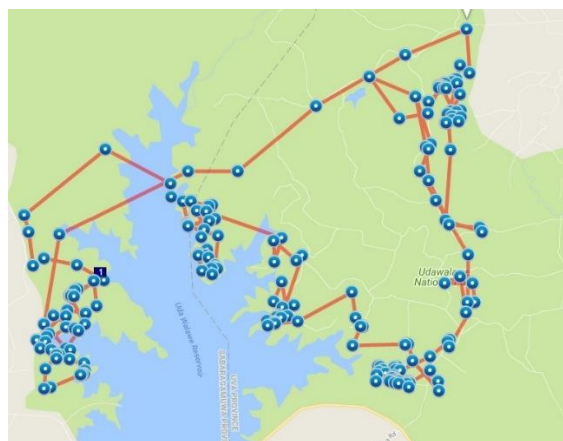
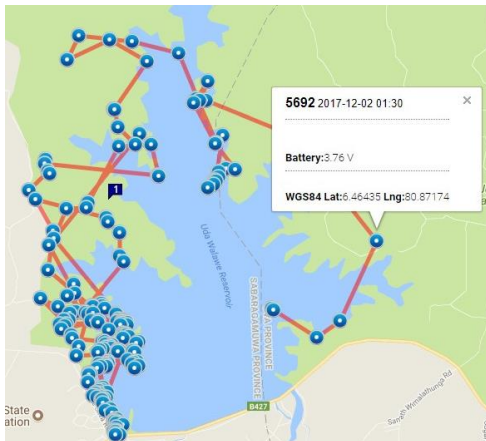


Figure 7.19 and 7.20. Monthly movement pattern of Vakarai during December 2018 and January 2019

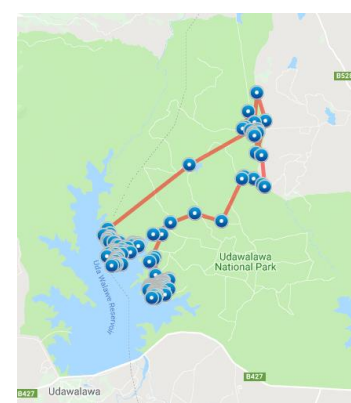
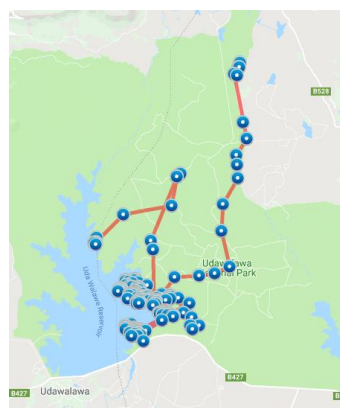
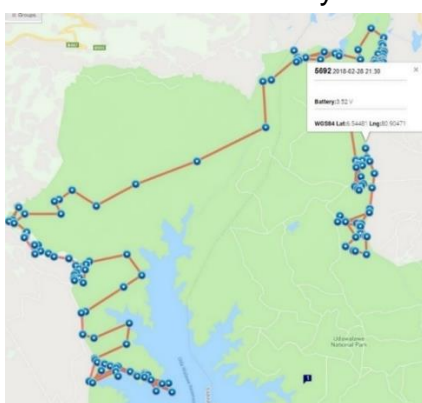


Figure 7.21 and 7.22 Monthly movement pattern of Vakarai during February, March and April during 2019

7.3.1.2 Ranging pattern of female elephant Gagani

The tracking collar placed on the female elephant, Gagani, remained functional from July 5, 2017, to November 14, 2019, covering a period of 948 days. During this time, a total of 1410 location positions were recorded. Gagani's approximate total distance traveled, excluding the 4-hour interval period between two positions, amounted to 1504 kilometers (**Figure 7.23**). The monthly movements of Gagani are illustrated in **Figures 7.24** to 7.48.

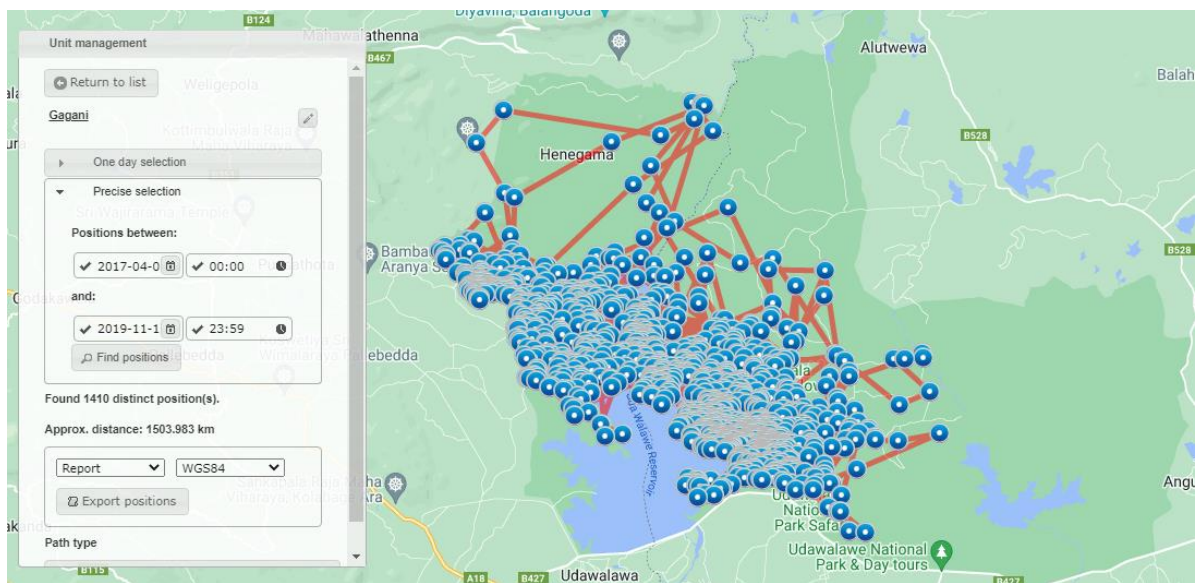


Figure 7.23 Monthly movement pattern of Gagani during 05.07.2017- 13.11.2019

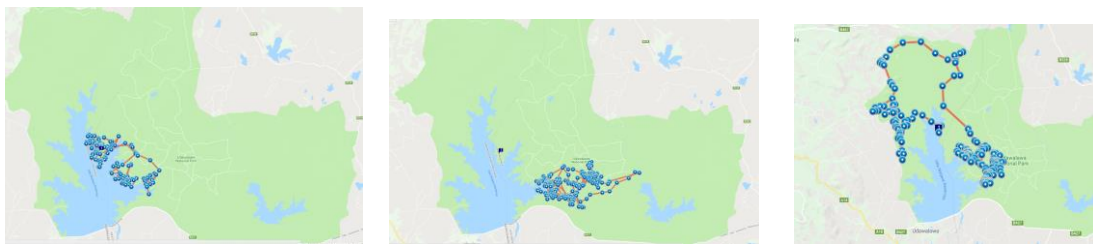


Figure 7.24, 7.25 and 7.26 Monthly movement pattern of Gagani in the month of April in 2017, 2018 and 2019

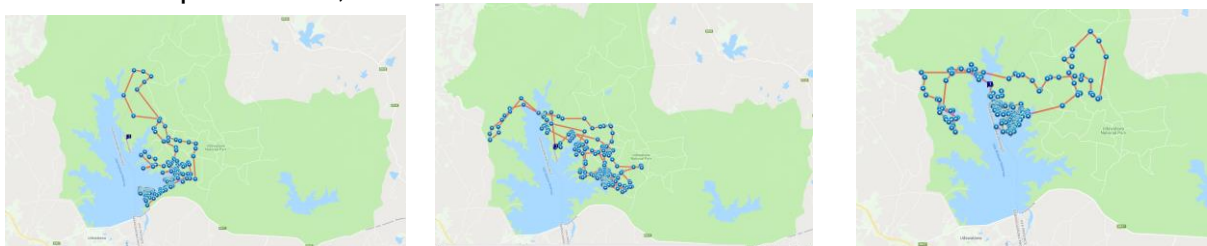


Figure 7.27, 7.28 and 7.29 Monthly movement pattern of Gagani in May in 2017, 2018 and 2019



Figure 7.30, 7.31 and 7.32 Monthly movement pattern of Gagani in June in 2017, 2018 and 2019

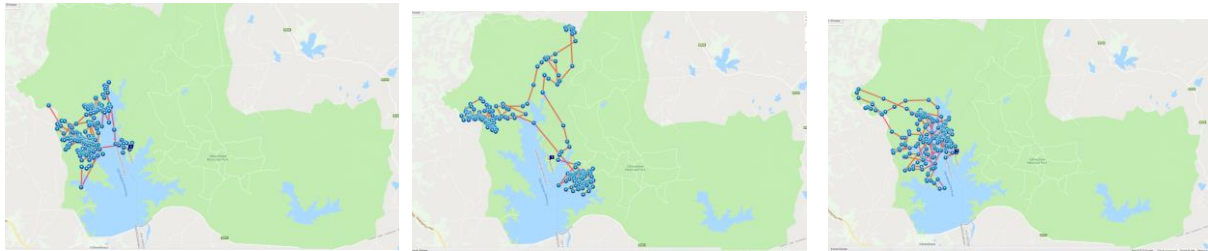


Figure 7.33, 7.34, 7.35 Monthly movement pattern of Gagani in July 2017, 2018 and 2019

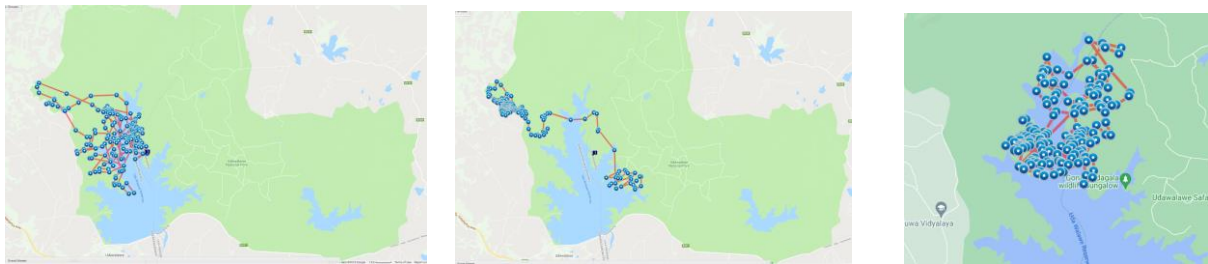


Figure 7.36, 7.37 and 7.38 The movement pattern of Gagani in the months of August 2017, 2018 and 2019

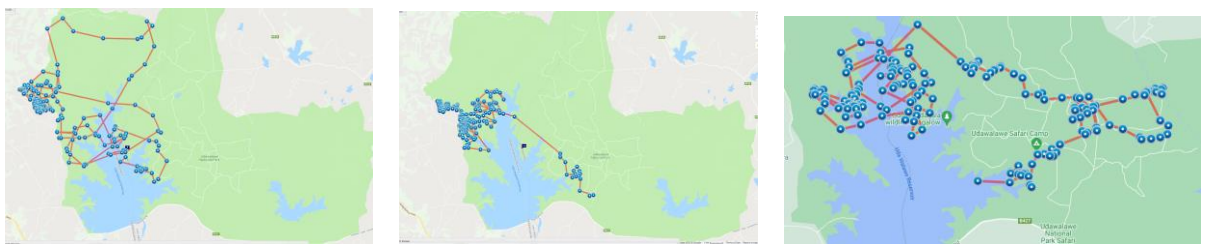


Figure 7.39, 7.40 and 7.41 Monthly movement pattern of Gagani during September in 2017, 2018 and 2019

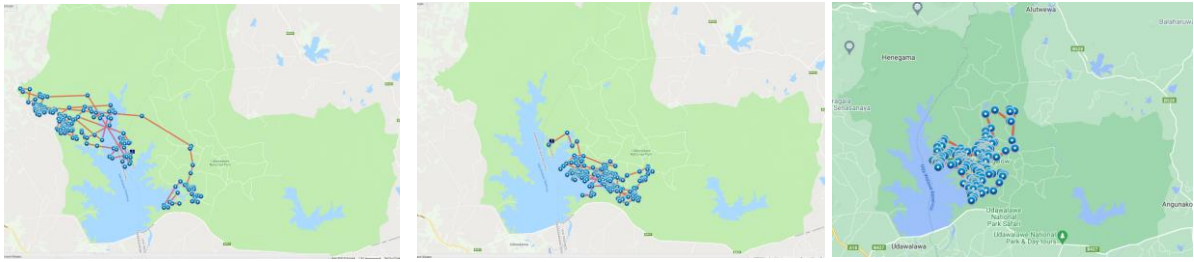


Figure 7.42, 7.43 and 7.44 Monthly movement pattern of Gagani during October in 2017, 2018 and 2019

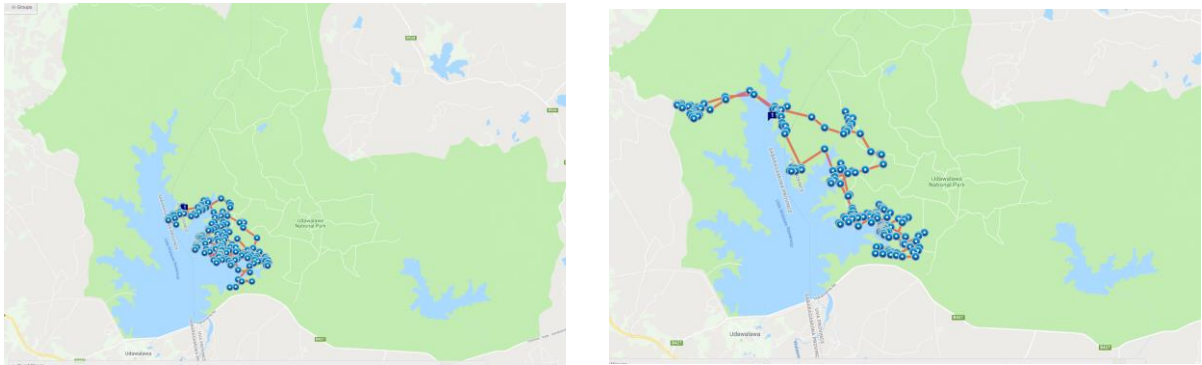


Figure 7.45 and 7.46 Monthly movement pattern of Gagani during November in 2017 and 2018

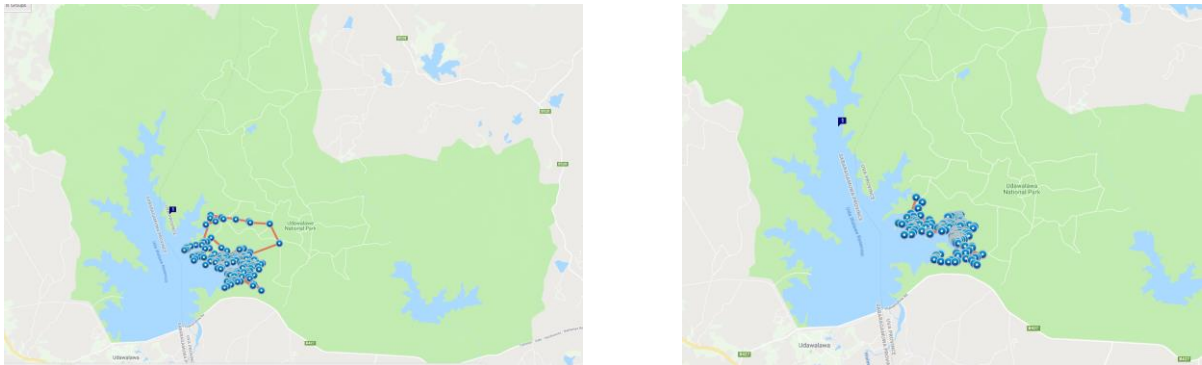


Figure 7.47 and 7.48 Monthly movement pattern of Gagani during December in 2017 and 2018

Gagani, the female elephant, demonstrates a consistent movement pattern within the vicinity of the Udawalawe reservoir over a period of 948 days. She covers an approximate land area of 150 square kilometers, utilizing both the eastern and western borders of the reservoir, but with a preference for the western area. Gagani's movement pattern is not heavily influenced by the annual rainfall pattern, unlike the male elephant, Vakarai. Instead, she consistently roams along the reservoir, indicating that it serves as a reliable water source and feeding ground for her. This suggests that Gagani has adapted her movement behavior to depend on the water resources provided by the reservoir, regardless of the fluctuations in annual rainfall.

Although Gagani's movement pattern demonstrates overall consistency, slight changes have been observed within each individual year. These variations could be attributed to factors such as changes in vegetation, availability of food sources, the water level of the reservoir, the presence of other wild elephant herds, or other ecological factors that influence her movement. Gagani's movement pattern reveals a preference for the western area of the Udawalawe reservoir, with consistent roaming behavior and a relatively stable range of movement. Her reliance on the reservoir emphasizes

7.3.1.2 Natural and anthropogenic hazards faced by Group 1 elephants released to UNP

Two elephants released to the UNP experienced tragic deaths. The first elephant, a male named Buwaneja, passed away in 2018. Post-release monitoring revealed that Buwaneja was in good physical condition and exhibited a healthy social life with both his fellow elephants and wild elephants in the area. However, approximately 28 months after his release, Buwaneja was discovered trapped in a mud pit near the reservoir. Buwaneja had been trapped for about a week before he was found, leading to severe exhaustion, dehydration, starvation, and sunburn. Despite rescue efforts and being brought back to the ETH for treatment, Buwaneja's condition deteriorated rapidly, and he succumbed to his condition within three days.

The second death involved a male elephant named Mattala. Mattala suffered severe injuries to the mouth due to the explosion of a jaw bomb, an illegal device commonly used by poachers to target wild boar. He was critically wounded and subsequently brought to ETH, where he received intensive treatment over a period of four months and eventually recovered. After his recovery, Mattala gradually left ETH and began roaming within the park. However, he was found dead two months later on the tank bed.

Two additional members of the released group were discovered with gunshot wounds. Degambada, a male elephant known for his history of crop raiding, was found

injured in 2016 at the Dahiyagala sanctuary. He received prompt treatment in the field and underwent a three-month recovery period at the ETH, showing a positive response to the administered care. Similarly, Samari, a female elephant, also suffered from gunshot injuries but displayed a favorable response to treatment provided in the field.

These incidents highlight the formidable challenges and risks faced by elephants in the UNP, including entrapment in mud pits, illegal poaching practices, and HEC. The efforts aimed at addressing these issues and delivering timely and effective treatment have resulted in both successes and unfortunate losses in the conservation and protection of these released elephants.

7.3.2 Observations of Group 2 after release into the MNP

On March 29, 2018, nine elephants were released into the MNP after being transported in two lorries over a distance of approximately 221 kilometers, as depicted in **Figure 7.49**. The MNP has designated elephant ranging areas, as illustrated in **Figure 7.50**. Out of the nine released elephants, four individuals (two males and two females) were fitted with GPS collars. However, after two weeks of being fitted, two of the collars malfunctioned. The remaining two collars functioned for 22 months and 11 months, respectively, providing valuable tracking data during that time period.

After their release into MNP, the nine elephants stayed together as a group for three weeks. However, after this initial period, Group 2 divided into two subgroups. Group 2a consisted of five elephants, while Group 2b comprised four elephants.

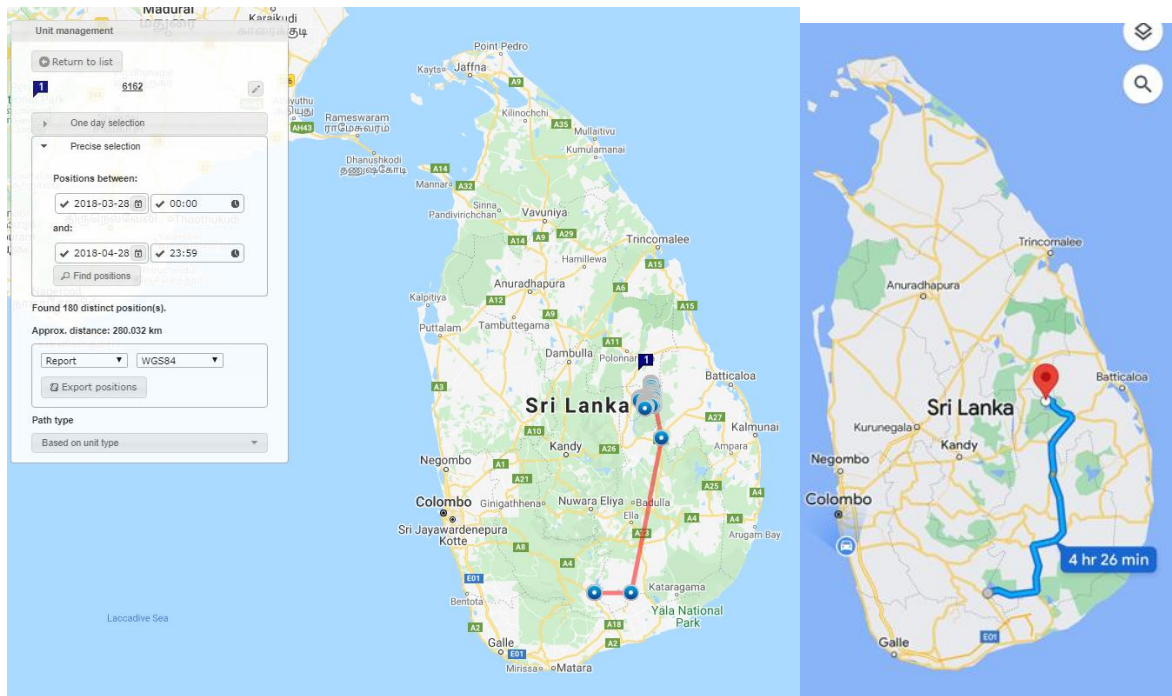


Figure 7.49. Geographical locations of ETH and MNP in Sri Lanka

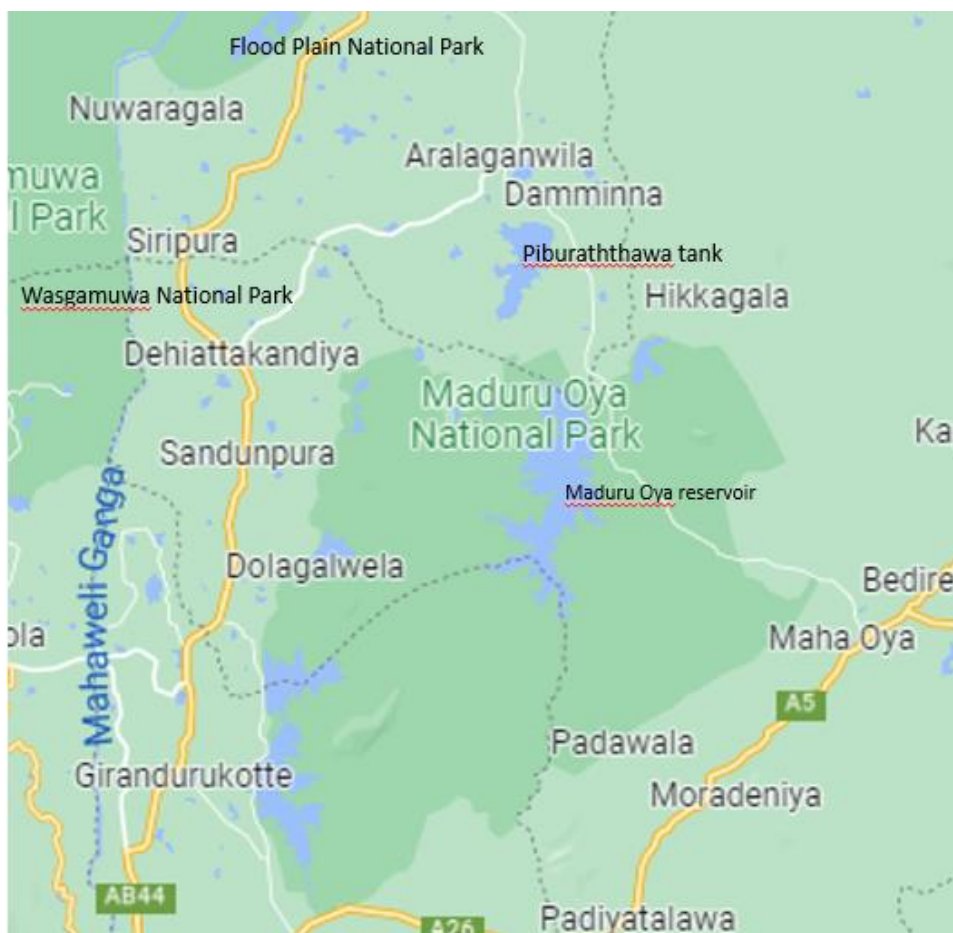


Figure 7.50 Geographical map of MNP and adjacent elephant ranging areas

7.3.2.1 Ranging pattern of Group 2a

Madurajah, a male elephant from Group 2a, was equipped with a GPS collar and monitored for a period of one year and ten months, totaling 701 days, as depicted in **Figure 7.51**. Throughout this 22-month period, Group 2a remained together and initially moved to the Piburaththawa tank area, but returned to MNP after one month. In July and August, they moved between the tank beds of Maduruoya and Piburaththawa. In September 2018, the group settled in the Diulana area, which is located outside the wildlife protected area. The home range of Group 2a encompassed three artificial lakes, which served as a water source, as well as thick forest patches and agricultural lands. This area was shared with wild elephants, many of whom were known to raid crops. It was reported that the released elephants from Group 2a also foraged in human-dominated areas surrounding the Diulana area and were involved in crop raiding activities. In October 2019, Group 2a moved to the Flood Plain National Park, but later returned to the Diulana area. At the time of writing, the members of Group 2a are still residing in this region. The monthly ranging patterns of the five individuals in Group 2a can be observed in **Figures 7.52 to 7.67**.

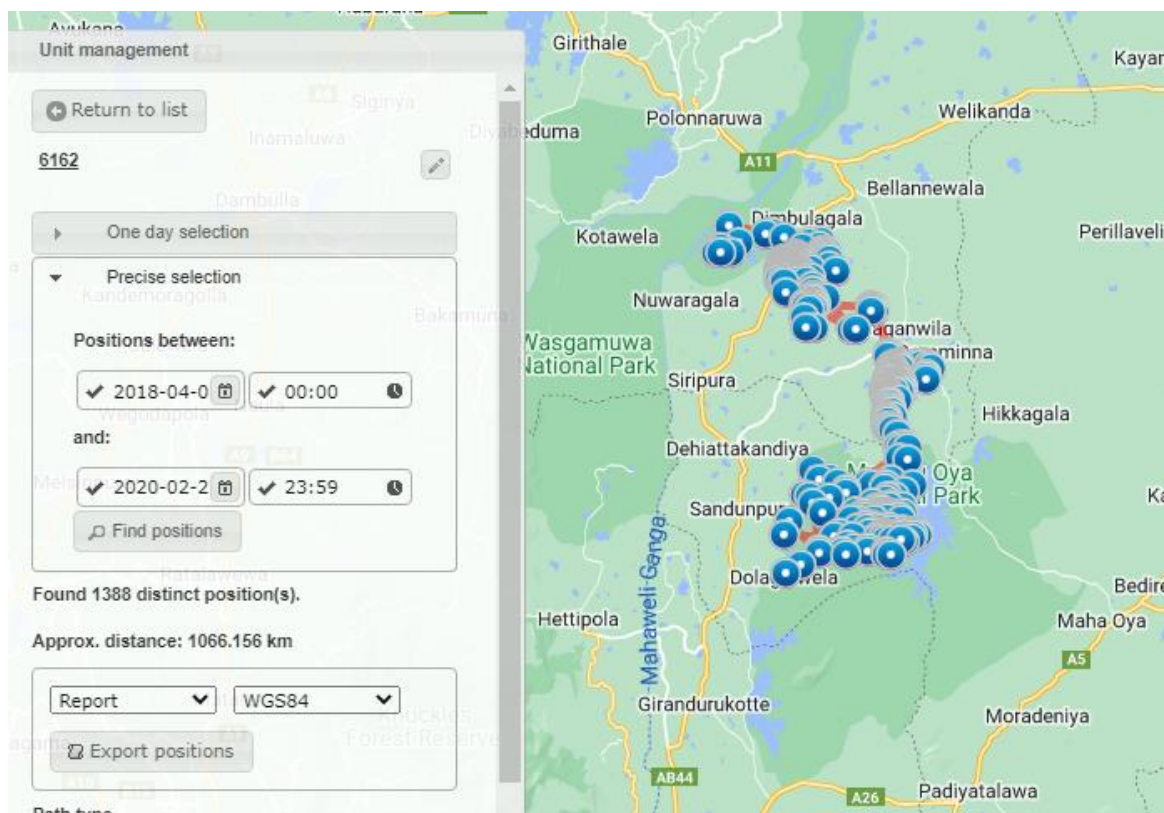
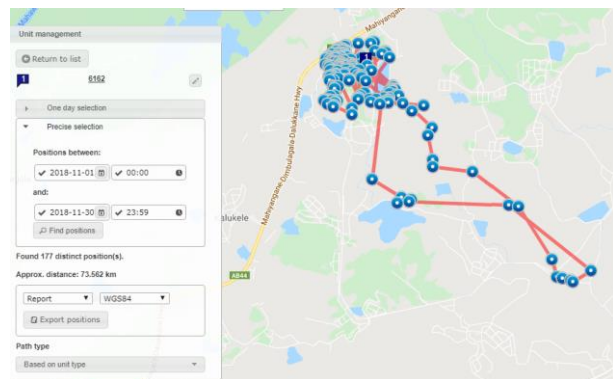
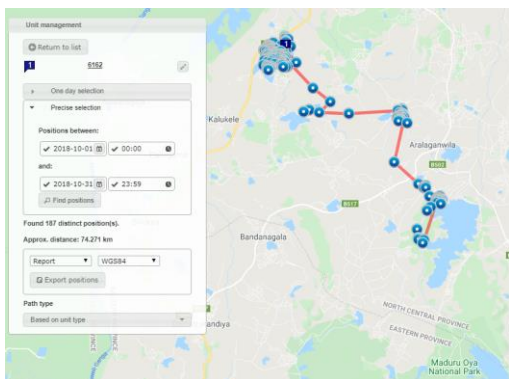
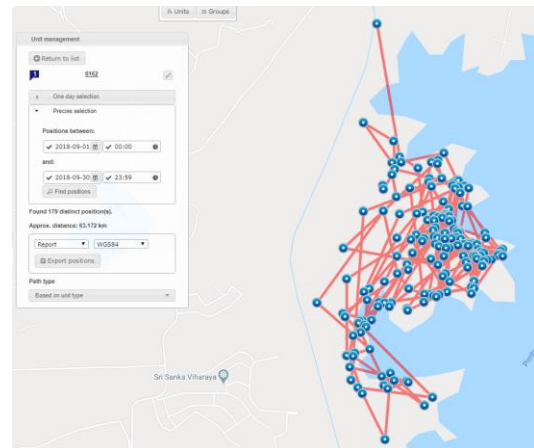
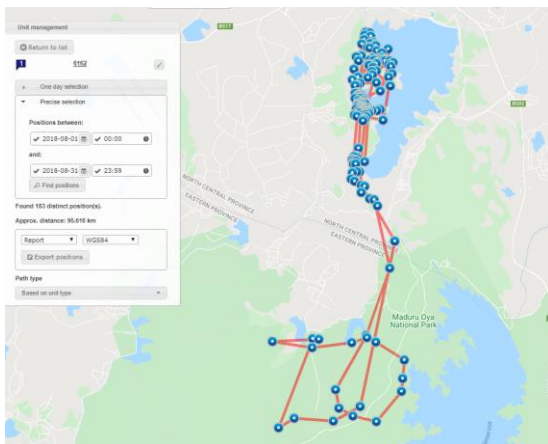
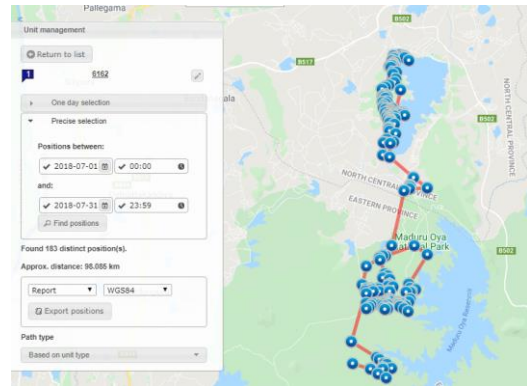
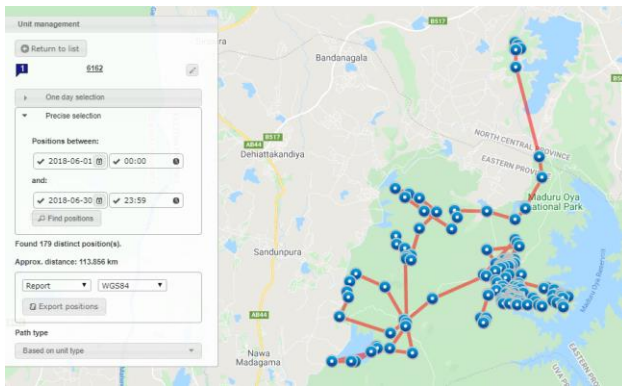
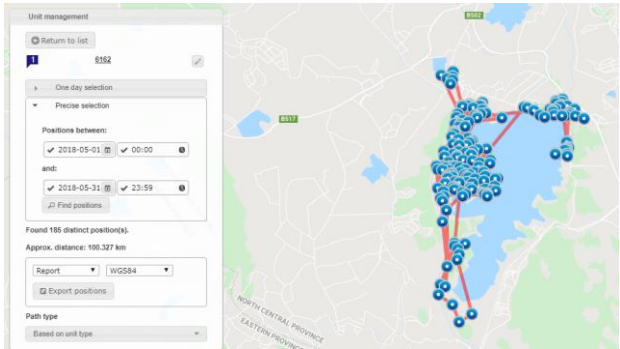
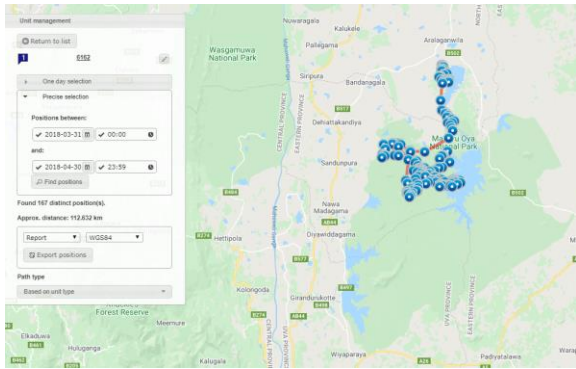
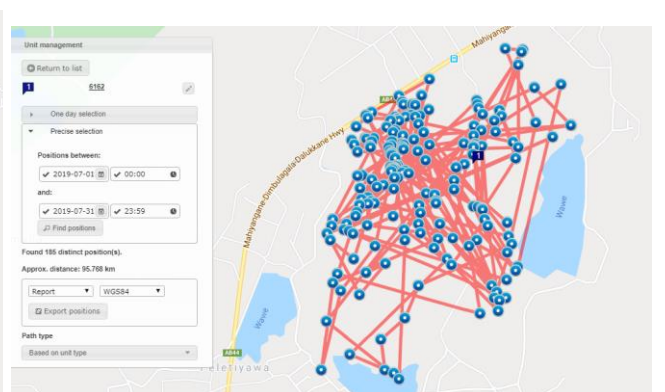
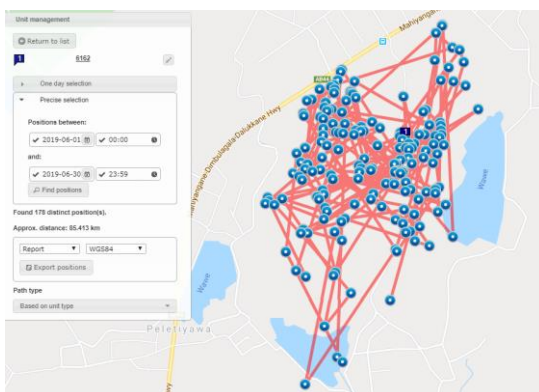
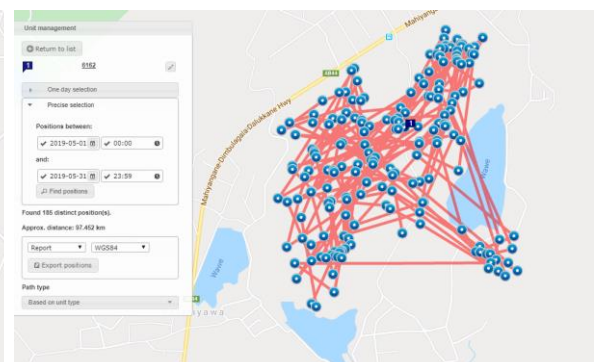
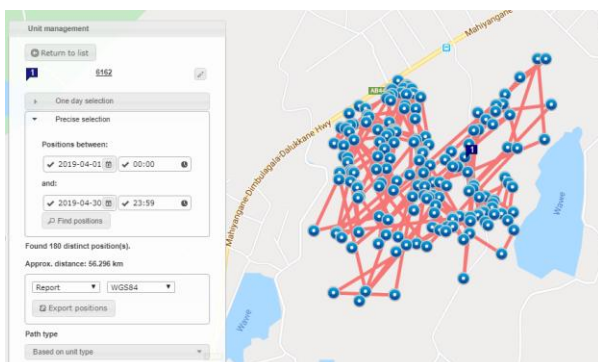
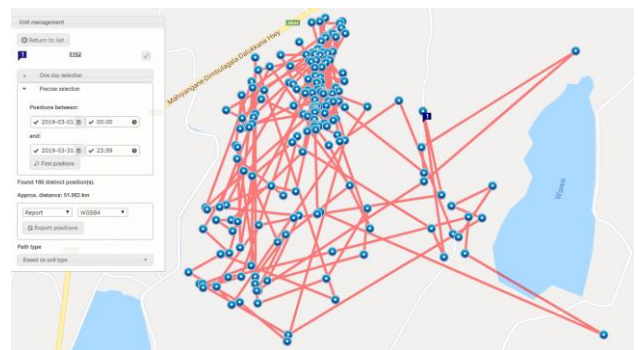
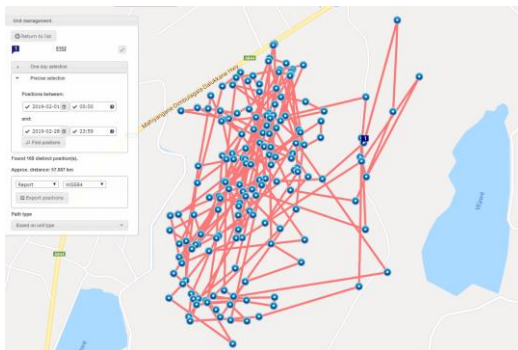
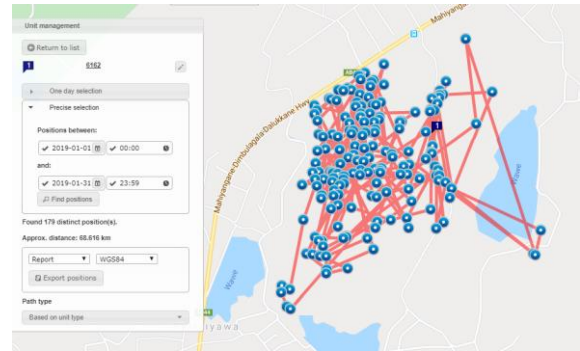
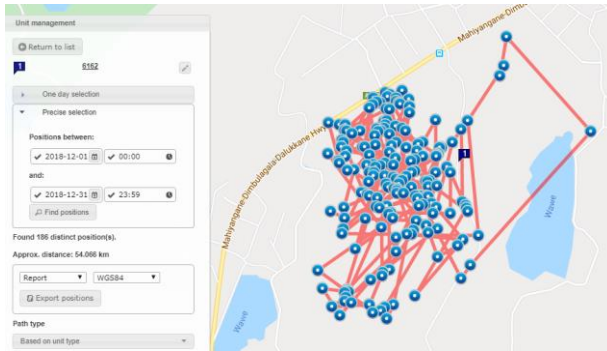


Figure 7.51 Ranging pattern of group 2a in a 22 months period





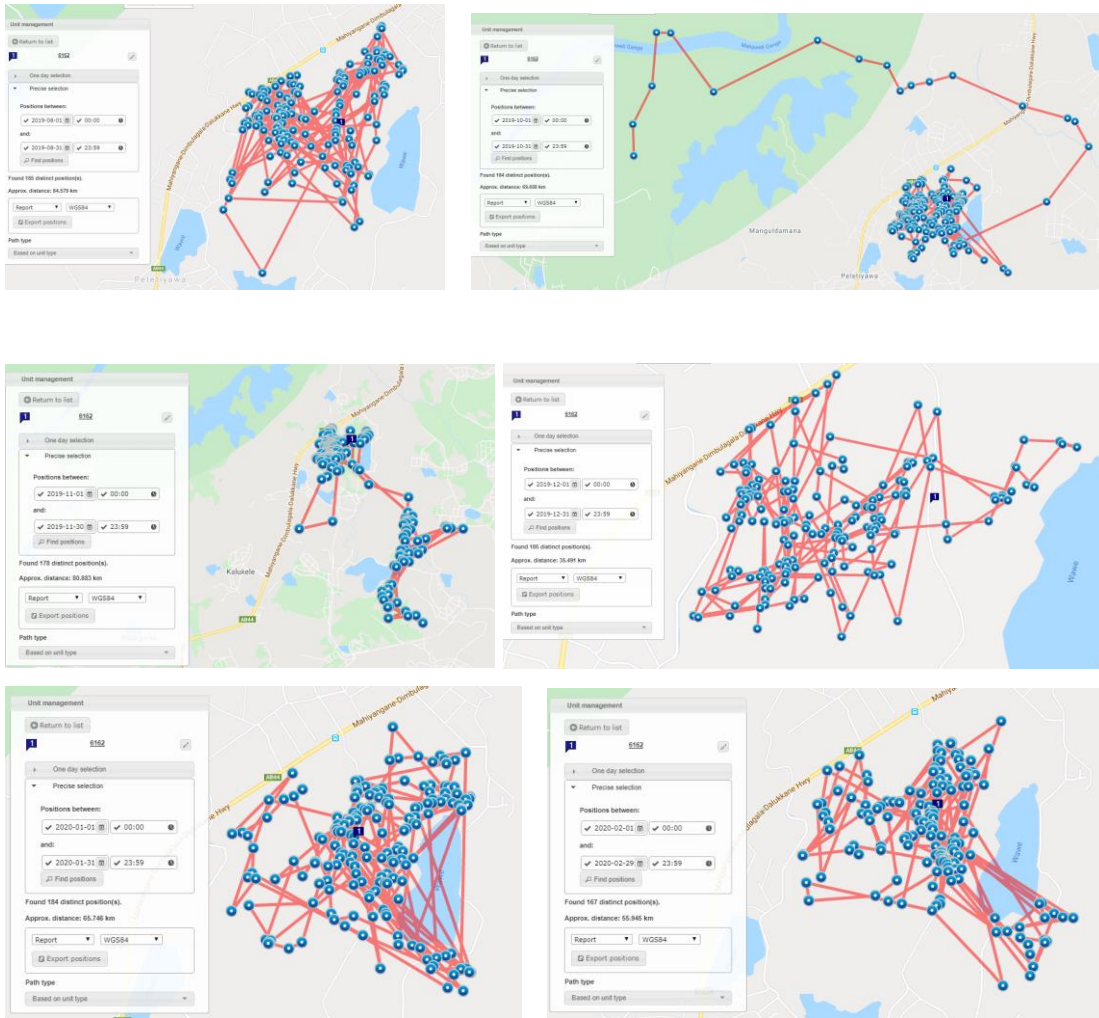


Figure 7.52 to 7. 73 Monthly ranging pattern of group 2a

7.3.2.2 Ranging pattern of group 2b (4 elephants)

The four elephants in Group 2b, as indicated by the GPS collar on Ridhma, exhibited a northward movement. These elephants ranged over an area which was shared with a significant population of wild elephants, leading to interactions between the two groups. The GPS collar on Ridhma remained functional from the date of release on March 30, 2018, until April 18, 2019, covering a total of 384 days. During this period, a total of 1149 distinct GPS positions were recorded, as illustrated in **Figure 7.74**. These positions indicate that the elephant traveled a total distance of 1034 kilometres. Based on the recorded data, the approximate extent of Ridhma's home range is estimated to be 180 square kilometres. The movement patterns of the elephants in Group 2b during each distinct month of the study can be observed in **Figures 7.75 to 7.95**.

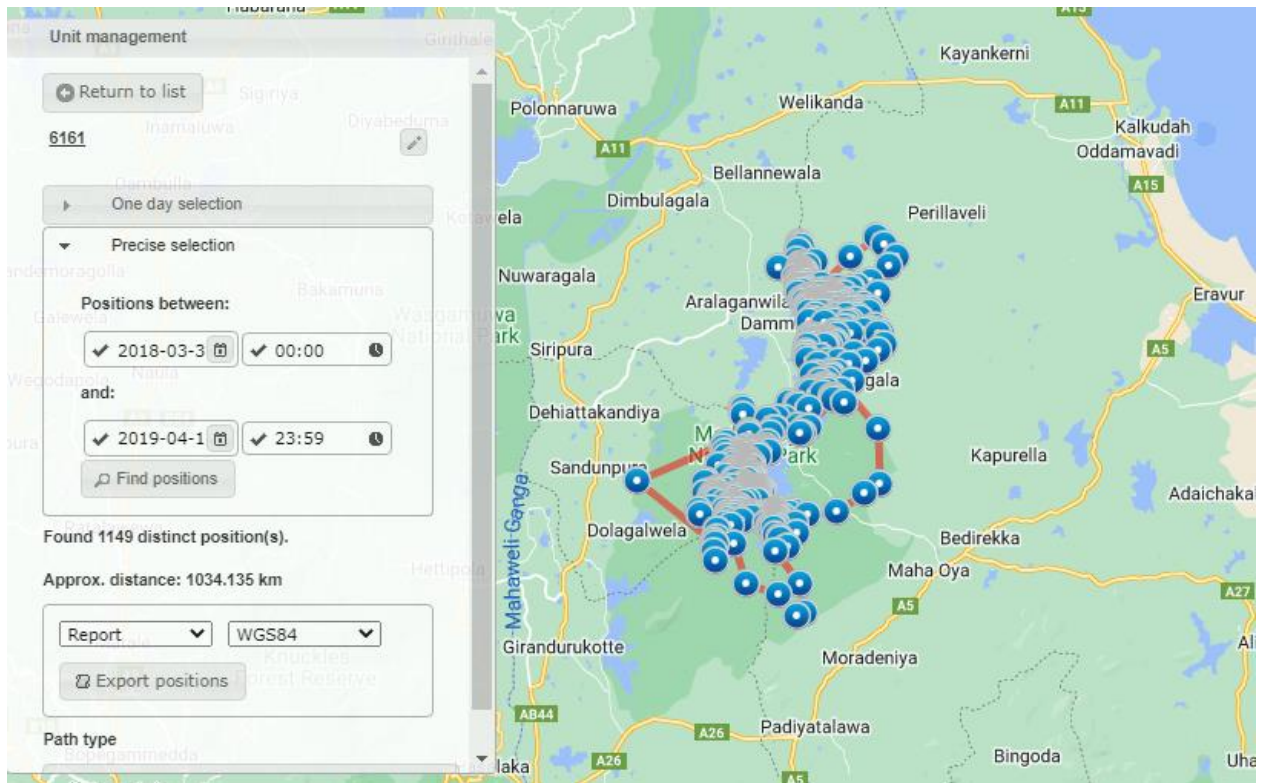
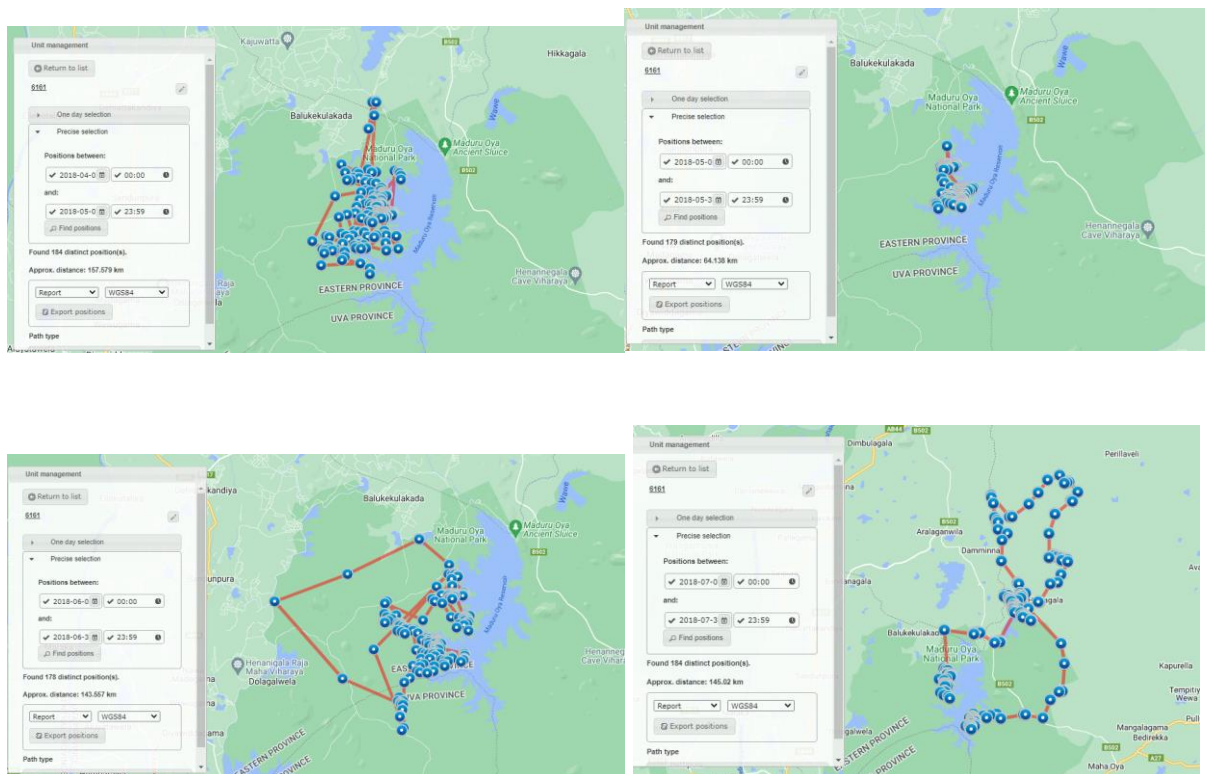
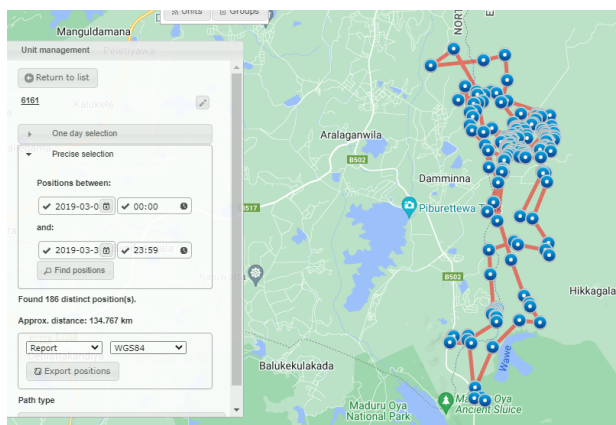
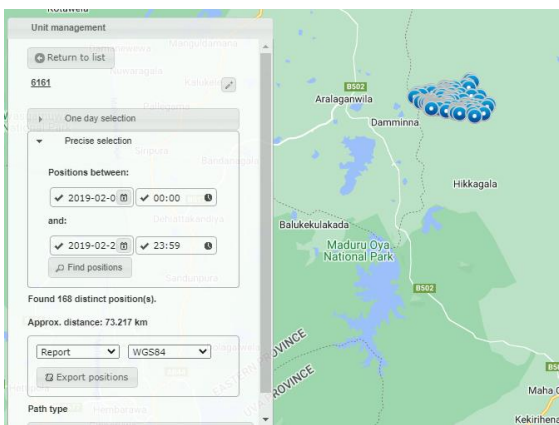
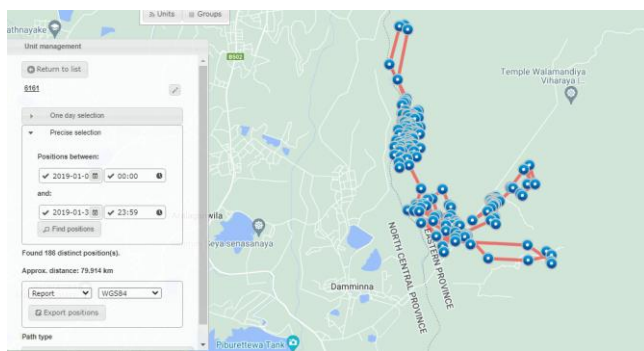
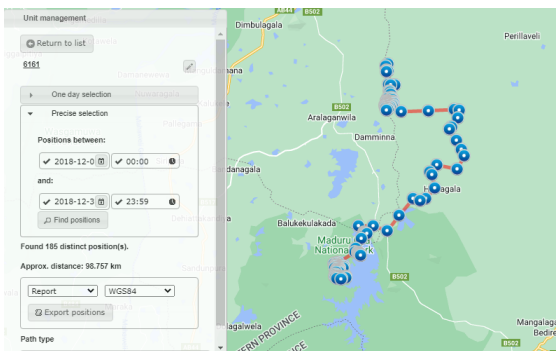
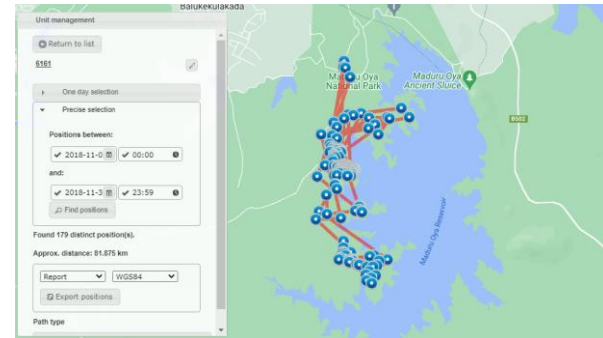
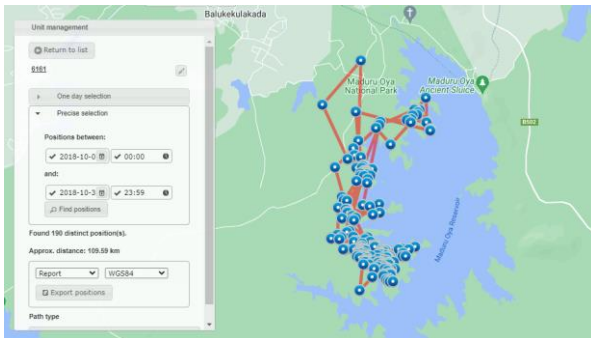
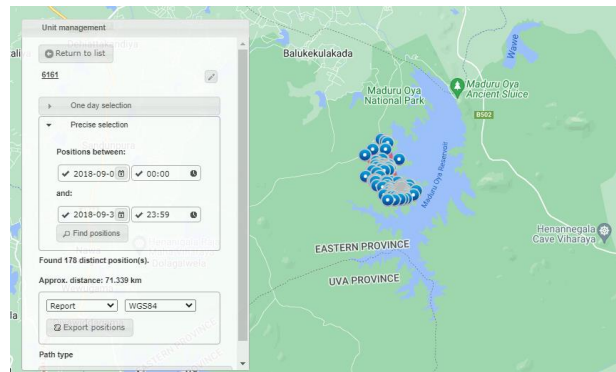
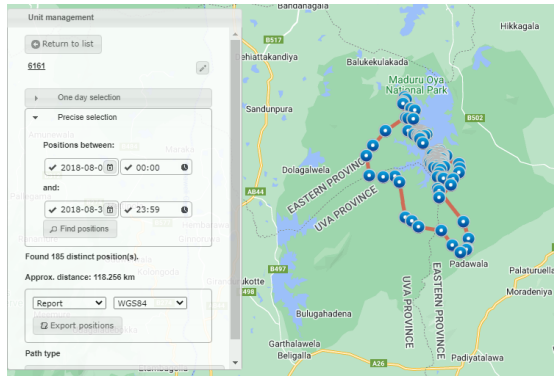


Figure 7.74 Pattern of movements in Group 2b during the first 384 days post release





Figures 7.75 to 7.93 Pattern of movements of elephants in Group 2b during each month of study

7.3.2.3 Natural and anthropogenic hazards faced by released elephants (Group 2) at the MNP

Two elephants died after being released into MNP. Deegawapi, a female elephant from Group 2b, passed away after 11 months of release. Deegawapi was found collapsed and trapped in a water hole, as reported by villagers. Despite receiving treatment, her condition deteriorated, leading to her demise. Post-mortem examination revealed a heavy infestation of parasites, including hookworms, which likely played a role in her death.

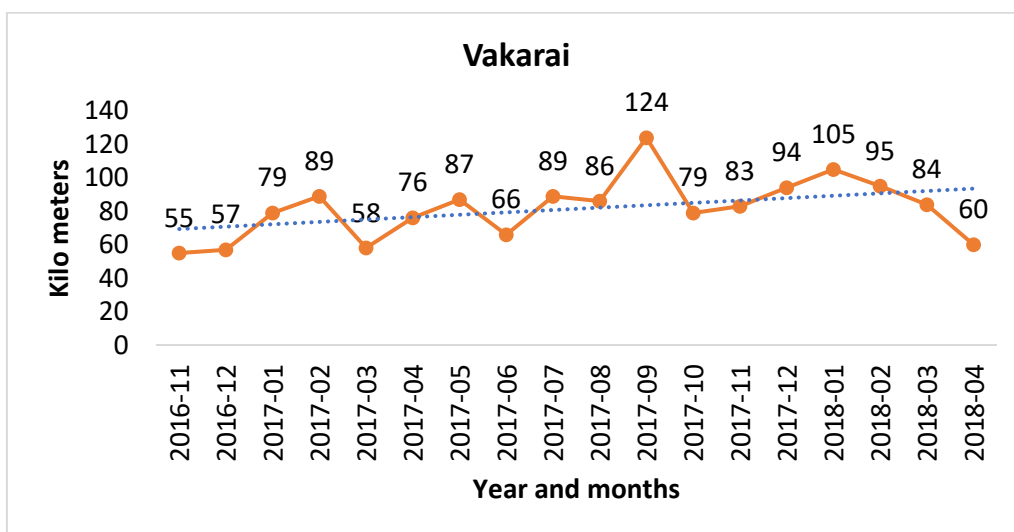
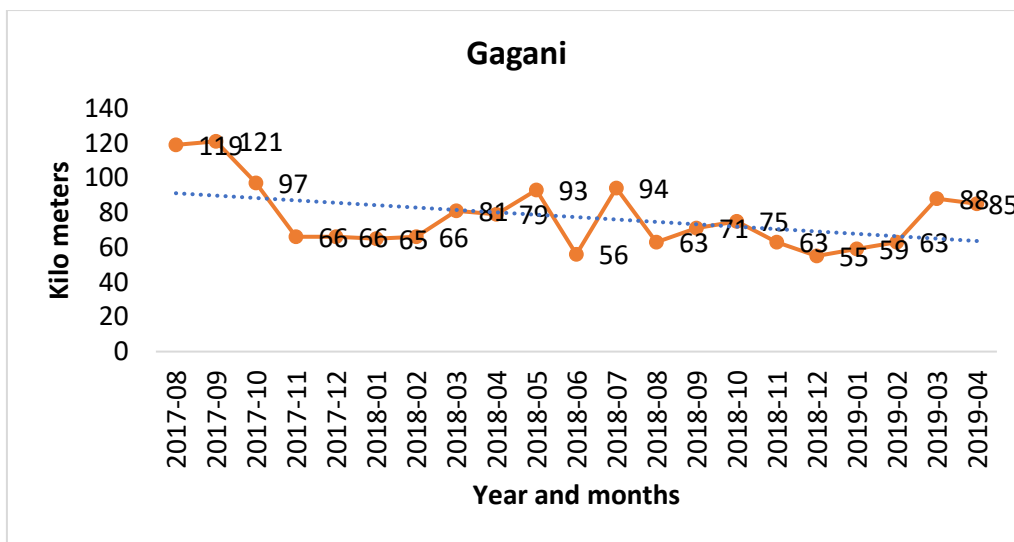
While Suriya, a male elephant from Group 2a, died after 16 months. Suriya was found deceased in the tank bed of NDK. Post-mortem analysis indicated that he may have died from septicemia, a severe blood infection, caused by infected wounds resulting from an explosion of a jaw bomb.

7.3.3 Monthly ranging distance of elephant groups

Based on the GPS positions of Group 1, the monthly movements of the female elephant Gagani and the male elephant Vakaraï were recorded to be approximately 77 ± 4.1 km and 81 ± 4.2 km, respectively. This translates to an average daily travel distance ranging from 2.55 km to 2.68 km per day, as presented in **Table 7.3**. For the male elephant Madurajah and the female elephant Ridhma, who were released into MNP, the average monthly distances traveled were approximately 78 ± 4.4 km and 106 ± 9.5 km, respectively. These figures are displayed in **Figures 7.94, 7.95, 7.96 and 7.97**. The data suggests that, with the exception of Vakaraï, the average distance traveled by the elephants appears to gradually decline over time.

Table 7. 3 Mean monthly distance travelled by study elephants with GPS collars

| | Gagani (Female) Udawalawe NP | Vakarai (Male) Udawalawe NP | Madurajah (Male) Maduruoya NP | Ridhma (Female) Maduruoya NP |
|-----------------------------------|---------------------------------------|--------------------------------------|-------------------------------------|------------------------------------|
| Mean Monthly travel distance (km) | 77±19 | 81±18 | 78±21 | 106±33 |
| Mean daily travel distance (km) | 2.55 | 2.68 | 2.55 | 3.50 |



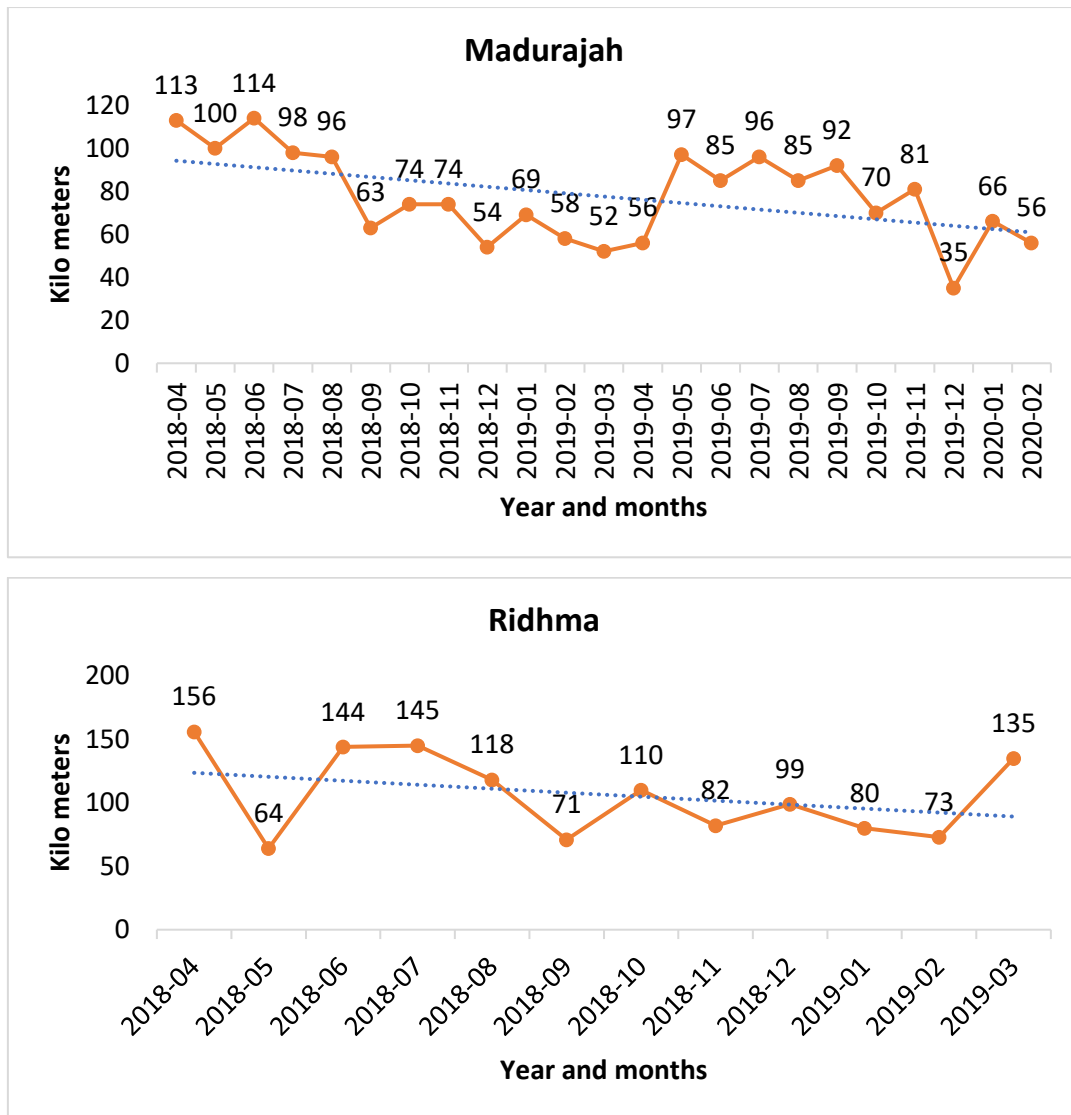


Figure 7.94-7.97 Average Monthly Distance Travelled by GPS-Monitored Released Study Elephants

7.4 Discussion

Telemetry is an invaluable research technique for studying wildlife in their natural habitats. It provides crucial insights into their behavior, dynamics, habitat preferences, home ranges, dispersal patterns, and migration behaviors. Additionally, telemetry helps identify potential threats to the survival of wild animals (White and Garrott, 1990; Cagnacci *et al.*, 2010; Habib *et al.*, 2014). The advent of GPS telemetry has revolutionized researchers' understanding of animal movements in various species. It has played a significant role in studying the movements of whales (Littaye *et al.*, 2004), African and Asian elephants (Galanti *et al.*, 2006; Ngene *et al.*, 2010; Fernando *et al.*, 2018; Bahar, Abu Kasim and Hambali, 2018), turtles (James *et al.*,

2005), and steppe eagles (Meyburg *et al.*, 2003). In this study, the use of GPS collars facilitated data collection, enabling the estimation of home ranges and the calculation of the average distance traveled by the study animals.

7.4.1 Social organization of released elephants

Three species of elephants, namely the Asian elephant (*Elephas maximus*), African savannah elephant (*Loxodonta africana*), and African forest elephant (*L. cyclotis*), exhibit complex social structures based on matrilineal groups. Social bonds within these species are often influenced by kinship, with the strength and quality of relationships being predicted by relatedness (Perry *et al.*, 2008; Pinter-Wollman, Isbell, and Hart, 2009b).

The elephants released from ETH came from different parts of the country, lacking close kinship among them. However, after spending a few years together within ETH, they gradually formed strong social bonds that persisted even after their release into the wild. In natural settings, elephants typically live in core groups that undergo frequent splitting and merging. The core groups that frequently merge are referred to as "bond groups," and when multiple groups share overlapping ranges, they are known as "clans" (Moss and Poole, 1983; Wittemyer *et al.*, 2005).

In this study, two groups of released elephants were observed, consisting of 10 and 9 individuals (Groups 1 and 2, respectively). Initially, both groups functioned as independent core groups. Group 1, released into the UNP, stayed together for nearly a year before splitting into two groups. Two female elephants from this group joined a wild herd, while the remaining eight animals reunited to form a new core group. The nine elephants in Group 2, released into the MNP, also split into two groups four months after release.

Elephants are highly social animals that maintain social relationships within and among family groups in their fission-fusion society (Sukumar, 2003). The composition of elephant groups can change dynamically over short periods, such as hours, days, or seasons (Moss and Poole, 1983; Wittemyer *et al.*, 2005). This flexibility allows individuals to adaptively respond to changes in resources or threats by altering their group size and composition (Archie and Chiyo, 2012). While the released elephants in this study exhibited social behavior similar to their wild counterparts, the impact of their "lack of kinship" is not fully understood. In the wild, relationships between kin are

generally stronger and more beneficial than those among non-kin (Silk, Alberts and Altmann, 2006). Close kinship ties can enhance female fitness as kin are more likely to cooperate in caring for offspring (Rossiter *et al.*, 2002; Archie, Moss and Alberts, 2011). The absence of close kinship among the released elephants may have influenced their social dynamics and cooperative behaviors.

In contrast to females, male elephants undergo dispersal from their natal core group upon reaching maturity and do not permanently join new core groups. Instead, they wander within and outside their natal population in search of mates and form broad social bonds with other males (Chiyo *et al.*, 2011; Lee *et al.*, 2011). When orphaned elephant calves are rehabilitated at ETH, they live together as a single herd consisting of approximately 50 animals at any given time. Initially, it is difficult to distinguish between male and female calves through visual observation alone. However, males often exhibit different behavioral patterns, displaying more aggression. Once males reach the age of 5 years, they typically stay on the periphery of the ETH elephant herd. At this stage, individual males form friendships with some males while displaying aggression towards others.

Observations have revealed that male elephants form "friendships" through engaging in playful fights. Juvenile males use play as a means of establishing relaxed contact with unfamiliar individuals, thereby gathering important physical and behavioral information about potential future friends, associates, and reproductive competitors (Lee and Moss, 2014). When selecting a group of elephants for release after rehabilitation, the ETH management takes into account the social relationships between males. They tend to prioritize the release of males that have demonstrated mutual "friendships" within the herd.

7.4.2 Distance Travel by Released Elephants

Various factors affect the distance and direction of elephant movements, such as geography, hydrology, vegetation cover, land use, nutrient concentrations and the demographics of other elephant groups, humans and livestock (Nellemann *et al.*, 2002; Wall, Douglas-Hamilton and Vollrath, 2006; Marasinghe *et al.*, 2012, Wall *et al.*, 2021). A number of studies have investigated the distance travelled by elephants in the wild and in captivity (Rowell, 2014). However, comparison with published data with regard to distance travelled by elephants is difficult due to differences in sampling,

data collection methods and durations of studies. For example, some have used a grid and camera system (Rowell, 2014), GPS collars (Leighty *et al.*, 2010; Horback *et al.*, 2012), accelerometers (Rothwell *et al.*, 2011) and direct observations (Whilde and Marples, 2012). Studies on African elephants reported daily distance travelled to vary from 1.7 km to 38.0 km (Miller, Chase and Hacker 2016). These studies demonstrate that when resources are plentiful elephants travelled less than 9.8km (Loarie, Van Aarde and Pimm, 2009) per day. Whenever resources are scarce, they travel much longer distances in search of water, at times even up to 38km (Viljoen and Bothma, 1990). A study conducted in Myanmar using GPS data hourly showed average daily distance travelled by elephants in dry season to be 3.9 Km (Chan, 2022) while others say it could be 5–10 Km a day (McKay, 1973; Kurt, 1974; Sukumar, 2003). The recorded mean daily distance travelled by Asian elephants in zoo habitats has also been measured: in Dublin Zoo 9.35 ± 1.57 km/day (Brady, McMahan and Naulty, 2021) and in Melbourne Zoo, Australia 9.05 ± 0.605 km/day (Rowell, 2014). Another study carried out with elephants living in thirty zoos (including 33 African elephants and 23 Asian elephants) found that mean daily walking distance was 5.34 km/day. African elephants walk an average of 5.40 km/day while Asian elephants walk an average of 5.26 km/day (Holdgate, 2015).

In this study, the daily distances traveled by each elephant were determined by summing the straight-line distances (in kilometers) between consecutive GPS locations obtained every four hours between 12:00 and 23:59 (Demma and Mech, 2009). The mean daily average distance traveled by elephants released to the wild in this study varied from 2.55 to 3.50 km/day. Additional unpublished monitoring data from another research program conducted by DWC revealed that the average distance traveled by three collared adult wild females (two individuals in MNP and one in UNP) was 1.07 km per day. The average distance traveled by a male animal translocated from Hambanthota to UNP was 2.98 km. Each collar used in the study recorded data once every 4 hours for GPS/satellite recorders.

The advent of GPS technology in wildlife telemetry has revolutionized the measurement of distance traveled in the field of wildlife science (Wall *et al.*, 2014). However, for accurate calculation of the mean daily distance traveled, GPS data must be collected at the shortest possible time intervals. Measuring the distances traveled by elephants by examining only a few GPS locations per day may underestimate the actual distance traveled over time, as elephants may sometimes travel in reverse

directions towards their original locations, which may not be noticeable. Real-life situations where elephants travel in reverse directions, and thus calculations using 4-hourly generated GPS points underestimating the true distances, have been documented earlier (Holdgate, 2015). In the study by Holdgate (2015), elephants were estimated to walk either 5.7 km/day (recorded at 5-second intervals), 5.2 km/day (recorded at 10-second intervals), or 4.2 km/day (recorded at 30-second intervals). Therefore, changing the sampling interval can result in a change in an elephant's reported distance walked, ranging from a few hundred meters to several kilometers (Holdgate, 2015). Therefore, the average daily distance traveled by elephants released in this study may be an underestimate.

7.4.3 Home Range of Released Elephants

The home range is a defined concept that refers to the extent and location of the area annually covered by a wild animal in its natural habitat (Douglas-Hamilton, 1973). Numerous studies have shown that wild animals tend to avoid certain nearby locations while displaying a preference for specific areas (Revilla and Wiegand, 2008). Elephants, being adaptable to diverse ecosystems, exhibit a wide range of home range sizes. However, the majority of wild elephants in Africa and Asia face challenges stemming from habitat loss, fragmentation, and the growing human populations in their habitats, among other associated factors (Wittemyer *et al.*, 2014; Thouless *et al.*, 2016; Williams *et al.*, 2020; Gobush *et al.*, 2021). The size of an elephant's home range depends on the availability of forage and water and is also influenced by the level of human disturbance (Williams *et al.*, 2020; Wall *et al.*, 2021). Studies focusing on African elephants have reported varying home range sizes, ranging from 15–52 km² in Lake Manyara (Douglas-Hamilton, 1973) to 3059–15,422 km² in the Namibian desert (Viljoen, 1989; Lindeque and Lindeque, 1991).

Male and female Asian elephants exhibit distinct home ranges and display fidelity to their established territories (Fernando *et al.*, 2008; Baskaran, Kanakasabai and Desai, 2018). In South India, the home range size for female clans falls between 550 and 750 km², while in North India, it ranges from 188 to 477 km² for both males and female clans (Baskaran *et al.*, 1995). Female elephants in Borneo have home range sizes ranging from 250 to 600 km² (Alfred *et al.*, 2012). A study conducted at the Yala National Park reported a mean home range size of 115.2 ± 64 km² (Fernando

et al., 2008). Yet another study involving two female elephant groups observed home ranges ranging from 217 to 326 km² (Marasinghe *et al.*, 2015b).

In the current study, the home ranges of elephants in the study area were estimated using the minimum convex polygon method, incorporating 95% of the animal's locations (MacDonald and Amlaner, 1980). The estimated home range sizes of the four GPS-collared elephants (Gagani, Vakarai, Madurajah, and Ridhma) were 190, 150, 90, and 180 km², respectively. These observed home range sizes (ranging from 75 to 250 km²) align with the previously described range for African and Asian elephants. The variation in home range sizes among individuals can be attributed to differences in resource requirements arising from factors such as body size, sex, reproductive status, sociality, as well as environmental factors including rainfall, productivity, and seasonality (Fernando *et al.*, 2008).

The presence of free-ranging elephants outside protected areas poses a significant conservation challenge in both Africa and Asia. A recent study conducted in Africa revealed that only 17% of the potential elephant habitat on the continent is currently utilized by elephants, with a vast majority (85%) of this habitat existing outside of identified protected areas (Wall *et al.*, 2021). Similarly, in Sri Lanka, elephants occupy approximately 59.5% of the country's land area, while human settlements are found within 59.4% of the elephant range. This highlights the immense difficulty of separating humans from elephants in a shared landscape. Moreover, Sri Lanka's elephants have lost around 16.1% of their range since 1960 (Fernando *et al.*, 2021). Consequently, confining rehabilitated elephants within protected areas after their release is not a practical solution. Post-release monitoring data clearly demonstrate the interactions between released elephants and humans, leading to damages for both parties. The fact that two released elephants suffered gunshot injuries and incidents of crop raiding further underscores the severity of this issue.

The UNP and the MNP in Sri Lanka have high elephant densities, with over 100 elephants per 100 km² (De Silva *et al.*, 2011; DWC 2013). Adjacent to these parks are both protected and non-protected areas. Sightings-based demographic models have previously indicated seasonal immigration and emigration of elephants into and out of these two parks. Being water-dependent species, elephants tend to forage near water sources to minimize travel distances for accessing water (De Beer, 2006; Epaphras *et al.*, 2008; Harris *et al.*, 2008b). This behavior is particularly prominent during hot and dry months when heat stress is high due to elevated environmental temperatures

(Coleman, Moore and Wilson 2004; Wakefield, 2006). Both UNP and MNP are situated within Sri Lanka's dry zone and receive similar rainfall patterns. Drinking water sources are abundant in UNP, primarily from three perennial water sources: Udawalawe Reservoir, Mau-ara Reservoir, and Walawe River. Similarly, water is readily available in MNP through Maduruoya Reservoir, Uihitiya Reservoir, and Maduru Oya Stream. Elephants mostly occupy grasslands near these water bodies, which are common in UNP and MNP. It is widely recognized that animal movement across landscapes is not random but rather follows the Optimal Foraging Theory, where animals seek the highest energy gain with the lowest energy cost to maximize their physical fitness (MacArthur and Pianka, 1966).

8.4.5 Survival of released elephants

Success rates of wildlife rehabilitation programs depend on recovery from initial injuries and release back into the wild (Sharp, 1996) long-term survival in the wild with successful reproduction (Morrison *et al.*, 1993). When rehabilitated animals are released to the wild, they are exposed to survival threats just as their wild counterparts. The four deaths recorded in 19 study elephants were due to natural causes (n=2) and anthropogenic causes (n=2). In Sri Lanka, 250 elephants lose their lives annually as a result of human–elephant conflict (Fernando *et al.*, 2011). Since there are around 6000 free ranging elephants in Sri Lanka the estimated mortality rate is 4%. The natural deaths of elephants are poorly recorded since such deaths occur away from human settlements and wildlife tourist areas (DWC, 2013).

Reinforcement, which involves intentionally releasing organisms into existing populations of the same species, is a crucial strategy in the rehabilitation of threatened species (IUCN/SSC, 2013). While the positive results reported in this study indicate the practicality and survival of released animals in the wild, it is important to acknowledge that many rehabilitation programs fail to demonstrate an increase in the actual population size in the wild, thus limiting their contribution to conservation efforts (Zuberogoitia, Torres and Martínez, 2003; Lunney *et al.*, 2004; Naidoo *et al.*, 2011; Thomas *et al.*, 2013). However, this rehabilitation program not only prioritizes individual animal welfare but also makes significant contributions to conservation. The released elephants exhibit notable similarities to their wild counterparts, including comparable survival rates, mortality patterns, movement behaviours, and habitat utilization. They form social groups that undergo dynamic changes, including fusion

and fission, and they even integrate with existing wild herds or groups. Despite occasional incidents of HEC resulting from issues such as malfunctioning electric fences, released elephants do not pose a greater threat to humans compared to wild elephants. They do not display higher rates of crop raiding or aggression towards humans. These findings highlight the peaceful coexistence of released elephants with human communities, reflecting the natural interactions between wild elephants and humans in their respective habitats. The remarkable similarities observed between released and wild elephants underscore the effectiveness of conservation efforts in successfully reintegrating and adapting released elephants to their natural environment.

CHAPTER 8

CONCLUSION AND RECOMMENDATION

Sri Lanka boasts a rich cultural heritage that emphasizes its close relationship with wildlife, evident in the establishment of the ancient 'Mahamegha Vana' wildlife sanctuary dating back to the 3rd century BC. With its status as a global biodiversity hotspot, approximately 29.86% (UNEP-WCMC, 2023) of Sri Lanka's land area is designated as protected. However, the high human population density of 358/km² poses challenges as wildlife and humans interact within shared and overlapping habitats. While many of these interactions have negative consequences for both parties, the rescue and release of rehabilitated injured or sick animals is a common practice in Sri Lanka. Elephants hold significant cultural and religious importance in Sri Lanka, particularly within Buddhism and Hinduism. As a result, the general public and wildlife authorities actively intervene to assist wild animals in need. This study evaluated the orphan wild elephant calf rehabilitation program of the ETH, documenting its successes while highlighting areas requiring improvement in current management practices.

In contrast to many wildlife rehabilitation facilities worldwide, euthanasia is not widely practiced in Sri Lanka due to cultural and religious values. Instead, considerable efforts are made to ensure the survival and quality of life for animals with limited chances of recovery. This is exemplified in the rehabilitation of wild elephant calves, where the initial mortality rate at the ETH is 41%. These rescued elephants face slim chances of survival upon admission to the facility. However, after the initial health stabilization phase, the mortality rate decreases to 5.5% during the rehabilitation process. This remarkable outcome can be attributed to the ETH's management practices, which prioritize the emotional and physical well-being of the calves within a natural setting.

Although the mortality rate is low during the rehabilitation phase at the ETH, elephant calves still face various health hazards, both physical and psychological. While management decisions are often based on a combination of experiences and scientific evidence, it is essential for the ETH to adopt science-based protocols for elephant husbandry, nutritional management, prevention and treatment procedures.

However, limited infrastructure facilities, research programs, and training opportunities hinder the implementation of evidence-based practices. Therefore, further research is necessary to enhance the health, welfare, nutrition, and behavior of elephant calves. Additionally, research on husbandry practices to reduce, monitor, and control emerging and zoonotic diseases, antimicrobial resistance, and the impact of parasites on elephant calves, both at the ETH and in the wild, is needed.

The growth rate of elephant calves at the ETH is lower compared to captive elephants. Increasing their growth rate can be achieved through providing more food. However, nutritional management should consider not only growth but also the expected outcomes of the rehabilitation program. This study found that the body condition scores of infants and calves elephant at the ETH are lower compared to wild elephant calves nursed by their mothers. However, as the calves age at the ETH, the average body condition scores of juvenile elephants, both at the ETH and in the wild, become comparable. This indicates that the rehabilitation program successfully prepares the calves for their release into the wild, where they can thrive similarly to their wild counterparts. Nevertheless, the body condition scores of all groups of calves remain lower compared to captive elephants in zoos with higher nutritional support. This suggests a common problem of food shortage for elephants at the ETH and in the wild. While good physical conditioning is essential for the long-term health, reproductive success, and survival of elephants, the effects of overnutrition during the calf stage require further research. Studies are needed to determine the optimal growth rate and nutritional support for rehabilitating elephants. If additional support for growth performance is necessary, it should be provided within the natural setting, prioritizing habitat enrichment.

Survival and reproduction are crucial indicators of the success of the ETH's elephant rehabilitation program. While released elephants may experience mortalities due to both health and anthropogenic hazards, the proportion remains within the range of experiences observed in wild elephant populations. Globally, populations of both free-ranging and captive Asian elephants are declining, emphasizing the need for captive breeding programs and the restocking of wild populations. The rehabilitation of orphan elephants plays a significant role in conservation efforts as these elephants represent threatened and endangered species at risk of extinction.

Recommendations for elephant rehabilitation:

1. This study demonstrates that the welfare status of elephants undergoing rehabilitation and those released is satisfactory compared to their wild counterparts. The involvement of local communities who share space with elephants is fundamental to the success of rehabilitation programs. Promoting the benefits of the tourism industry, which supports local and national economies, as well as upholding the ethical and cultural values of the country, should be emphasized. Education and public awareness programs should be planned in conjunction with the establishment of rehabilitation facilities.
2. The rehabilitation program should prioritize the health and welfare of the animals throughout the entire process, from rescue to release and beyond. It is essential to follow evidence-based species handling techniques and rehabilitation protocols, if available. Strict adherence to these protocols is crucial for ensuring the highest quality of animal management and care.
3. Rehabilitation programs are often costly. Therefore, understanding the costs involved is fundamental to ensure a safe and successful outcome based on welfare-focused rehabilitation models.
4. The ETH, with its significant collection of semi-captive Asian elephant calves originating from the wild, holds invaluable potential for conducting research on nutrition, health, and behavior. These researches are essential for Asian elephant conservation, both in situ and ex situ, on a global scale.
5. The ETH should further develop as a conservation education center for Asian elephants. This could involve conducting internship and training programs for local and foreign students, conservationists, and elephant enthusiasts.

Sri Lanka is home to the highest concentration of wild Asian elephants among all countries where these majestic creatures are found. Currently, restocking the wild elephant population with rehabilitated elephants and their offspring holds limited conservation value in Sri Lanka. However, considering the alarming rates of elephant deaths, habitat fragmentation, and the use of electric fences and other barriers that confine elephants, coupled with inadequate surveillance and reporting of emerging diseases, the potential for a catastrophic situation is imminent. In light of this, the valuable experiences gained from the compassionate rehabilitation program at the ETH can serve as a guiding framework for establishing similar rehabilitation models in the face of future catastrophes, both within Sri Lanka and globally. By implementing

the recommended strategies, Sri Lanka can bolster its wildlife rehabilitation efforts, make substantial contributions to the conservation of endangered species, and serve as an exemplary model of compassionate rehabilitation practices. The ETH's rehabilitation program has achieved remarkable outcomes, and the wealth of knowledge accumulated through this program will play a pivotal role in equipping stakeholders to effectively address future challenges in wildlife conservation, both at the local and international levels.

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Appendix A. Figures 1 and 2- Rescue and Health Stabilization Phase



Figure 1: Orphan elephant calves found in the wild and rescued by wildlife officers or villagers, subsequently transported to the Elephant Transit Home.



Figure 2: Orphan calves receive veterinary care and appropriate nutrition during the health stabilization phase.

Appendix B. Figures 3 and 4- Rehabilitation and release into the wild



Figure 3: During the rehabilitation phase, calves live in a herd, have access to various habitats, interact with wild elephants and other wildlife, and voluntarily come for regular milk feeding.



Figure 4: Loading of elephants onto the lorry and transportation to the destination during the hard release process. The released elephants gradually acclimate, evolving into matriarchs and dominant bulls over time.