A study on elephant and human interactions in Kodagu, South India

Malavika Hosahally Narayana

A thesis submitted for the degree of Doctor of Philosophy

School of Natural Sciences, Psychology

University of Stirling

March 2015

Declaration

I declare that the work undertaken and reported within this thesis is my own and has not been submitted in consideration of any other degree or award.

Malavika Hosahally Narayana

21st March, 2015

Abstract

Increasing human populations have resulted in the extensive conversion of natural forests and rangelands into agricultural lands, resulting in an expansion of the interface between people and elephants across the elephant range countries of Asia and Africa. This interface describes the nature of two-way interactions between people and elephants, which can be positive and reverential or hostile and negative. Elephant crop-raiding, one of the most negative interactions for people at the interface, is not only the result of decreased food resources and space, but has also been attributed to a preference for cultivated crops and to damage caused during elephant movements between habitats. The aim of this thesis was an attempt to understand the use of coffee agroforestry areas by elephant populations in a South Indian district, Kodagu, and to assess the risks to elephants and people of coffee plantations. Geographically, located at a significant position in the Western Ghats, Kodagu district is a part of one of the largest wild Asian elephant ranges harbouring India's largest elephant population. Kodagu has a unique topography and coffee agroforestry system in considered as the boon for conservation. This thesis is the first long term (one year) study on the elephant populations using coffee estates in Kodagu.

Crop-raiding events across Kodagu and their intensity of occurrence were determined from the Forest Department compensation records. Virjapet *taluk* was one of the three administrative units of Kodagu with frequent incidences of crop-raiding, including elephant mortality and human deaths. High rates of crop-damage in Virajpet included both coffee and paddy rice produce as the land is conducive for the cultivation of both. To understand the use of coffee estates by elephants, coffee estates in Virjapet were directly and indirectly monitored for the presence of elephants using dung sampling (N=202), camera trapping, video and photo documentation, as well as sightings

(N=408) and reports by local workers, in order to identify the individuals or groups of elephants frequenting these coffee estates. Lone male and all male groups used coffee estates most frequently and family herds ranging in group size from 2 to 10 were present mainly during the peak season of coffee ripening (post monsoon). Presence of large numbers of elephants, especially with large female groups, was associated with crop-damage during the months of December-January. As seasonal movements of elephants in Kodagu districts are still not known, it is unclear why the number of elephants in coffee estates post-monsoon increases when food availability should also be higher in forests. These large coffee estates were used as refuge areas by elephants during the day by all individuals and groups, and feeding on estates occurred during the night to early morning hours. Dung analysis and observations suggested that coffee estates were attractive for elephants due to the constant availability of water (for irrigation), green fodder, and cultivated fruit trees, especially jackfruit. Coffee plants were damaged both due to consumption (47% of dung samples in this study) and accidental damage during elephant movements within the estates. Although the dung sampling could not confirm whether coffee had become a novel food resource, the presence of large number of elephants during the coffee ripening season suggested that the potential for coffee berries to be added regularly to the diet in the future, with potential consequences for coffee invasion of native forests through dung seed dispersal.

People working on large coffee estates were accustomed to the presence of elephants and were generally knowledgeable of the areas that elephants frequented, thus avoiding fatal encounters. However, safety of farmers and other people working on the estates remains a major concern, especially for large coffee estates owners. The constant interaction between elephants and people also led to more negative perceptions of

elephants, and reduced the tolerance of elephants in the area. The unique topography of Kodagu as a mosaic of forests and farms challenges the number of possible mitigation methods to prevent negative encounters between people and elephant. The elephants of Kodagu may have adapted behaviourally to the presence of people, but long-term monitoring of the elephant population is important to understand their ecological and social adaptations to the various costs and benefits of using this agroforestry landscape. Suggestions for management of the elephant-human interface and mitigation of negative attitudes and actions were made, through a model that incorporates a multiple stakeholder (including elephants) action plan.

Acknowledgements

'Greeting Rumbles' to the most beautiful elephants of Kodagu, for tolerating us and without whom, this work would never be possible.

I would like to thank my supervisor Professor Phyllis C. Lee, for all the inspiration and advices that she provided throughout this journey. Her patience, persuasiveness and belief in me are the reasons that I started this whole thesis. I would also like to thank Dr. Sarah-Jane Vick, for all her encouragement and suggestions. Thank you to both for listening and tolerating all my meaningless rambles whenever we met.

I would like to thank my dad and mom for encouraging and supporting my decisions to pursue my interests. Thank you for always being there with me and believing in me. I would like to thank my husband Anand for his patience and taking in all my frustrations.

I take this opportunity to thank Dr. Mewa Singh at Mysore University for his constant support and advice during my field work especially in sorting out the permissions and logistics. I am very grateful to Dr. André Pittet (Center for Electronics Design and Technology, Bangalore) for providing me with the camera trap units as a student loan and Mr. Srinivas for the technical support throughout the study. I would also like to thank Dr. Veeramani (Periyar Foundation) for providing me the design of metal cages for the protection of the camera trap units in the field.And I would also like to thank Dr. Raghavendra S Gowda for helping me with detailed information about the landscape of Kodagu. I am grateful to the Karnataka Forest Department for granting me the permission to conduct my research work in Kodagu and to TATA Coffee Limited for allowing me to work on their estates. I would like to thank my research assistants

Sharath and Prathap for putting up with my moods and the days when they had to work hours without food. I am grateful to Mr. Rajeev for providing me research station at Yemmegoondi estate premises which helped me immensely in making the field sites easily accessible. The staffs of Yemmegoondi division has been exceptional in providing us accurate information on elephants, whether on their estate or others and also to the canteen personnel for the delicious food served every day. Particular thanks are owed to Mr. Ramaiah and Mr. Karyappa for providing information on elephant's presence throughout this study. I would also like to acknowledge all the managers and office personnel of the various estates, forest officers and office staff, estate workers, estate guards for helping me in whatever way they could.

I would also like to thank the Psychology Department and people from the Behaviour and Evolution Group at the University of Stirling, for their advice and support: Vicki for her suggestions during the initial stage of this thesis and Michelle for her help in statistics. And, to Malida for being a great companion and friend through these four years.

This study was supported by the Ruffords Small Grants for part of my fieldwork and Scottish Overseas Research Student Award scheme for part of my tuition fees. And a big Thank you and gratitude to my main financial sponsor, my dad.

Table of Contents

Chapter 1

ELEPHANTS, COFFEE PLANTATIONS AND INTERACTIONS WITH PEOPLE

CHAPTER 1: ELEPHANTS, COFFEE PLANTATIONS AND INTERACTIONS WITH PEOPLE

People have always interacted with other species in their environment. Hunter-gatherers are dependent on the natural ecosystems for food and other resources, and hunting does not necessarily imply intolerance towards wildlife. People have also been able to gain access to certain food resources from cues of animal movement and behaviours. For example, in Africa, the greater honeyguide (*Indicator indicator*) bird is known to guide the honey gatherers (nomadic Boran people) to the location of bee colonies (Isack & Reyer, 1989). A system of mutual benefits for both people and birds seems to have been established since in return, when the honey gatherers collect honey, they leave pieces of honeycomb for the bird to feed on the larvae and wax.

However, with increasing human population, industrialisation, intensification of agricultural practices and in the context of assigning an economic value to natural resources, people's perceptions of wildlife have changed dramatically. Now positive interactions with wildlife are mostly those where people intentionally chose to interact for recreational activities such as tourist viewing or safaris. Aside from people who choose to interact with wildlife, certain potential negative levels of interaction are inevitable (Madhusudan, 2003), especially in those areas in close proximity to forests or other reserves for wildlife, or with degradation and loss of habitat due to agricultural intensification, livestock grazing and other human subsistence activities. Wildlife populations confined within limited spaces left after human co-option of land or seas are raising the levels of co-occurrence and potential for "conflicts of interest" for sustaining both wildlife and people in these areas (Goswami *et al*., 2014).

Human-wildlife interactions throughout the world share similar causes and consequences. Bell (1984) has described human-animal interaction as 'a rolling stone of attrition" whereby the use of wildlife has been immense but largely coincided with their elimination. However, it is important to distinguish between the impact of human-wildlife interactions (Woodroffe *et al*., 2005) that focusses on the impact of wildlife on humans and their activities, and the consequences of underlying human-human interactions (Young *et al*., 2010) that addresses the differences between the pro-wildlife positions and those supporting other positions. The re-evaluation of human-wildlife interactions (Yamakoshi, 2005) and a more comprehensive understanding of specific causes and effects of these interactions, depending on factors like ecological, cultural, socio-economic and political contexts, are crucial for resolving any negative situations arising. Creating the capacity for human co-existence with wildlife (Naughton-Treves *et al*., 2006; Lee, 2010) as a tool for conservation management of threatened species is the key to being able to both protect these species and also to protect and sustain livelihoods of people. Hence, this thesis aims to examine which human and which elephant factors could potentially contribute to a greater capacity to share space between the endangered Asian elephant and people in the region of Kodagu, South India.

1.1 Human-Wildlife Interactions

In 2003, the World Park Congress defined human-wildlife interfaces as contexts "*when wildlife's requirements overlap with those of human populations, creating costs*[1] *to residents and wild animals*" (World Conservation Union). Negative impacts as a consequence of increased interfaces between people and wildlife have led to 'conflict of

[1] Costs in terms of loss of crop, properties, and injury and loss of life to both parties; psychological effects and behavioural changes

interests' between them. Human-wildlife conflict is defined as 'when an action by either humans or wildlife has an adverse effect on the other' (Conover, 2002).

For a balanced view of understanding human-wildlife interactions (See Section 1.1), it is important to differentiate between human-wildlife co-existence (Conover, 2002; Graham *et al*., 2005), human-wildlife competition (Matthiopolus *et al*., 2008), and/or human-human conflict (Marshall *et al*., 2007). Most human-wildlife interaction studies are known to predominantly address food resources and people's safety, especially in developing countries. While in developed countries, economic conflicts of interest between interested (human) parties tend to be the more common social context of human-wildlife interaction (For example, debates over carnivore reintroductions; Suryawanshi *et al*., 2013).

When wildlife causes serious damage to livelihoods and risks to their lives, people gradually become intolerant and take extreme methods for their protection. For example, farmers suffer loss to their agricultural crops and injuries or death to live stock which forms an important part of their livelihood. Both wild animals and the farmers risk injuries or death due to hostile interactions. This may lead to retaliatory killings of wildlife and no tolerance for wildlife's conservation. Thus, the most significant threat to conservative initiatives is negative encounters resulting from human-wildlife interactions (Madhusudan, 2003; Osborn & Hill, 2005).

1.1.1 The term 'conflict' when referring human-wildlife interactions

This section gives a brief summary of my rationale for not using the term 'conflict' when referring to human-animal interactions throughout this thesis.

Human society is characterised by conflict (Ramsbotham *et al*., 2011). As social beings, we sometimes compete with each other for resources like food, space, water, power, etc. and in human societies this can lead to conflicts for social, economic and political power over others. Of course not all human societies are engaged in competitive struggles within or between groups. However, the paradigm of competition derived from a context of control over scarce resources has become almost ubiquitous in its application to human-wildlife interactions.

Conflicts between people and wildlife are often described as the situation where there is an overlap of resource use by both parties (Conover, 2002; Graham *et al*., 2005). Various terminologies have been used to describe the interface between people and wildlife, such as, interaction, relationship, association, co-existence, co-occurrence and co-operation. However, when the focus is on the impact and consequences of such interactions for humans and wildlife alike, terms such as competition, conflict or conflict of interests, encounters, confrontations, struggle etc. are used to describe the events. These terms merely describe the 'act' and not the impacts of human-wildlife interaction. It is also important to note that such reports on the human-wildlife interface are not limited to human-animal interaction but also to the underlying human-human and animal-animal dimensions. Young *et al*. (2010) suggest that human-wildlife 'conflicts' should be categorised into two components, (a) human-wildlife interactions that focus on the impacts of wildlife on people and their activities and (b) the underlying human-human dimensions that involve different stakeholders who are either for or against wildlife conservation. For the management of the impacts resulting at human-wildlife interfaces and for the effective implementation of solutions for conservation, an interdisciplinary approach is needed. This approach enables consideration of people's socio-economic and cultural contexts and also the psychological reaction of people towards wildlife (Marshall *et al*., 2007; Young *et al*., 2010). Furthermore it provides involvement of stakeholders in policy and decision making (Marshall *et al*., 2007; Redpath *et al*., 2014).

Activities and policies to promote the conservation of wildlife are generally considered to be in 'conflict' with other human activities, for example agricultural intensification, infrastructure development, etc. And thus, a biodiversity conflict is defined as:

'*situations in which the interests of two or more parties towards the goods and services provided by a wildlife-related resource differ, and when at least one of the parties is perceived to assert its interests at the expense of another party's interests*' (pp 3130, Marshall *et al*., 2007).

Conflict is not that which arises directly out of competition for limited resources (Peterson *et al*., 2002); rather a conflict in this context represents the (human) parties' perception of the situation and mainly their differing goals, value and interpretation of such situations (Yasmi *et al*., 2006). In similar terms, Redpath *et al*. (2013) suggested that it is more apt to consider 'conflict of interests' between human-human actors rather than those of human-wildlife actors. Conservation conflict is thus defined as:

'*situations that arise when two or more parties have strongly held views (over biodiversity objectives) and one of those parties is attempting to assert its interest at the expense of the other'* (pp 2, Redpath *et al*., 2014; See also Bennett *et al*., 2001; Marshall *et al*., 2007; White *et al*., 2009; Young *et al*., 2010; Redpath *et al*., 2013).

In other words, human-wildlife interactions may have resulted in different 'conflict of interests' between different sections or groups of the society. They suggest that with this definition, the ‘conservation conflict’ occurs primarily between people and their perception and opinion of these situations. It is important to understand the changing human social contexts for ‘conflicts’ between wildlife and welfare of people as these social contexts are central to the conservation of biodiversity (Czech *et al*., 1998; Chan *et al*., 2007; Peterson *et al*., 2008; 2010).

Human-wildlife interaction studies tend to focus on issues relating to food resources or other resources or property that have value in people’s views. Animals causing damage to what people value are often termed ‘conflicts’ establishing the anthropomorphic view that animals have ‘human’ consciousness, interests and intent to deliberately cause damage to people, thus representing them as human antagonists (Peterson *et al*., 2010). It is perhaps possible to reduce the negative impacts of human-wildlife interactions, but differences between stakeholder requirements can also hinder the resolution of human-human conflict (Redpath *et al*., 2013). It has also been suggested that the specific language used and rhetorical framing when referring to human-wildlife interactions enables the identification and cooperation mostly among the different human stakeholders involved (Peterson *et al*., 2010). They argued that language, especially words with negative connotations, may perpetuate the problem, reducing the options for solutions to the problem and for their effective implementation.

Use of the term ‘conflict’ in relation to human-animal interactions has negative connotations, and changes the perception of such interactions into one of deliberate antagonism and thus these interactions can become associated with negative experiences and attitudes. Such anthropomorphic and anthropocentric terms may not necessarily address important factors influencing the events or the consequences of interactions. Frequent use of the term ‘conflict’ to refer to any contacts between wildlife and humans and with human-related resources has resulted in people perceiving any reference to human-wildlife interactions as negative and provoking hostility towards the situation (Lee, 2004). Such negative perceptions and attitudes derived from specific interactions may prove to be detrimental to wildlife conservation more generally. Siex and Struhsaker (1999) suggested that it is important not to assume that when a wild species crosses into agricultural land it has come to raid crops or that when they are just passing through a cultivated area along an habitual movement path that does not necessarily result in conflict. It is important to recognise that damage to crops is not always deliberate and perceiving damage as intentional results in more negative perceptions of the situation, as may be the case for example with elephants breaking fences to gain access to water, food or movement routes. Thus, human-wildlife 'conflict' and its various definitions may suggest that wildlife is involved as a conscious human antagonist (Peterson *et al.*, 2010; Redpath *et al.*, 2013). Alternatively, they suggest that human and wildlife interactions can be explained in terms of human and wildlife co-existing and competing for limited resources available, rather than two parties who are engaged in a deliberate 'goal-seeking capacity' at the expense of the other's welfare.

My deliberation on the use of the term 'conflict' is that it is not necessarily appropriate when describing human-wildlife interactions or human-elephant conflict specifically, as it does not represent an equal or balanced view of the interests of both parties involved. The terminology 'human-wildlife impacts' (Redpath *et al.*, 2013) represents both positive and undesirable consequences of human-wildlife interaction. Although terms such as 'interaction', 'interface', 'encounters', 'competition', 'co-occurrence' still do not always adequately describe the nature or extent of human-wildlife relationships, they are more neutral in tone and have fewer negative connotations. Again, although the term ‘competition’ has certain negative connotations attached to it (for example, an act of contesting with another individual, see Chapter 8), it does at least modestly describe the ‘tangible’ effects of human-animal interactions. However, it is important to note that the term ‘competition’ does not include the behavioral modifications of both people and animals, especially the evolving perceptions and attitudes of people towards animals which are central to conservation. Throughout the thesis, I have tried to maintain a neutral tone by using terms like ‘interactions’, events, interfaces, etc.

1.1.2 Human Population

Increased human population, forest degradation and fragmentation, low resource availability and behavioural changes among many species have resulted in increased direct contact and competition between human and non-human species. An increasing human population and their activities will influence the long-term viability of elephant populations and their distributions, especially outside protected areas (Buij *et al*., 2007). The intensity of interactions is known to be high in areas with high human population co-existing with wildlife (Ogada *et al*., 2003). For example, the largest buffer zone of Tsavo National Park in Kenya supports about 250,000 people and similar situations are found in India where 69% of the nature reserves support more than 3 million people (Patterson *et al*., 2004).

Significant proportions of human population across the world are dependent on land for their livelihoods. Growing human population has become a primary cause for the encroachment of remaining ‘protected’ areas of wildlife worldwide. This has resulted in very few places remaining with no or low human interference. There is an increasing demand for agricultural land areas, which has resulted in cultivating lands in close proximity to the forest boundaries and thus, leading to slow shrinking of forest areas; as a result the geographical ranges of many species are also diminishing.

1.1.3 Loss of Natural Habitat

With the growing human population, there will be more habitat loss and an increased human-elephant interface in the future (Hoare & du Toit, 1999; Hedges & Gunaryadi, 2010). Increasing forest degradation and fragmentation and land cultivation have resulted in higher levels of direct contact and competition between human and non-human species (Lee & Moss, 1986). Anthropogenic activities like deforestation for agricultural lands, logging and other infrastructure and development activities have also resulted in extensive fragmentation of tropical rainforests leading to massive loss of biodiversity (Laurance & Bierregard, 1997; Benitez-Malvido & Martinez-Ramos, 2003).

Recently, natural habitats have been transformed and modified into agroforestry systems (see Appendix 1 for definition) causing an increase in the overlap of resources used by people and wildlife (Hill, 2002; Naughton-Treves, 1997). Shrinking natural habitats have curtailed the movement of wildlife confining them to the degraded and fragmented forests engulfed within human settlements. Loss of natural habitat results in reduced availability of space and resources and increased competition among wildlife for resources, forcing them to venture out of their limited natural habitats. Agricultural lands in close proximity to the forests are thus often more affected more by wildlife crop-raiding.

When animals raid crops, each species poses different types of problems to the farmers. It is not just the threats or risks from each species involved, but also what crop was destroyed, which part of the plant or at what stage of crop maturity that they being destroyed (Webber *et al*., 2011). Hill (2005) suggests that these various outcomes are related to species' dietary preferences, body size, dexterity and food processing capabilities. Also, the species-typical social structure and grouping patterns, activity patterns, and ranging behaviours may all influence the type of crop damage, especially daily and seasonal patterns of crop damage. All these animal-specific variables can have a significant impact on the implementation and success of the farmers' coping strategies (Sukumar, 1990).

Losses incurred by farmers due to crop damage are especially high in developing countries and these are rarely compensated for either financially or in terms of subsistence losses (Sekhar, 1998; Rao *et al*., 2002; cf. Linkie *et al*., 2007). The laws protecting endangered species and their ecosystem have only a very small effect when such losses are incurred. The problem animals are in danger of being killed illegally[2] by people who have incurred heavy losses to their livelihood and danger to their lives, or legally by wildlife authorities as lethal control due to the political pressures on these authorities to manage crop losses. Individual farmers have different capacities to cope with such losses and usually it is the small and subsistence farmers who are the least tolerant[3] (Naughton-Treves, 1997).

Most crop-raiding or damage to property arises beyond protected area boundaries, in surrounding agricultural lands and human settlement areas. Spatial segregation between wildlife and human settlement areas has been designed and implemented across heterogeneous landscapes, with the intention of providing refuge areas for wildlife

[2] Most endangered wildlife species is protected by the law and deliberate killing (for trade and/or retaliatory purposes) is illegal.
[3] Tolerant towards wildlife damages to crop, property loss and threat to human life

away from human activities and threats (Margules & Pressey, 2000; Hansen & DeFries, 2007). However, protected areas with no human presence are very few across the globe and also are limited in size (Woodroffe & Ginsberg, 1998). The persistent use of protected areas by people and wildlife use of human-dominated landscapes (Saunders *et al*., 1991; Ricketts, 2001) has created a continued and increasing interaction between them.

Few protected areas are free from human activities, as there are many reserves where humans hunt or extract resources within protected areas. For instance, in the Reserve Forests of Kodagu (Southern India), both intensive cattle grazing and collection of fuel woods are still taking place and although these activities are illegal, farmers with low economic status are forced to resort to such actions (personal observation). This creates competition for resources between wild animals and livestock. There is also the possibility of livestock spreading diseases to other wild animals that may be detrimental for the survival of the local populations of wildlife. Keeping animals within protected area boundaries has been shown to be ineffective in that fencing or hard boundaries (for example stone walls) produce their own significant impacts on ecosystems and the species within them (Fernando *et al*., 2008a; Ekanayaka *et al*., 2011; Wilson *et al*., 2013). The quality of the area of co-occurrences is of greater importance than the size of the area in relation to the inviolate protected areas (Goswami *et al*., 2014).

Negative encounters with wildlife may also have a profound impact on the entire ecosystem which goes beyond the extinction of local population of an individual species. For example, the extirpation of grey wolves and grizzly bear from the northern Rocky Mountains has had a great impact on the ungulate density (for example, increasing the number of moose) and in turn this has impacted on the habitat suitability for Neotropical migrant birds (Berger *et al*., 2001). Thus, exterminating the carnivore populations has resulted in structural modification of the vegetation and changed the riparian habitat availability. However, it can be difficult to isolate effects of species extinction from other environmental factors such as fire or climate change, etc.

1.2 Elephants and People

About 60 million years ago (Mya), elephants originated in Africa and then spread across the continents, except Australia, and diversified (Shoshani, 1998). Currently, there are only two extant species of elephants, African (*Loxodonta africana*) and Asian (*Elephas maximus*). African elephants have two sub-species, African savannah elephants (*Loxodonta africana africana*) and African forest elephants (*Loxodonta africana cyclotis*) and there are four sub-species of Asian elephants - mainland elephants (commonly referred to as Indian elephants; *Elephas maximus indicus*), Sri Lankan elephants (*Elephas maximus maximus)*, Borneo elephants (*Elephas maximus borneensis*) and Sumatran elephants (*Elephas maximus sumatranus*). Ecologically African forest elephants are considered to be more similar to the Asian elephants than they are to the African savannah elephants (Blake & Hedges, 2004).

Elephant habitats cover many different environmental conditions, i.e. they inhabit six to nine of the fourteen major terrestrial habitats (Biomes) on Earth (Olson *et al*., 2001). The wide array of habitats of elephants has resulted in elephant populations having different diet compositions, movement patterns and social behaviour (Campos-Arceiz & Blake, 2011). Historically, Asian elephants ranged from West Asia, the Indian sub-continent, to Southeast Asia which included Sumatra, Java, Borneo and China as far as Yangtze River (Sukumar, 2003; See Figure 1.3). Over the years, elephant ranges throughout the world have now reduced to a fraction of their earlier distribution and remaining habitats are fragmented due to extensive human pressure (Nath & Sukumar, 1998). Asian elephants occur mostly in the tropical moist and tropical dry broadleaf forests. Currently, Asian elephants range in only 13 countries over 0.5 million km^2 with a population of about 25,000 to 45,000 (Blake & Hedges, 2004; Sukumar, 2003; Choudhury *et al*., 2008).

The Asian elephant (*Elephas maximus*) is considered to be the flagship species for conservation in its range countries. Their ecological vulnerability and the high market value for ivory have placed them on the list of 'Endangered' species in International Union for Conservation of Nature (IUCN) Red List and on Appendix I of the Convention on International Trade in Endangered Species of Wildlife Fauna and Flora (CITES).

1.2.1 Human-Elephant Interactions

The IUCN/SSC African Elephant Specialist Group (AfESG) has broadly defined 'human-elephant conflict' *as "any human-elephant interactions which results in negative effects on human, social, economic or cultural life, on elephant conservation or on the environment*" (pg 1; Hoare, 2001a). It is also defined as negative interactions such as crop-raiding by elephants, human injuries and deaths caused by elephants and killing of elephants for reasons other than ivory extraction (Nath & Sukumar, 1998). It is important to recognise that both these definitions represent the views on socio-economic and cultural values. People's perception and interpretation of their interactions with elephants shapes their attitudes and values of wildlife conservation. How people want elephants to behave in their environment, where and when elephants move, and what resources are made available for elephants to feed on, is dependent on how much people are willing to share their space and co-exist with elephants.

The reduction in areas of natural habitat is associated with increased human-elephant interactions and possibly with the rise in direct human-elephant encounters (Nelson *et al.*, 2003). Such encounters have led to fear among people (Naughton *et al.*, 1999) decreasing their appreciation of wildlife and animosity towards wildlife and its conservation efforts (De Boer & Baquete, 1998; Nhyus *et al.*, 2000). Most of the 37 elephant ranges in Africa and all the 13 elephant ranges in Asia have reported damage to property or livelihoods as a result of interactions between elephants and people (Hoare, 2000). In China, even with a tiny elephant population of only a few hundred, high damage to crops due to drastic changes in the habitat and illegal ivory poaching of elephants is reported (Zhang & Wang, 2003). With the demand for ivory rising, elephant populations, especially African elephants, are dwindling in numbers (Wasser *et al.*, 2010). Whereas, Asian elephants' survival is more threatened by human population expansion causing extensive habitat loss and fragmentation (Linkie *et al.*, 2007).

1.2.2 Human-dominated landscapes

Conversion of forested lands into agricultural areas has resulted in significant decreases in elephant habitat (Blair *et al.*, 1979). In countries like Malaysia and Indonesia, large areas of forest continue to be cleared for commercial plantations like oil palm or for resettlement of migrants. In India, the reasons for elephant habitat loss varies between regions; in north-eastern India, shifting cultivation as practiced intensely in recent years has led to rapid clearing of forests, whereas in south and north-west India infrastructure development activities like construction of roads, canals, railways, etc. and also agriculture expansion are the causes of habitat loss.

Increase in human population has resulted in human expansion into elephant habitats (Hoare & Du Toit, 1999; Hoare, 2000) which has resulted in elephants exploring and expanding into ranging areas well beyond protected areas (Walpole *et al*., 2004). In agricultural environments, it is difficult for elephant and humans to co-exist because the elephants feed and trample on agricultural produce, damage water sources or alter soil substrates. There is thus almost no area where elephants can now exist in harmony[4] with small scale agriculturalists, although they may be tolerated by larger landowners (Kulkarni *et al*., 2007; Bal *et al*., 2011; Personal communication with local farmers). This is probably because the cost of the damage has less impact for large scale farm/estate owners. With pastoralists, competition may be limited to localized areas such as waterholes and during dry periods and thus co-existence is easier to achieve although there may be some competition for grazing resources (e.g. Amboseli elephants and traditional Maasai pastoralists) that can result in a lack of tolerance between elephants people (Kangwana, 2011; Browne-Nuñez, 2011). Overall, with the intensification of agricultural practices and rising socio-economic status, the effects of animals using human-dominated lands have been perceived negatively by people, resulting in less tolerance towards the animals in recent years.

Globally, the greatest threat and challenge for the mutual well-being of humans and wildlife is in the areas of co-occurrence because of conflict of interests between them (Naughton-Treves, 1998; Woodroffe *et al*., 2005; Karanth *et al*., 2013). In particular, these conflicts of interest are more evident in relation to the large bodied mammals which require larger home ranges (Karanth & Sunquist, 2000; Fernando *et al.,* 2008b) and greater resources. Moreover, the shrinking of protected areas and other forest areas

[4] Without any (or negligible) negative impacts of people and elephant interactions like crop and property loss and with zero deaths or injuries to both (although unavoidable incidence of accidental encounters may occur).

has forced wildlife to 'compete' more with people for space and resources. Over the years, the process of landscape changes, including habitat degradation and fragmentation has resulted in a gradual increase in wildlife use of human-dominated landscapes and thus exacerbated crop-raiding problems (Mahanty, 2003). Initially, these interactions were considered as a two-sided equation of both parties incurring mutual costs and benefits, but now they have led to intolerance and the exclusion of elephants (Parker & Graham, 1989; Hoare & Du Toit, 1999).

Large mammal species like elephants, leopards, etc., are generally thought to 'adapt' to human-dominated landscapes and may even be present at higher densities in the areas of co-occurrence, especially when these areas are in close proximity to the natural forests (Athreya *et al*., 2013). Their increased presence within these boundary areas has created more frequent interactions with people in competition for space and resources. The consequences of such interactions can be human-induced mortality of wildlife which may lead to areas of co-occurrence becoming population sinks (Woodroffe & Ginsberg, 1998; Balme *et al*., 2010; Newby *et al*., 2013) rather than acting as 'proxy' habitat to natural forests (Goswami *et al*., 2014). Although creating space for wildlife outside the protected areas may provide increased resources (Bali *et al*., 2007), there are serious ethical, legal and political concerns of human displacement[5], and perhaps a limited likelihood of sustained success of such a strategy.

[5] Displacement of people from existing protected areas/and or to create new protected areas and their effective implementation are yet to be fully measured through long-term monitoring, for instance, the successful resettlements of displaced people in their new environment or do new people acquire the now vacated land or will the forest regenerates for wildlife use. In India, on-going work on creating elephant corridors is being carried out in collaboration with non-government NGOs like World Land Trust. They have now established two corridors Siju-Rewak Corridor in Meghalaya and Tirunellu-Kudrakote Corridor in Kerala.

1.2.3 Elephants as crop-raiders

Crop-raiding by elephants is not a new phenomenon and has been reported from Asia and Africa for millennia (Osborn, 1998). Asian elephants have been known to raid crops ever since the beginning of agriculture and have been mentioned in many ancient texts. For example, Gajaśāstram, an elephant lore by Palakapya (6 to 5th century BC) describes the havoc caused by elephants in the kingdom of Anga (Sukumar, 2003; Wakankar and Mhaiskar, 2006). Kautilya's Arthashastra (300 BC to 300 AD) clearly describes the need to protect cultivated crops from depredation by wild elephants, but also addressesthe issues of protection of elephants, capturing wild elephants and managing captive elephants.

In the last few decades, crop-raiding by elephants has received considerable attention by researchers and conservationists. As well as human populations expanding agriculture into previously unexploited elephant habitats as discussed above, it has been suggested that this recent attention is also a function of changing landscapes of politics and land ownership (Naughton-Treves and Treves, 2005; Mahanty, 2003), which produces hostile perceptions of disenfranchisement in local communities. Crop-raiding is considered to be one of the main issues that considerably eroded peoples' tolerance of elephants in Asia (Sukumar & Gadgil, 1988, Santiapillai & Widodo, 1993; Balasubramanian *et al*., 1995; De Silva, 1998; Williams *et al*., 2001) and Africa (Thouless, 1994; Barnes *et al*., 1995; Tchamba, 1996).

Known for their distinct movement patterns during different seasons, elephants are now in contact with the sea of agricultural lands along these paths. Development activities, especially construction of dams for generating hydro-electric power has had a mixed impact on elephant habitat (Sukumar, 1989); i.e. while disturbing the traditional elephant movements, it has also created a source of perennial water. Elephants using these water sources may raid the cultivated lands nearby, which were now easily accessible and contained highly nutritious and palatable foods. Similar results have been found in Africa, with elephant and human interactions associated with access to water resources, and more frequent interactions observed during drought periods (Kangwana, 1993; Thouless, 1994). For example, frequency of human-elephant interaction was found to be significantly associated with the distance to water, mean elevation and the length of the protected area frontage in the Tsavo ecosystem of Kenya (Smith & Kasiki, 2000).

Two hypotheses have been proposed as the cause of crop-raiding: resource limitation and evolutionary strategy (Sukumar & Gadgil, 1988). Reasons for crop-raiding could be much more than simply proximate explanation of habitat degradation (Sukumar, 1994). Temporal patterns of crop-raiding are considered to be associated with the seasonality of availability of wild plant species, specifically high quality wild grasses (Osborn, 1998). However, studies in both Africa (Naughton-Treves, 1998) and Asia (Sukumar, 1989; Webber *et al.,* 2011) have shown that regardless of the availability of wild plants for foraging, elephants have raided crops during the ripening of paddy rice or maize suggesting that elephants' selection of crop traits is also based on the ripening stage or nutrient density. Some alternative proximate causes are the compression of elephant populations (Hoare, 1997; Graham, 2006), rainfall patterns (Hoare, 1997; Graham, 2006), expansion of cultivated land and increase in human movements in elephant habitat (Blair *et al*., 1979), and the preference for crops by elephants (Sukumar,1989).

In contrast, Sukumar & Gadgil (1988) suggested that the ultimate cause for crop-raiding by elephants can be attributed to the social organization and the "high-risk, high-gain" crop-raiding strategy to increase fitness (Sukumar, 1991; Chiyo *et al*., 2011) and reproductive success in the context of male-male competition. Sukumar (1989) observed that the male elephants seemed to form associations with other bulls in the vicinity during crop raiding. Male elephants were rarely found together inside the forests but most formed groups before raiding; this may lead to higher success rates of raiding when acting in groups, and responding to hostile farmers. In addition, most raids were found during ragi millet ripening season when the other food was plentiful. Chiyo *et al.* (2011) found enhanced growth among raiding males suggesting that the payoffs are worth the risks. My observations during field season of a family group found that the group was constantly followed by male elephants. The presence of both family and male (all male and/or lone male) elephants and their preference for specific crops may alter the elephants' behavior; heightening levels of alertness to the possible threats from people and thus making them seem more aggressive towards people.

1.2.4 Mitigation methods for better co-existence between elephants and people

The complexities of human-wildlife interactions management become two-fold when it involves endangered species like elephants, primates, or tigers. One section of the society wants to preserve the animals and their habitats, while the other section wants any resulting problems to be completely resolved. Young *et al*. (2010) suggested the same when they argued that the impacts of human-wildlife interactions should be addressed based on two components and underlying consequences of human-human interactions is one. With this ethical dilemma, not only do the farmers have to deal with crop-raids, risks of human injury or loss of life, destruction of property, and restrictions to their activities (Osborn and Hill, 2005) but their methods of crop protection also come under scrutiny to ensure that no illegal method is used to harm the animals while protecting the crops from them (Hill, 2005).

Various mitigation measures have been used and are under constant review to provide efficient results in managing and reducing hostile situations between elephants and people. However, given the varied ecological and social settings in the Karnataka State, effective mitigation for people involved in elephant interfaces have to be equally diverse to result in any successful conservation efforts. Using multiple management measures, from physical barriers like trenching and fences to *post-facto* measures like ex-gratia payments, is required. In some extreme cases, elephants are captured and either translocated or kept captive. Unlike in Africa, culling elephants is a sensitive issue in India (Sukumar, 1989; 2003), but some elephants are killed if they are considered unsuitable for even captivity or some killed during retaliatory killings by local people. For example, a critically injured elephant will be killed rather than translocated.

Although effective initially, most management measures to protect crops have been a failure to some extent, either due to elephants' habituation, or their out-manoeuvring these measures. For instance, elephants learn to cross solar powered electric fences by placing a tree on the fence wires (See Figure 1.1; See Video 1 Appendix 12), which might break at several locations or make enough of a passage for elephants to cross these fences by walking on the tree trunk to avoid getting electrocuted (Personal Observations). Male elephants are known to use their tusks to break the wires of such fences as tusks are bad conductors of electricity. They will also cooperate to jointly break a fence. Thus, we are left with a challenging situation as to how to reduce or eliminate these incidences of crop-raiding. It is now becoming an 'arms race' where people constantly have to come up with new innovative methods to reduce crop damage while elephants eventually (or even remarkably quickly) learn to cope with these methods, such as electric fences, trenches, bee hives, chili sprays, etc. [e.g. Chelliah *et* *al*., 2010; Fernando *et al*., 2008a; Hedges and Gunaryadi, 2010; King, 2010, 2011, 2012; Nath & Sukumar, 1998; King *et al*., 2007, 2009, 2010, 2011; Kioko *et al*., 2008; Vollrath & Douglas-Hamilton, 2002; See also Chapter 8]. Also it is important to recognise and acknowledge that success of mitigation methods is dependent on region-specific context. Topographic and landscape variations, different agricultural practices, elephant population dynamics and their nature of use of the landscapes, local people priority of the impacts of the wildlife interactions (safety and/or reduced crop-damage) are factors that need to be considered while designing suitable management strategies and their implementation.

Figure 1.1 Boundary fence of Yemmegoondi coffee estate (TATA). Red arrow indicating the tree, which the elephant used to break the electric fence (blue arrow) (See Figure 1.2 a and b). The stone fence may have been broken previously by the elephants and the electric fences are fixed to the trees.

(a)

(b)

Figure 1.2 (a) and (b) Camera trap pictures showing an elephant entering Yememgoondi coffee estate from a neighbouring coffee estate by placing a tree on the electric powered fence.

Understanding of behavioural and population dynamics of 'problem' species is necessary for better co-existence between people and wildlife across the unprotected human-dominated landscape. It is thus important to identify individual elephants and their seasonal movement path within agricultural lands (in this study, on coffee estates) to be able to reduce the negative impact of co-existence. Knowledge of basic elephant ecology and their behavior on the part of local communities living in elephant ranges is important; understanding elephant behavior should reduce the risks of encounters for both humans and elephants. Thus, awareness and understanding of elephant movement patterns and their responses to certain management methods will help empower local communities to use appropriate techniques for avoiding or reducing severe crop damage and fatal encounters. This can be one of the major conservation tools for managing co-existence between people and elephants.

1.3 Elephant and People Interactions in India

1.3.1 Elephants in India

India has the second largest human population for any country in the world with population density estimated to be 311 inhabitants per square kilometre (Census of India, 2001). India has only about 4% of forested areas in the total land area, which consists of 600 protected parks. These 'protected' areas for wildlife are not contiguous but spread across the different parts of the country with set boundaries. India harbours the largest population of Asian elephants in the world. Currently, there are estimated to be only 45,000 wild Asian elephants remaining distributed across South and Southeast Asian (Sukumar, 2003; See Figure 1.3) and in India the elephant range covers only 3% of the geographical range of the country (Sukumar, 2003). The historical and present distribution of Asian elephant range indicate the drastic decrease in elephant populations (Arivazhagan & Ramakrishnan, 2010) and corresponds with the deterioration of natural habitats, capturing and taming, ivory poaching, retaliatory killings, etc.

In India, Asian elephants are listed in the Schedule I of the Indian Wildlife Protection Act (1972) and recently have been considered as a national heritage. Historically, Asian elephants ranged over the entire Indian-sub continent. However, they are now restricted to merely five discontinuous and fragmented landscapes in North, North-East, Central, and Southern India) (See Figure 1.3).

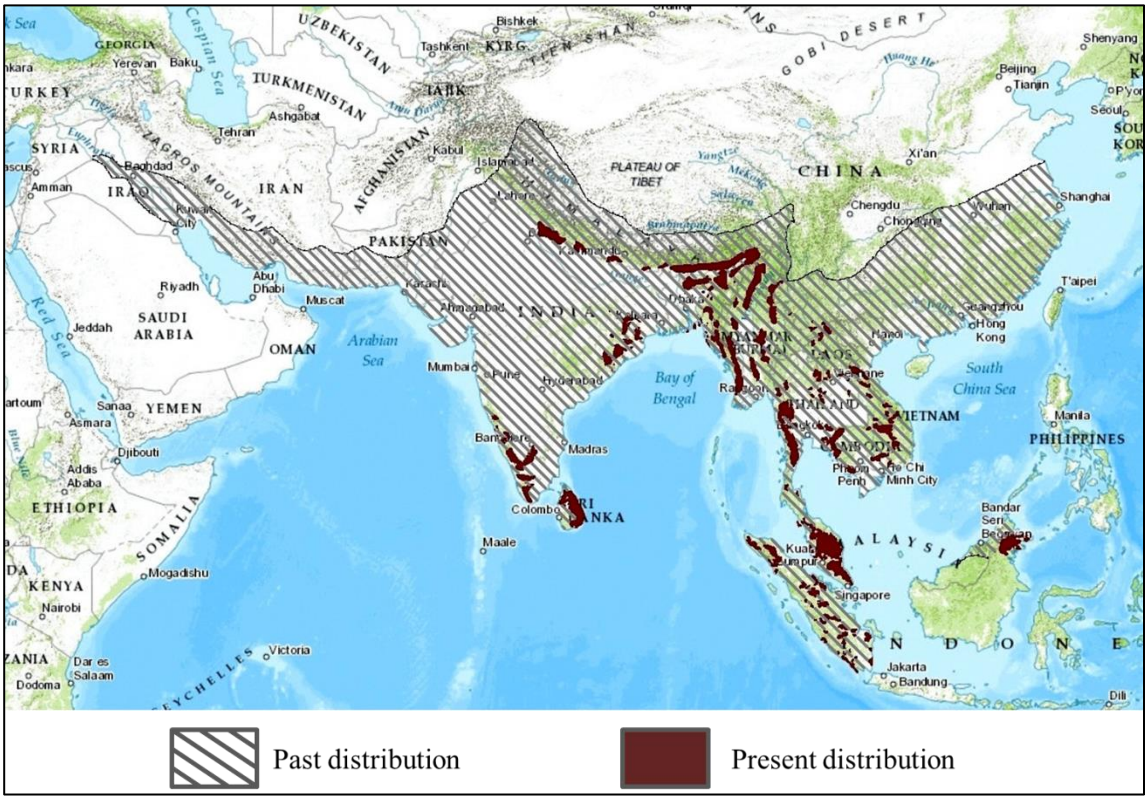


Figure 1.3 Former and Present distribution of Asian Elephants (Source: Santiapillai and Jackson, 1990; IUCN 2014).

India has about 60% of total Asian elephant population (approximately 24,200-30,000; Riddle *et al*., 2010). Indian elephants are distributed across the north-eastern and north-western Himalayan foothills, central and southern India with the population sizes of about 9,000-10,000, 1000-1500, 1500-200 and 12,500-14,500 respectively (Sukumar & Santiapillai, 1996; Asian Elephant Research Conservation Centre (AERCC), 1998; Bist, 2002; Sukumar, 2003). Four elephant reserves are located in Southern India, which differ in vegetation types and ecosystems and also in elephant density across these reserves.

The distribution of the elephant population in southern India is mainly in the hill forests of the Western Ghats and adjacent eastern Ghats in the states of Karnataka, Kerala and Tamil Nadu (See Figure 1.4; Nair & Gadgil, 1978; Nair *et al*., 1980; Sukumar, 1986; 1989) and these areas are thought to harbour the largest elephant population not only in India but also in Asia (Baskaran & Sukumar, 2010; Baskaran & Sukumar, 2010). In protected areas of these states, the elephant density is estimated to range from 1 to 3 per km^2 (Kemf & Santiapillai, 2000; Baskaran & Sukumar, 2010; Baskaran, 2013).

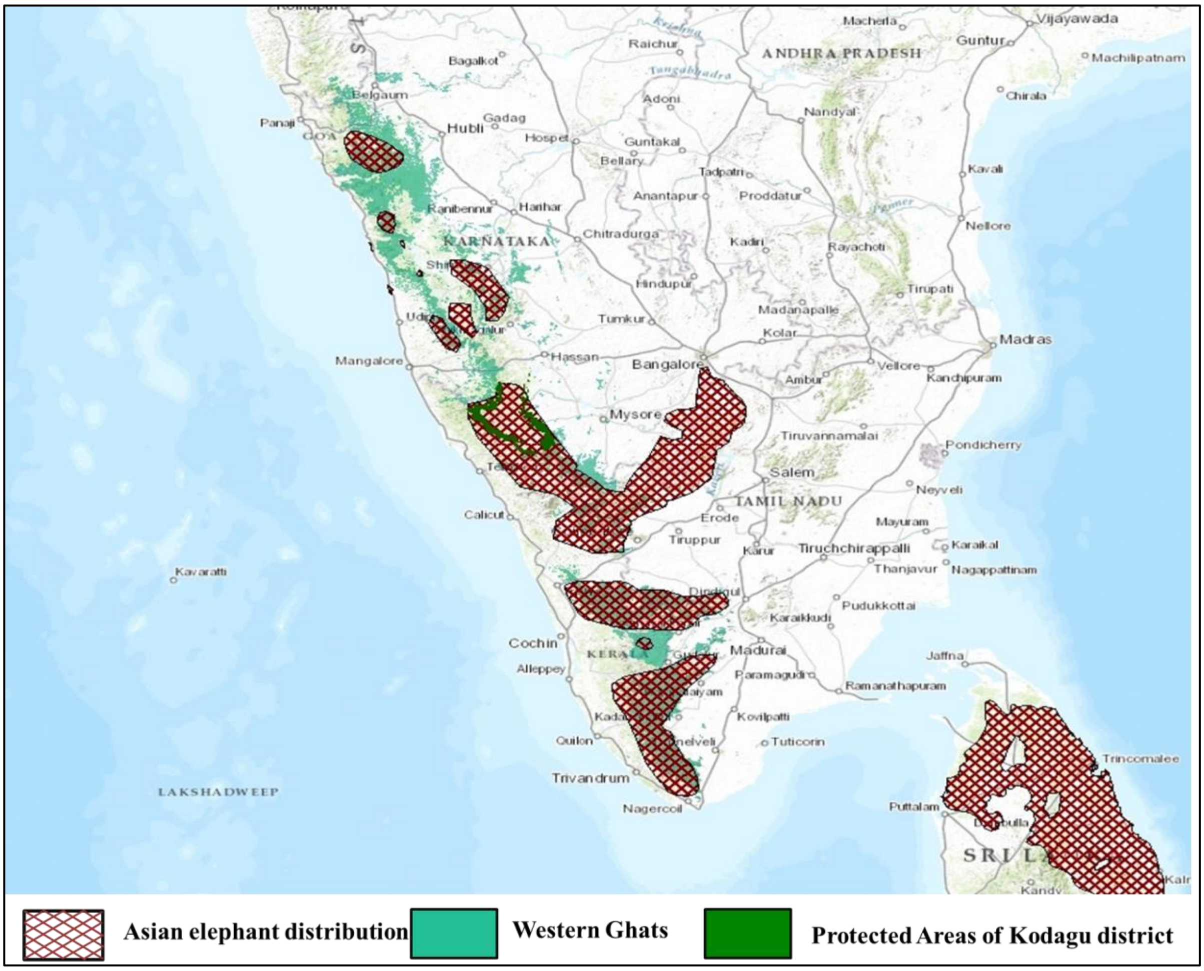


Figure 1.4 Distribution of Asian Elephant in Southern India (Source: IUCN, 2014). Outline of the Kodagu Distrcit is depicted in the above picture by the Protected Areas (Green) bordering the district.

Of these areas, Karnataka State has about one-fifth of the total elephant population in India, with about 5300-6200 elephants in an area of 14,500 km^2 distributed over the Eastern and the Western Ghats. A recent State census (2012) estimated 6072 elephants in Karnataka with the majority of the elephant population concentrated in the southern Mysore Elephant Reserve (MER) over an area of 6,463 km^2 (Varma *et al*., 2011). The Mysore Elephant Reserve has 5,945 of the total estimated elephant population (or 97%). This makes it an ecologically viable population for long-term study. The northern part of Karnataka has a very small elephant population with bulls moving out of their natal family and establishing home ranges. There are also 159 elephants in various captive situations like forest camps, zoos, circuses, temples and private ownership.

1.3.2 Culture and co-existence

People's willingness to tolerate wildlife is often influenced by the cultural factors (Kuriyan, 2001). For centuries, numerous religious, cultural and agricultural practices across the world have fostered co-existence between people and wildlife and resulted in some protection for local wildlife.

In India, both animal and plant species are revered across the country and are linked into one or many 'forms of Gods'. Animals are associated with particular Gods and Goddesses which may have been a symbolic of deity's power (for example: Airvata the white elephant as God Indira's 'vehicle'). In such cultures, animals play an important role in their mythology (monkeys and elephants are symbolised as Hanuman and Ganesha respectively) and sometimes the Gods themselves are manifested in the form of animals (God Vishnu as the wild boar). In some-traditions like hunter-gatherers and tribal societies are nature worshippers (See Chapter 2, Section 2.7). Certain species of plants and trees like tulsi[6] (*Ocimum tenuiflorum*), peepal (*Ficus religiosa*)[7] are worshipped for their medicinal uses and thus are known for these medicinal purposes and religious symbolism. Cultural associations between elephants and people have been known in India from historic times, with both wild and captive elephants mentioned in ancient scripts and in the art and sculptures in temples, as noted above.

---

[6] Aromatic plant or Holy basil
[7] Sacred Fig

In India and few other south-east Asian countries (Sri Lanka, Thailand) people revere elephants as one of the most important Gods of Hinduism and Buddhism. The first mention of Ganesha (See Figure 1.5), the elephant God was in the 3rd or 4th century, and was called the God of destruction who caused problems to people. Later manifestations of Ganesha came to be associated with that of God of Obstruction. Manifestations of the elephant-headed God may have created strong ethos against killing of elephants (Sukumar, 1989) playing a key role in influencing people's perception of the loss caused by elephants, leading to partial acceptance (Imam & Malik, 2002).

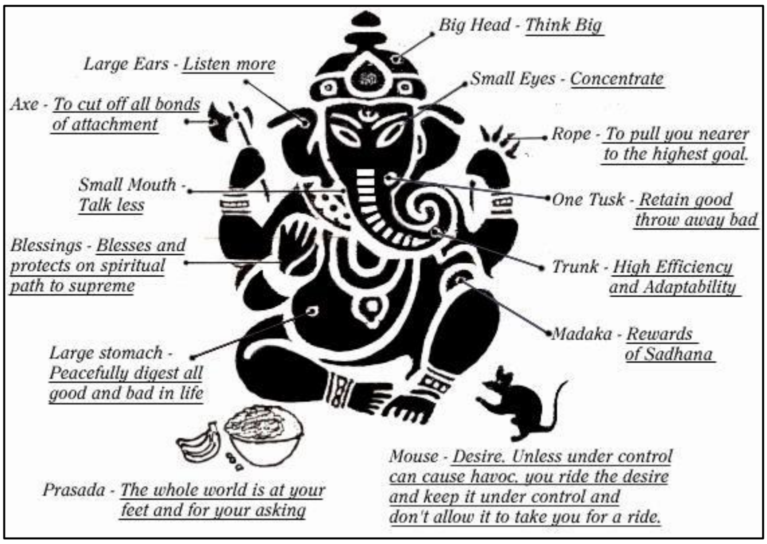


Figure 1.5 Elephant symbolism as *Lord Ganesh* in India. Each part of the body represents life values for people to follow, for example large/big head implies think big, etc. (Source: www.shreeganesh.com/symbol.htm).

Strong religious beliefs and reverence towards animals and plants has prevented people from persecuting large bodied animals and wild animals in general, thus ensuring the survival of elephants in India in larger numbers than anywhere else within the Asian elephant ranges (Sukumar, 1989; 2003; Madhusudan, 2003; Mishra *et al*., 2003). However, growing economic development and rising living standards of people have resulted in the gradual erosion of traditional faith and belief systems. In addition, the increased population in India has created a struggle for space, leading to loss of forests for wildlife. This increase in economic development is often unequal; people disadvantaged by interactions with wildlife are also likely to be those with the lowest level of socioeconomic development and thus the burden of loss is greater for this sector of the population.

1.4 Thesis Aims

This study is the first to integrate elephant's use of human land and their interactions with people through observations of elephants in the Kodagu region.

Specifically, the aims were to:

- To assess elephant human-interactions in the region generally through exploring crop-raiding patterns as recorded by crop compensation events (Chapter 4).
- To examine the pattern and frequency of use of a small number of coffee estates (as representative of coffee estates generally) by elephants to identify what factors attracted the elephants and how these varied over time.
- To assess the role of cultural values and perceptions of dangers and risks to livelihoods, and to the conservation of elephants in this region.

1.5 Thesis Structure

Understanding how the history and dynamics of the long and complex relationship between humans and elephants on the Indian subcontinent feeds into our current and changing perceptions of elephants which will determine the future of elephants in the wild. Chapter 2 thus describes in detail the study area of Kodagu as well as the background to the elephant population. Chapter 3 provides details of rationale for the methods used in this study.

The first data chapter (Chapter 4) explores the location and frequency of crop-raiding events, based on claims submitted to the Forest Department for compensation for crop loss. As discussed above, temporal and spatial patterns of crop-raiding may indicate how the elephants in this region are using the landscape (at least in relation to the claims made). Are particular regions or areas within the *Taluks* (or Districts, see chapter 2) more vulnerable to raids or more representative of elephant use of human crops?

The next two data chapters (Chapter 5 and 6) look in detail at the use of large coffee estates by elephants. Coffee loss or damage by elephants, as the major cash crop in this region, could determine the attitudes of people towards elephants and predict the success of activities to promote their conservation. Furthermore, I aimed to explore whether the use of coffee estates was specific to individuals or small groups, or whether it was a general outcome of the population moving between forest areas (Chapter 5). The diurnal and monthly use of estates was examined in relation to potential for travel routes, the presence and use of elephant foods in the estates and the occupation of safe refuges from human disturbance in these areas (Chapter 6). In addition to the other fruits consumed by elephants, I used dung samples to explore whether elephants were consistently consuming coffee as a resource (Chapter 7), as this had been observed recently in Kodagu (Bal *et al.,* 2008). Elephant consumption of coffee on estates could produce hostility over and above that of the risk to human life through elephant encounters, given the importance of coffee as a biodiversity friendly cash crop in this region.

Having provided the background portrait of the elephants and their use of the general area, and the specific “habitat” of coffee estates, I then relate the elephants to the human perceptions of elephants, and resulting attitudes towards elephants (Chapter 8). This chapter builds on my pilot interviews with landholders and farmers (Narayana, 2009), and integrates that work with the current perspective on the elephant use of crops (Chapter 4) and their presence on estates (Chapters 5-7). Local attitudes are explored in the context of the general beliefs and history of development of Kodagu as set out in Chapter 2. The implications of these patterns of interaction and human attitudes towards elephants are discussed in relation to conservation in Chapter 9.

Chapter 2

STUDY AREA: KODAGU

CHAPTER 2: STUDY AREA: KODAGU

2.1 Topography

The Western Ghats of India were formed during the collision of the southern landmass of Gondwanaland with mainland Asia about 150 million years ago. Along with the Eastern Ghats, these hills run along the periphery of the Indian Peninsular. The Western Ghats represent a globally unique biogeographical region due to the varied altitudes with changing climatic conditions and varying rainfall. The Western Ghats are located along the west coast of India between 8º 56´ - 20º 40´ N latitude and 73º - 79ºE longitude forming a chain of mountains of 1600 km long and 5 to 150 km wide. Its biodiversity consists of many endemic species of flora and fauna, which are estimated to be between 10,000 to 15,000 species, with many yet to be discovered. Meyers *et al*. (2000) considers the Western Ghats as one of the top twenty five biodiversity hotspots and the one of the eight hottest hotspots, in the world.

Kodagu is the second smallest district[8] of Karnataka, southern India (See Figure 2.1 a and b). During the British Rule, it was anglicized as 'Coorg' meaning steepness. It is located on the eastern slopes of the Western Ghats, extending between 11º 56´ - 12º 52´ N longitude and 75º 22´-76º 11´ E latitude (Pascal & Meher-Homji, 1986). The total area of the district is 4,102 km² (1,584 sq m). Kodagu is situated at the centre of the Western Ghats and is located at the border of the first biosphere reserve of India, Nilgiri Biospehere Reserve. It is bordered by Dakshina Kannada district to the northwest, Hassan district to the north, Mysore district to the east, the Kannur district of Kerala to the southwest, and the Wayanad district of Kerala to the south (See Figure 2.1).

[8] district: India is a federal union of states and union of territories. These states are further divided into smaller administrative units called districts.

Kodagu's elevation ranges between 300m and 1750m (Pascal & Meher-Homji, 1986) with an average rainfall between 800mm-7000mm (Elouard, 2000). Rainfall is intense during the months of July and August which is primarily received from South-west monsoons until the end of September. From October to December, the district receives rains from North-east monsoons, which are considerably lower compared to previous months. Rainfall decreases from west to east accompanied by a longer dry season (Sathish & Kushalappa, 2006). The average temperature is about 15°C (59° F), ranging from 11 to 28°C (52 to 82°F). The highest temperature occurs during the summer in April and May. The average temperature of the coldest months of December to February ranges between 16 to 23 degrees centigrade.

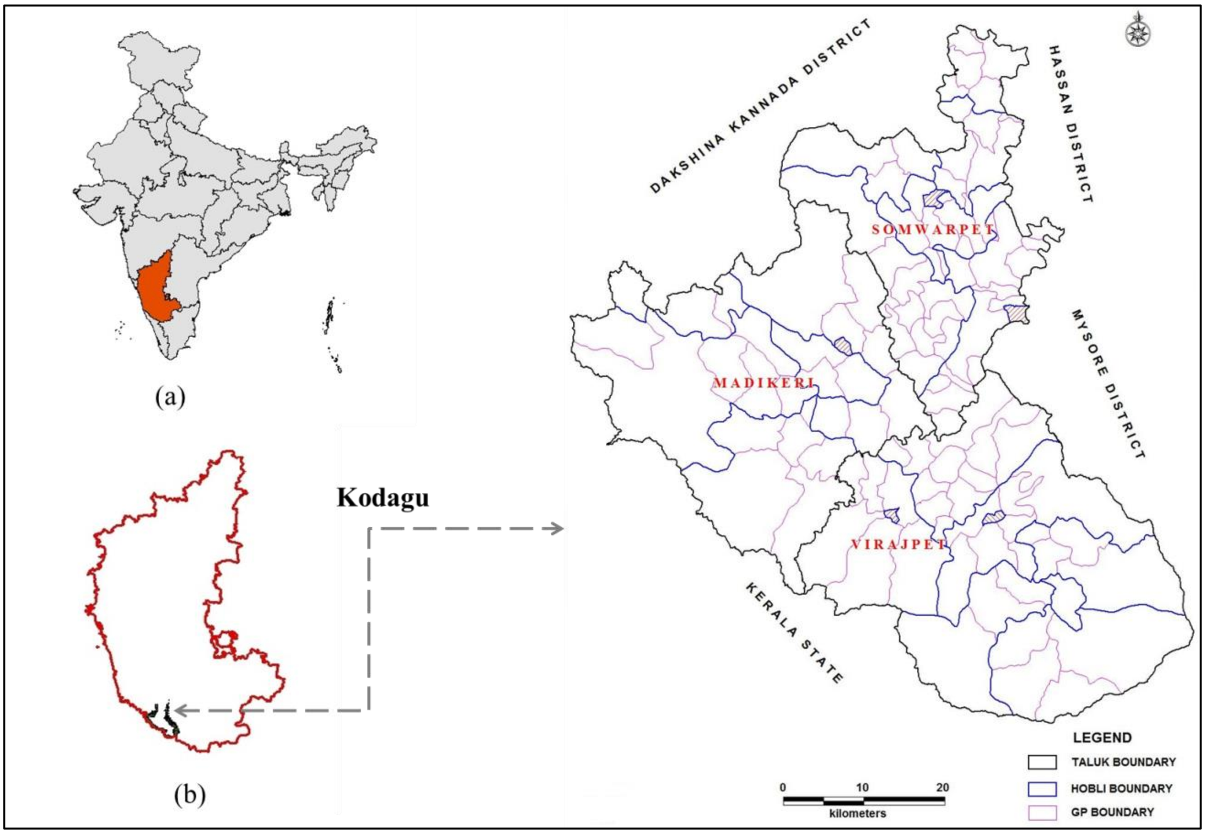


Figure 2.1: Kodagu district administrative map with *taluk*[9], *hobli*[10] and *gram panchayat*[11] (GP) boundaries[12] (a) India map indicating the State of Karnataka, Southern India (in orange). (b) The Karnataka State Map indicating the location of Kodagu.

Topographic variation is seen across Kodagu (See Figure 2.2), with the western and south-western areas dominated by the Western Ghats highlands, which flatten in the east and again gently rises westwards with small valleys and isolated hillocks occurring centrally. Four types of habitat vegetation are found to be dominant in the district: Evergreen and semi-evergreen in the western borders, dry-deciduous in the east and northeast border and moist-deciduous in the central region (Elouard, 2000).

[9] *taluk*: Each District is divided into groups of several villages for administrative purposes.
[10] *hobli*: A subdivision of a taluk, comprising a cluster of adjoining villages for administrative purposes
[11] *gram panchayat*: A cluster of villages governed by local self-government (or Rural self-government). People within the local community elect the heads of these self-governing bodies.
[12] Map Source: Kodagu Zilla Panchayat, http://www.kodagu.nic.in/zp/pages/about/maps.html.

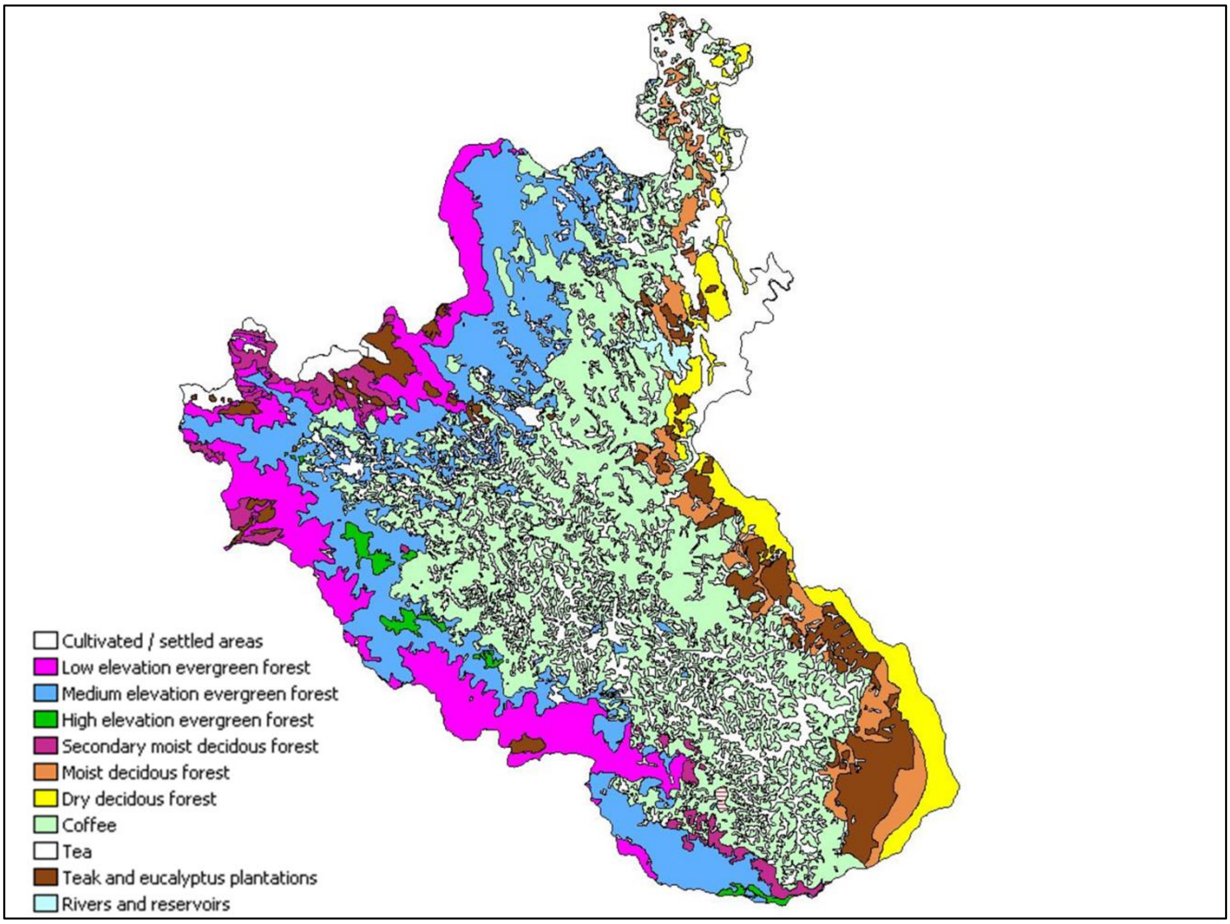


Figure 2.2 Kodagu map showing different vegetation in the district (Source: French Institute of Pondicherry, 2007; See Appendix 2 for Mercara-Mysore Vegetation Map).

In the 2001 census, Kodagu had a human population of about 548,561 people, equating to 134 people per km^2 (347 per sq m). According to the 2011 census, Kodagu has a population of about 554,519 people, with a population density equal to 135 people per km^2 (District Census, 2011, Census of India). The growth in population was only 1.09% in ten years compared to a 12.31% increase between 1991 and 2001. Kodagu ranks 539 out of 640 districts with regards the total population (District Census 2011, Census of India).The district's sex ratio was 1019 females: 1000 males. The literacy rate is 82.52%.

2.2 Vegetation

Kodagu is an excellent example of a multi-use landscape, with forest lands covering 46% of the total landscape. An agro-forestry cultivation system was chosen due to the structural complexity, abundance and tree diversity found in this landscape. The vegetation is defined as a medium elevation, wet evergreen forest type (Pascal & Meher-Homji, 1986). The most common type of vegetation is found is *Messua ferrea – Palaquium ellepticum* type. Some of the economically important and commonly found trees are *Arcocarpus fraxinifolius* (used as a shade tree in coffee plantations), *Artocarpus hirsutus* and *Mangifera indica* (edible fruits), *Cedrela toona, Dipterocarpus indicus, Dysoxylum malabaricum, Hopea parviflora, Hydnocarpus wightiana* (fruits having medicinal use), *Callophyllum tomentosum, Canarium strictum, Mesua ferrea, Sterculia alata* and *Vitex allistima* (Sha, 1987; Forest Survey of India, 1995). Some of the important Angiosperms found are Clusiaceae (*Mesua, Calophyllum, Garcinia*), Sapotaceae (*Palaquium*), Meliaceae (*Algaia*) and Euphorbiaceae (*Agrostistachys, Mallotus, Drypetes*) (Sha, 1987).

Until recently, many plantations retaining considerable native tree diversity with coffee cultivated as "shade-grown" (See Figure 2.3). Coffee agro-forestry is considered as a 'boon' to the biodiversity of the region due to its diversified habitat across the district (Sathish & Kushalappa, 2006).

Figure 2.3 Coffee agroforestry, cultivation under tree shade. The above picture is an example of monoculture plantations where, the shade trees are *Grevillea robusta* (silver oak; See Section 2.3).

2.2.1 Wildlife

The most common animals found in Kodagu are Asian elephants (*Elephas maximus*), tigers (*Panthera tigris*), leopards (*Panthera pardus*), Indian wild boars (*Sus scrofa*), Indian gaurs (*Bos gaurus*), deer (*Cervus axis axis*, *Cervus unicolour*, *Muntiacus muntjac*), wild dogs (*Cuon alpinus*), Hanuman langurs (*Semnopithecus entellus*), Malabar giant squirrels (*Ratufa indica centralis*) and sloth bears (*Melursus ursinus*).There are also brown palm civets (*Paradoxurus jerdoni*), Nilgiri langurs (*Trachypithecus johnii*), Asian clawless otters (*Amblonyx cinereus*), Nilgiri martens (*Martes gwatkinsii*) and lion-tailed macaques (*Macaca silenus*). Some other species are occasionally sighted, such as jackals (*Canis aureus*), small cats (*Felis chaus*, *Prionailurus rubiginosis*, *Felis bengalensis*), civets (*Viverricula indica*, *Paradocurus hermaphroditus*), and mongooses (*Herpestes edwardsi, Herpestes vitticollis, Herpestes smithi*). The bird species found in this region include great hornbills (*Buceros bicornis*), black eagles (*Ictinaetus malayensis*), rufous woodpecker (*Celeus brachyurus*), greater racket tailed drongo (*Dicrurus paradiseus*), Green Imperial pigeon (*Ducula aenea*) and many more There are also many reptile and amphibians that are endemic to the region (Sha, 1987; Forest Survey of India, 1995).

2.3 History

Kodagu is a hilly region with some flat land for agriculture and livestock grazing in the central region of the district. A few centuries ago, this region was covered by thick forest and due to its climatic conditions, it was considered as the one of the coolest regions within India. It is commonly believed that coffee was introduced from the Yemeni port of Mocha by Baba Budan, a Muslim saint in the 16^{th} century (Ukers, 1935; cf. by Neilson, 2008). In 1834, when British occupied Kodagu, it was still covered by thick forests or jungle (to the East; Pouchepadass, 1990). Coffee plantations emerged only after the European planters settled in Kodagu and established the first plantation in Mercara (Madikeri) in 1854. After its introduction by British and European settlers, Kodavas embraced coffee cultivation (Ritcher, 1870; cf. Neilson, 2008). Today, India is the fifth largest coffee producer in the world and Kodagu produces about one-third of all Indian coffee (Coffee Board of India, 2006), making it one of the most important coffee growing regions of India. The arrival of British also resulted in natural forests first being used for timber and then slowly converted these cleared forest areas into coffee plantations, with many British and Europeans settling in the region. This resulted in dramatic changes in the economic and environmental management structures of Kodava society.

The British cultivated coffee under dense-canopy tree cover (Belliappa, 2008; Boppanna, 2010; Kalam, 2001). Post-independence, people carried on cultivating coffee as before and slowly it became one of the main sources of income for people in the region. Paddy rice was cultivated to a lesser extent resulting in tree-cover being little altered between 1850-1980 (Moppert, 2000; cf. Bhagwat, 2002). Arable crops like paddy rice and maize are specific to certain regions of Kodagu, typically near the boundaries where landscape becomes drier, and unlike in the coffee plantation areas there are very few trees.

Coffee as a cash crop soon resulted in the intensification and privatisation of coffee and led to a major transformation of the landscape during the early 1970s, at the expense of native tree species and vegetation cover (Garcia *et al*., 2007). Since the mid-19th century, Kodagu has undergone a rapid transformation with about 35% of the original wet evergreen forest area being planted with coffee (Elouard, 2000). During 1977-1997, Kodagu went through another major transformation with an increase in coffee cultivation resulting in a reduced forest habitat from 2566 km^2 to 1841 km^2. Most of the conversion occurred within the privately owned landscape (Ramakrishnan *et al*., 2000). Although some farmers have replaced native trees with exotic silver oak (*Grevillea robusta*), the majority of coffee plantations, especially larger estates, still grow coffee under the canopy of native tree species. Only 8% of the land is not covered by trees, such as areas with paddy cultivation (Moppert, 2000; cf. Bhagwat, 2002; See Figure 2.2).

About 6% of Kodagu is covered by plantations including teak, cardamom, eucalyptus and rubber (See Figure 2.2). Few coffee planters have cultivated cardamom (See Figure 2.5) in their coffee estates and because of constant price fluctuations and diseases to the plant, cardamom plantations are gradually being converted into coffee areas. In Kodagu, coffee planters consider themselves to be the stewards of the environment and are willing to make significant contributions to biodiversity conservation on their estates (Ninan and Sathyapalan, 2005; Nielsen, 2008). Thus, canopy cover seems to be little altered, even though the forest diversity and distribution has been degraded.

Figure 2.5 Illustration of the intercropping of cardamom, and pepper within coffee estates.

2.4 Protected Areas of Kodagu

Kodagu is surrounded by thick forests, except in the northern tip where forests are mostly present in severely fragmented condition (See Figure 2.4). It covers an area of 1588 km², with approximately 30% of the landscape considered to be above national or global averages of forest cover, and exceeding the IUCN (1994) recommendation of 10%. Today, these forests form a network of protected forests stretching continuously along the western and the south western boundaries of the district consisting of wildlife sanctuaries, national parks, reserved forests and other community and private owned forests. The three wildlife sanctuaries are the Brahmagiri Wildlife Sanctuary, Talakaveri Wildlife Sanctuary and Pushpagiri Wildlife Sanctuary. Reserved forests, in comparison to the wildlife sanctuaries and national park, had fewer restrictions of use of the forest area and products. The Karnataka Forest Act (1963) enforced strict laws for the protection of reserved forests. However, Kodagu had already the first wildlife sanctuary in 1955, the Nagarhole Wildlife Sanctuary, located in the South-east of Kodagu, which now has the status of national park (Rajiv Gandhi National Park or Nagarhole National Park). Forest reserves act as buffer zones for the three wildlife sanctuaries and one national park.

Of the remaining landscape, about 60% is covered with shade grown coffee plantations and other crops like cardamom. Since most of the coffee bushes are grown under tree canopy cover, these plantations resemble natural forests. About 8% of the landscape is considered to be treeless which is mainly used to cultivate paddy rice.

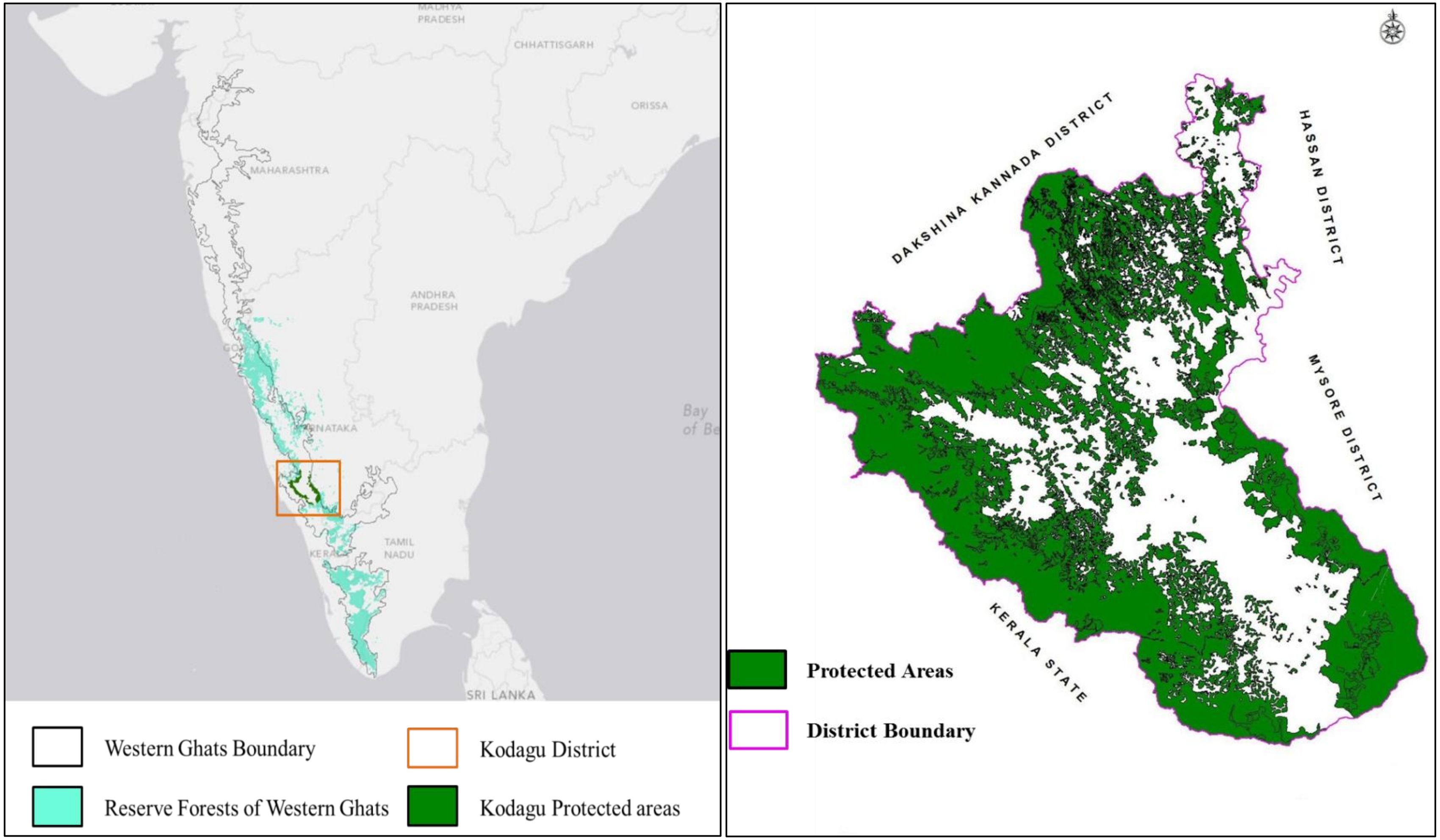


Figure 2.4 (a) Geographical importance of Kodagu in relation to the Western Ghats. (b) Protected Areas across Kodagu, (Source Kodagu Zilla Panchayat, http://www.kodagu.nic.in/zp/pages/about/maps.html).

2.4.1 Elephants in Kodagu

The elephant population in Kodagu district is important given the geographical location at a key position connecting the states of Kerala and other districts of Karnataka (See Figure 2.1 and 2.4 a and b) which are key elephant ranges (See Figure 1.4). Despite containing three wildlife sanctuaries and one national park (with tiger reserve status), little was known about elephant population ranging in this district until recently (See Section 2.8 below). There have been no studies that have documented the distribution of the elephant population in Kodagu or their movements. Evidence of how this agro-forestry landscape is used as a corridor by the elephants during migration between large natural forest patches is also lacking. The district consists of many reserve forests, privately owned forests[13] and community owned forests like *Deverakadus* (sacred groves). This district is also a part of the Nilgiri Biosphere Reserve, a protected forest network, which is an International Biosphere Reserve.

The importance of these protected areas for the long-term survival of elephant populations of the region and for the management of the human-elephant interface are yet to be examined. In Sri Lanka, it was suggested that for long-term survival of elephants, the usage of both protected and private landscapes is important, in particular the use of the unprotected areas (Bandara & Tisdell, 2002; 2004). The protected area networks of forested land and the shade-grown coffee with dense canopy cover does not conform to the traditional concept of 'landscape fragmentation', but rather a 'modified landscape' (Bhagwat, 2002; Bhagwat & Rutte, 2006). Modifications of forested landscapes of Kodagu district have resulted in deterioration in terms of wild species

[13] In Kodagu, these are areas owned privately, found in coffee and cardamom plantations which support a wide variety of tree vegetation. For both privately owned forests and community owned forests, the ownership depends on the type of land tenure in Kodagu.

diversity, but the total tree coverage has been little altered (Sathish & Kushalappa, 2006). It is similar to a ‘managed forest’ under cultivation, providing at least the potential paths for wildlife movements, and therefore does not conform to the concept of ‘landscape fragmentation’ (Sathish & Kushalappa, 2006) as in other tropical forest ecosystems (Laurance & Bierregaard, 1977) or ‘landscape transformation’ (Elouard, 2000).

However, human activity is not lower in those areas of high cover, because coffee production is year-round preparation for one annual harvest and people are present all year round. The agroforestry landscape may be especially critical in providing refuge areas for species like elephants during their movements between other foraging areas, in forest areas, paddy fields, etc. These agricultural areas also have abundant food and water resources for elephants. Coffee is harvested annually and is an important cash crop for the farmers. Damage to coffee plants and berries has an adverse effect on production and consequently on annual income, especially for small farmers (See Chapter 3 for definitions of farm sizes). Apart from damage to crops, farmers and workers also feel that elephants are a threat to their lives and livelihoods, due to the presence of elephants near settlements and working areas. It is the perception of risk, rather than actual encounters resulting in injury, which appears to generate plantation workers’ negative attitudes towards elephants (See Chapter 7).

2.5 Land-ownership in Kodagu

Kodagu has a distinctive land tenure and land ownership system. There are at least four different types of land ownership in the district: private, co-operative, government non-forest lands and government forest lands. Around 1400 km² constitute about privately owned lands that range in size from 0.405 ha[14] to 404.686 ha.

The cooperative lands are usually owned by the local community as common property resources which are usually uncultivated. Maintaining such land is a religious practice and symbolizes the traditional function of the community. Although these lands are regulated by the community itself, in recent times, a breakdown of traditional social ties and an increase in population has led to the encroachment on and over-utilization of these lands (Kalam, 2001). Government non-forest lands are classified into three categories: Cultivable lands, disturbed forests and uncultivable lands. These government non-forest land areas are sometimes used for resettlement or encroached upon by migratory local communities. Finally, there are government forest lands which are of three types: Reserved forests (controlled utilization), wildlife sanctuaries (higher restrictions on human movement and utilization of resources) and national parks (unauthorized human movement and utilization of resources).

2.6 Sacred Groves

The local ethnic group, Kodavas, are known to protect certain patches of forest between cultivated lands for religious purposes. These are called the *Deverakadus*[15] which means "God's forest" or "God's jungle" (Kalam, 2001). These are considered to be an important storehouse of biodiversity in the district (example: Kalam, 2001; Bhagawat, 2002). Their existence and associated religious practices were present before the advent of British rule (Brandis, 1897; cf. Bhagwat, 2002). However, discontinuity in the management system imposed on sacred forests, from the forest department to the

[14] 1 acre = 0.404686 ha

[15] Deva/Devi means God; Kadu means Forets or jungle in Kannada, Kodava and other Dravidian Language

revenue department and back to the forest department, has contributed to their degradation and fragmentation. Ultimately, the preservation of these forests depends on the local community. There are about 1214 sacred groves remaining covering 2500 ha of the total area of Kodagu and it is estimated that for every 300 ha of land there is one such forest (Bhagwat, 2002). Each village has at least one sacred grove, and a few have as many as 17. It is estimated that the largest remaining sacred grove is 50 ha but most are fragmented into small patches of less than 2 ha and only 123 sacred groves exceed more than 4 ha (Kushalappa & Kushalappa, 1996; cf. Bhagwat, 2002).

Although sacred groves have received considerable attention for their role in conserving biodiversity, there is a fear that people are losing faith in social values, religious beliefs and especially nature worship (Kalam, 2001; Bhagawat, 2002; Bhattacharya, 2014). The abundance of rich natural resources available within these forest patches have resulted in various forms of human interference, for example, timber extraction. The remaining sacred groves are mostly degraded and encroached, especially those near to the roads and cultivated lands, and those few that remain intact do so because they are inaccessible to people.

Although groves are considered to be natural and traditional refuges for biodiversity, the extent of their role as elephant habitat is still unexplored. A considerable part of the elephants' range area is known to be located outside protected areas (See Figure 2.5) and in proximity to human settlements; sacred groves may act as refuge areas along elephant movement paths. As most of the sacred groves are small patches of forest located between the agricultural lands, the elephants may be using these sacred groves, especially around smaller coffee plantations, to avoid the risks of encountering people.

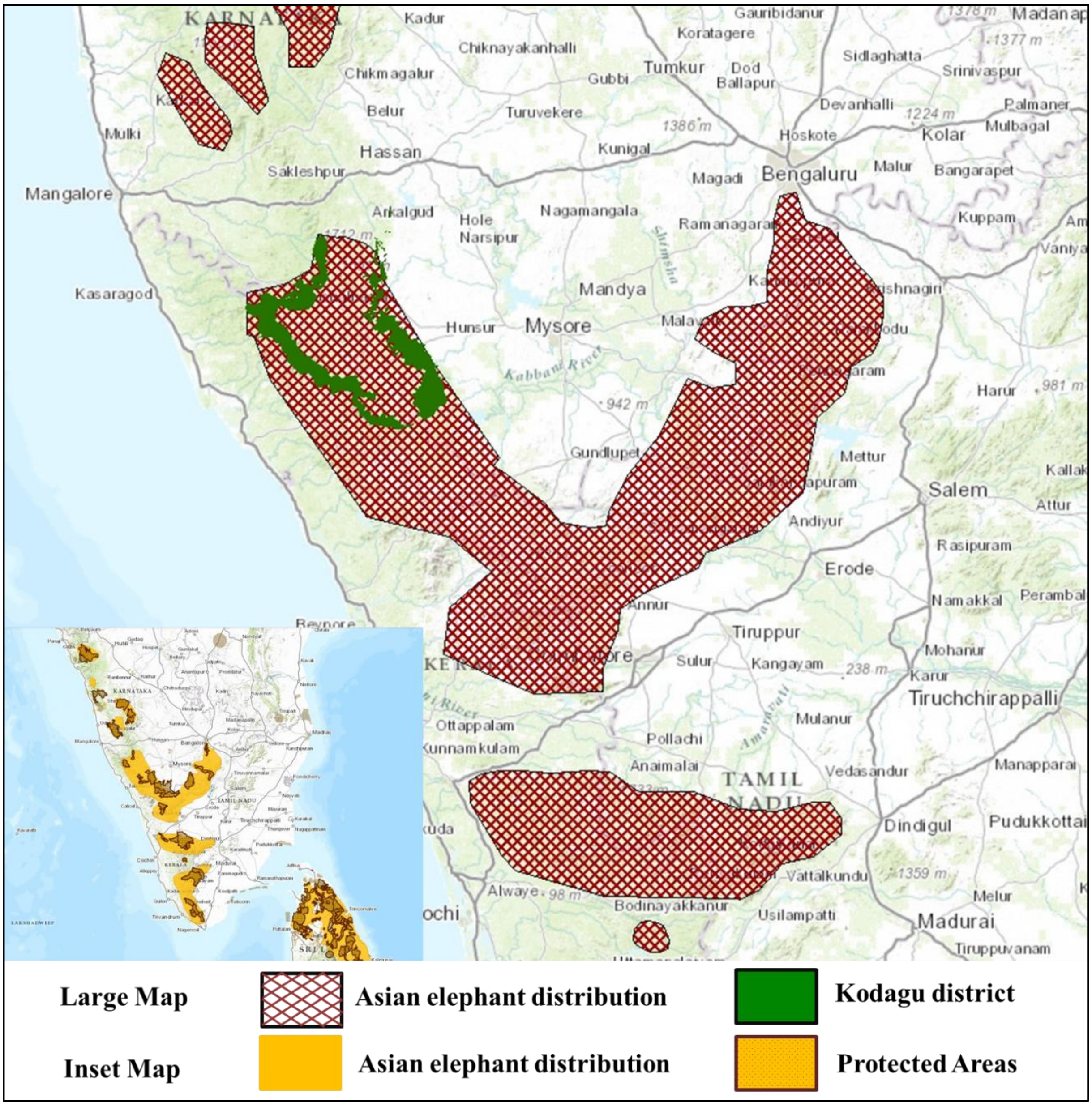


Figure 2.5: Asian Elephant distribution in South India with the protected areas of Kodagu highlighted. These protected areas[16] are located at the district boundaries. The inset map shows Asian elephant distribution in southern India, with important protected areas highlighted.

[16] The protected areas shown in this map only refer to those forest areas that have the highest protection status.

2.7 People and traditional beliefs

Residents of Kodagu come from diverse ethnic origins (Belliappa, 2008; Bopanna, 2010). However, the original residents of Kodagu were tribals[17] called Yeravas, Kembatties and Kudiyas. These tribes lived mainly in the hilly and forest regions of the district and practised shifting agriculture in the hills.

The present inhabitants of Kodagu, mainly the Kodavas, are believed to have settled in this region at the beginning of the first millennia (Ponnappa, 1997; cf. Bhagwat, 2002), and are considered to be the dominant community of the district. The other main settlers were Gowdas[18], followed by traders and entrepreneurs consisting of Malyali[19] and Mapillies[20] and Muslims from the Malabar Coast. The latter were basically rice cultivators who started agriculture as their main occupation and cleared the valley bottoms for paddy cultivation. Agriculture slowly spread across the district to become the main occupation. During the time of Rajas (regional Hindu rulers), the Kodava region (See Figure 2.6) was described as containing areas at a medium elevation (900-1200m) under tree cover, with low-lying ground under paddy cultivation, and with high mountain under shifting cultivation (Bhagwat, 2002). The main language spoken in Kodagu is Kodava, along with Kannada, Malyalam and Tamil.

[17] Native indigenous people of Kodagu
[18] A titular surname widely used in Karnataka among Hindus
[19] Native speakers of Malayalam, from Kerala State
[20] Descendants of Kodavas who converted to Islam

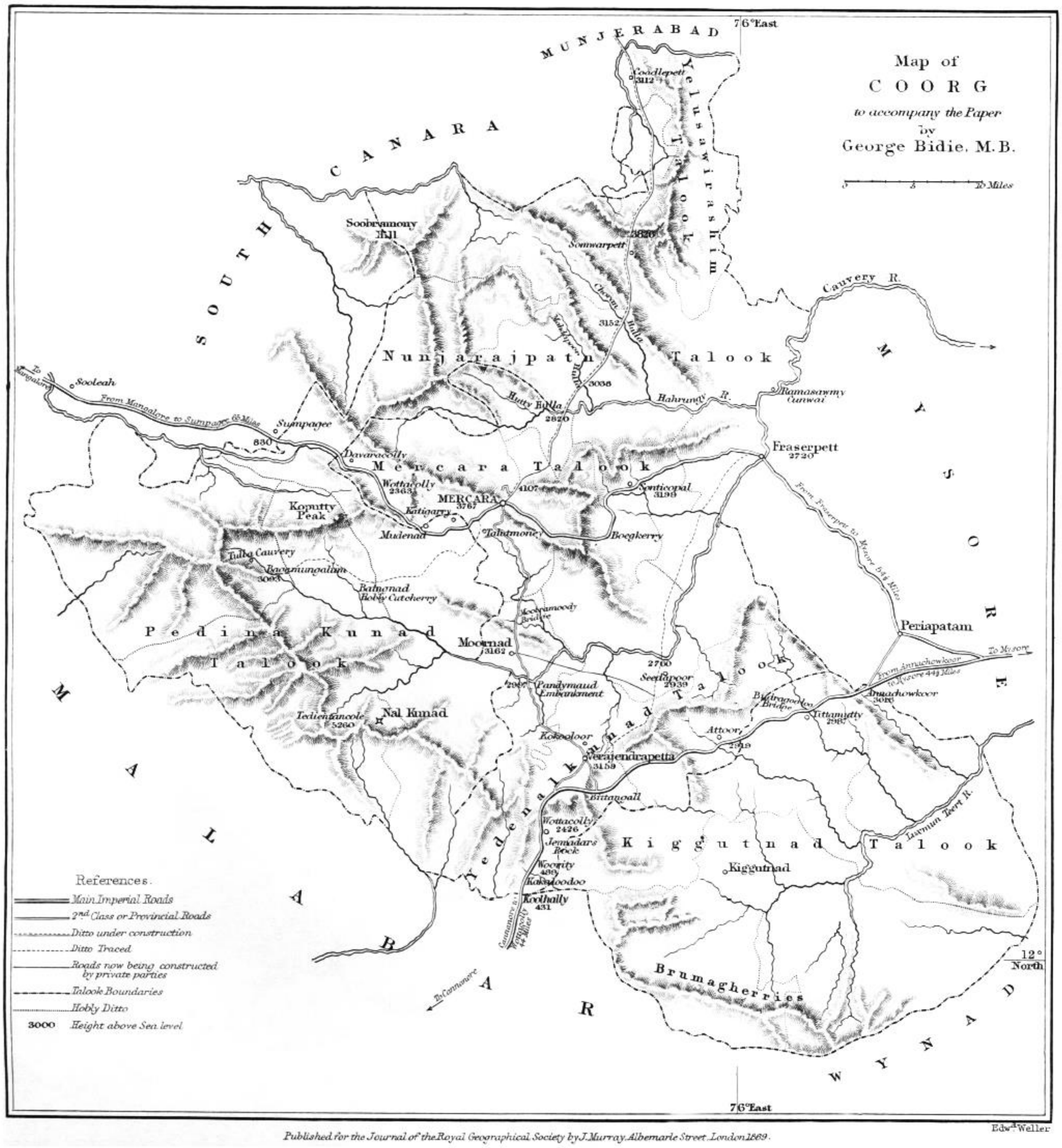


Figure 2.6: Map of Coorg (George Bidie (1869) Effects of Forest Destruction in Coorg. Journal of the Royal Geographical Society of London, 39:77)[21].

The Kodavas are considered the dominant community, and were originally hunter-gatherers who then settled in areas suitable for cultivation. This community traditionally

[21] Source: http://commons.wikimedia.org/wiki/File:CoorgMapBidie.png/
http://www.coorg.com/remembering-dr-bidie-his-observations-on-destruction-of-forests-in-coorg/

followed religious and social practices that revolved around animal practices. They are known to be ancestral and nature worshippers and to follow agrarian and martial traditions. Thus, the tools and weaponry used for agricultural practices, hunting, and for waging wars, are strongly associated with deep emotional and religious beliefs. Their reverential attitude towards nature had created a deep sense of respect and resulted in the protection of many forest landscapes, believed to be the forest dwellings of their Gods. Such values are also likely to have provided further protection to the wildlife inhabiting those landscapes. There is also some indication of a significant interaction between people and wildlife within some local traditions. For example, the festival of *Kailpodu* (celebrated in September month) signifies the need to prepare to guard the paddy crops from wild boars and other animals. However, some more common festivals like Ganesh (festival of the Elephant God) were not known to be a part of this local culture and belief system, but these are also now celebrated because of increased ethnic diversity within the region.

2.8 Human Elephant Interactions in Kodagu

As noted above (See Section 2.4.1), Kodagu is one of the important regions for elephant corridors in the state of the Western Ghats (See Figure 2.5). The elephant population in Kodagu is estimated to be around 1022 (Baskaran & Sukumar, 2010) which is about 16% of the total elephant population in Karnataka. The Elephant Preservation Act (1879) was the earliest attempt to protect wildlife in Kodagu (Sha, 1987; Bhagwat, 2002). This act could be due to the early recognition of the usefulness and popularity of elephants for timber transportation during British rule. Post-independence, Kodagu's forests were still being exploited for timber, although there seems to be some sort of protection of elephants incorporated into Forest Management systems. Kodagu's coffee agroforestry cultivation resembles natural forest areas are considered to be the resource storehouse for elephants especially with the native tree species as shade trees. With the availability of diverse elephant foods including fruiting trees (wild mangoes (*Mangifera indica*), jackfruit (*Artocarpus heterophyllus*), guava (*Psidium guajava*), orange (*Cirrus reticulata*), etc), browse and understory grasses, the elephants have been using the coffee estates regularly.

With the intensification of agricultural practices (growing economic demands, the shortage of available labourers for maintaining the right amount of tree-shade for coffee plant growth and better yield), coffee growers have been shifting to monoculture exotic plantation. Another important factor in the shift to exotic tree species in monoculture coffee plantations is because the elephants' frequent visits cause damage to coffee seeds and lead to higher levels of interaction with people. Poor visibility in coffee estates causes concerns over the security of people's lives and restricts their daily activities.

Hostile interactions between elephants and people are not a new phenomenon in Kodagu. However, the recent and escalating reports of elephants venturing into areas never previously reported (See Chapter 6) is a cause for concern for many, residents and conservationists alike. With increasing human-elephant encounters around the protected areas, the elephants' use of novel areas may become a much more widespread problem across the district, although this would not necessarily result in an increase in the intensity (or nature) of the problem.

Interactions between elephant and people and their consequences are also affected by various socio-economic and political factors in Kodagu and this has resulted in a failure to implement effective management techniques. With its unique terrain and agricultural practices, it is evident that these issues are multidimensional (Bal *et al*., 2008) and thus previous efforts to reduce the interactions between people and elephants have failed in Kodagu. Thus, this thesis aims to address these key issues in the context of the elephants' use of coffee estates and how people perceive the elephants.

Chapter 3

STUDY SITES AND METHODS

CHAPTER 3: STUDY SITES AND METHODS

3.1 Introduction

In this chapter, I describe the study sites and outline the data sources and methods of data collection used to assess interactions between elephants and people within coffee estates in Kodagu in Southern India. This chapter also provides a rationale for the choice of data collection methods reported in the remainder of this thesis.

3.2 Study Sites

In the previous chapter (Chapter 2) I broadly described the topography and history of Kodagu district. Here, I explain the reasons for the choice of my study sites; first, the choice of Virajpet *taluk*, and second, the selection of specific large coffee estates and their locations.

3.2.1 Coffee estates

In India, approximately 55.5% of the total land area planted with coffee is within Karnataka State (Reddy, 2013). Within Karnataka, Kodagu has the highest (57.5%) land under coffee and not surprisingly, coffee (*Caffea sp.*) is the main cash crop of the people of Kodagu (Deepika & Jyothishi, 2013). It is an annual crop and is labour intensive and both Robusta (73.3%) and Arabica (26.7%) varieties of coffee (See Appendix 3) are cultivated.

As described earlier (See Chapter 2, Section 2.4), coffee cultivation is carried out under the shade of native or exotic tree species, and such agro-forestry systems are thought to enhance biodiversity within a nonetheless human-dominated landscape. These coffee estates mirror natural habitats as they are covered with rich native tree species.

Although people are gradually turning to monoculture plantations, there are still large coffee estates that maintain a substantial native shade cover and also receive incentives for growing coffee in ecologically viable conditions. However, wild animals are not compelled to stay within the boundaries of protected areas and they move outside these areas during travel or in search of food and water resources. With an agroforestry system of cultivation, coffee estates have abundant foraging and water resources (for irrigation) that may attract wild animals. With coffee estates mirroring natural forest conditions and availability of food resources, it is important to examine the role of coffee estates in elephant movement paths and to try to identify the elephant populations who frequent these areas.

3.2.1.1 Protection from elephants entering coffee estates

Many endemic species of amphibians, small mammals and birds have survived because of a continued practice of agroforestry-cultivation system. As mentioned earlier, there are still large areas of coffee estates under native tree species, although exotic tree species are taking over as shade trees (See Chapter 2, Section 4). These areas also have water resources, in terms of water tanks for irrigation located within coffee estates. These resources attract many wild animal species from amphibians to small mammals (such as wild pigs and civet cats) to large mammals like elephants.

These wild animals cause considerable damage to cultivated crops and especially coffee, which is the major cash crop in this area. Elephants cause damage through trampling newly planted or replanted coffee plants, accidental damage during their movements within the coffee estates, and opportunistic consumption of coffee berries (Bal *et al*., 2008; See Chapter 7). Apart from elephants, there are other wild animals that cause considerable damage to crops and plants. Wild pigs cause considerable damage to crops like paddy rice, coffee, pepper, etc. Although they do not consume coffee berries or pepper, they damage the roots of these plants and uproot newly planted coffee or pepper plants when digging in search of food resources. Monkeys are also known to cause considerable damage to coffee berries during opportunistic consumption and related accidental damage.

Farmers are required to invest in protecting their crops from wildlife. In Kodagu, wild animals are prevented by management efforts by the Forest Department and the coffee estate owners from entering human settlements and agricultural lands. To prevent elephants and other wild animals from crossing over into the agricultural landscape, the Forest Department have dug elephant proof trenches (ETPs), or installed electric fences (or a combination of both) at forest boundaries. The effectiveness and management of these interventions are discussed in Chapter 8, Section 3.1).

Coffee estates are mostly protected by electric/ solar fences or barbed wire installed by the farmers. Electric or Solar fences require high maintenance and these are mostly installed by rich farmers (with large land-holdings), corporate estates and by a few village communities. These estates have a maintenance team of two to three people who check for any damage and carry out repairs (See Chapter 8). Although these fences aim to prevent elephants from entering agricultural land, the haphazard installation of fences across different locations may have resulted in deterring elephants from following their 'usual movement paths' (Hayward & Kerley, 2009; Loarie *et al.*, 2009; Vanak *et al.*, 2010). As a result, elephants may be using new areas and causing crop damage, which in turn affects the medium and smaller sized coffee estates that have little or no protection from wild animals. However, the benefits of installing these barriers may be short-lived; it is evident that elephants quickly learn to manoeuvre around or over these obstacles (See Figure 1.1 and 1.2; 3.1). Future research should focus on understanding the effectiveness of this unsystematic use of electric fences in preventing elephants entering coffee estates.

Figure 3.1 Two adult males crossing the electric fence between two large coffee estates. The top left panel shows that this fence is already bent (wooden pole) prior to the event when these photographs were taken.

In most large coffee estates, a few people are employed as guards or watchers to prevent coffee or pepper crop theft. One of their other duties is to check for presence of elephants in the estates (See Chapter 8, Section 4) and inform officials who will then alert the people working in the estates and sometimes the neighbouring estates. Corporate estates, like TATA Ltd., use a mobile network system where they send information on the presence of elephants in their estate through messages. Such networks not only prevent crop damage but also protect the people working in these estates. Other methods used by farmers to prevent crop damage or injury or death of people include poisons, gunshots, or illegal high voltage in electric fences. Similar methods are used across coffee estates but these have yet to be documented.

3.2.2 Selection of the study region

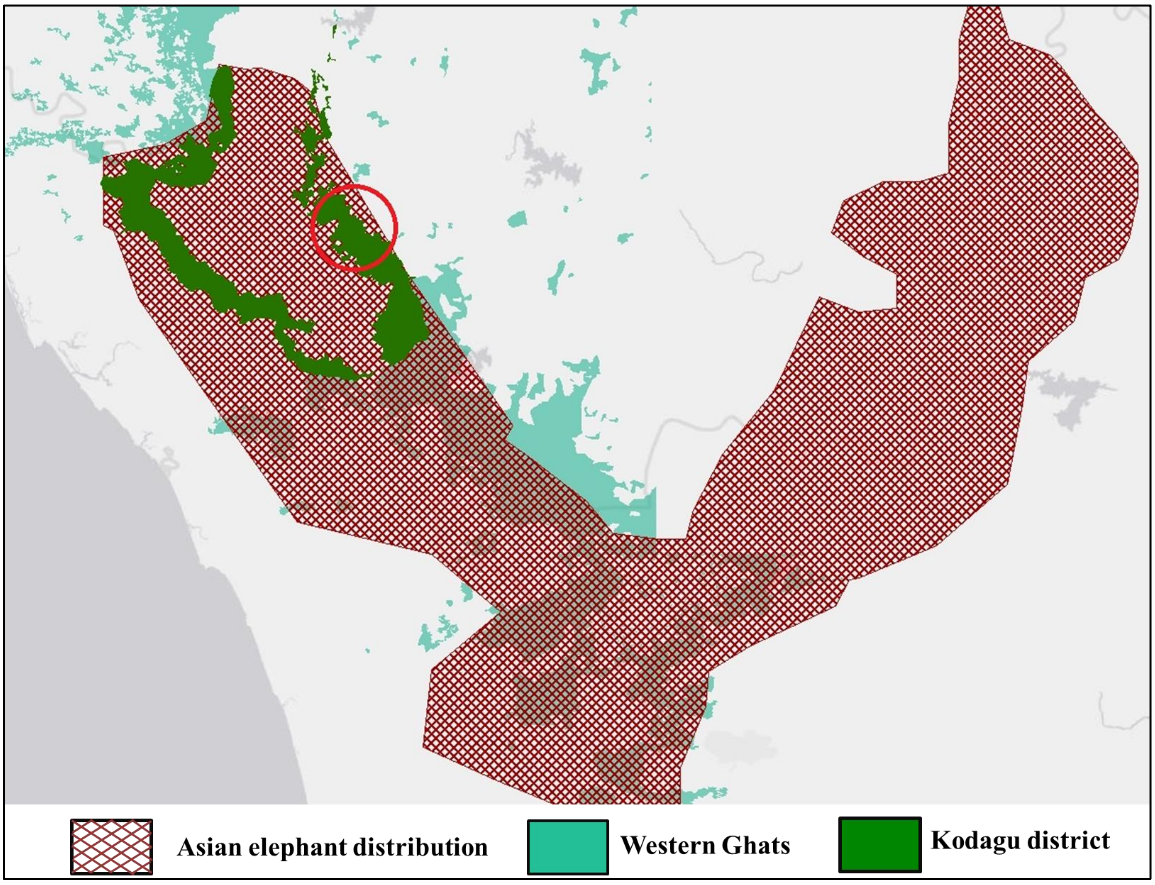
Preliminary results from compensation records[22] (Narayana, 2009) and previous studies (Nath & Sukumar, 1998; Kulkarni *et al*., 2007; Bal *et al*., 2008) suggested that the interface between elephants and people was highest in the north eastern region of Virjapet and Madikeri *taluk* respectively (See Chapter 4).

- In the Madikeri *taluk*, forests are mainly concentrated in the north eastern region, but these are severely fragmented and surrounded by agricultural lands and human settlements. The high level of human-elephant interaction was mostly attributed to an isolated elephant population within this area (number of elephant=25) (Bhoominathan *et al*., 2007)
- In the Virjapet *taluk*, the forest available to the elephant population is less fragmented, forming a continuous stretch of reserve forests and National Parks. However, preliminary analysis showed high levels of crop-raiding in north eastern areas, with a pattern suggesting that crop-raiding events had spread from east to the west over recent years[23] (Nath & Sukumar, 1998; Kulkarni *et al*., 2007; Bal *et al*., 2008).

[22] In addition to data collected for my Master's thesis, I revisited the compensation records to collect additional information and data during the first phase of my PhD fieldwork.

[23] Farmers have only recently been claiming compensation for the damage caused by wildlife, especially elephants. Previously, the number of complainants was low due to a lack of awareness of compensation schemes. There is no other documentation of the level of crop-raiding events across Kodagu, except for Forest Department Records (and these are only available from 1992 onwards). The available data indicates that crop-raiding events spread across the district from east to west.

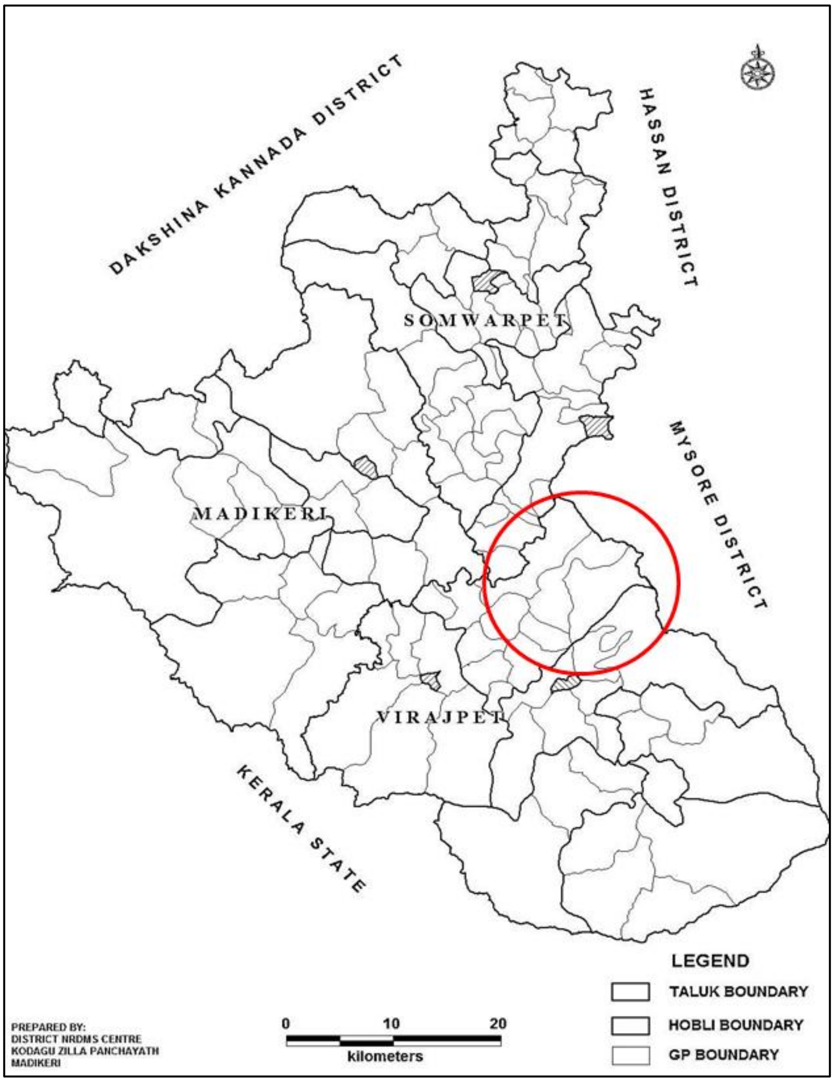
Reports on human-elephant interaction in North Kodagu, i.e., Madikeri *taluk* (e.g. Bhoominathan *et al*., 2008; Sukumar *et al*., 2012) have recommended the removal and translocation or captivity of elephant populations from this region[24]. Thus, the focus of the study concentrated on the Virajpet *taluk* (See Figure 3.2 a and b), in particular the north-eastern region. Within this area, the level of interaction between elephants and people was considered to be high and is also the location of most of the large area coffee estates.



(a)

Figure 3.2(a) Location of the study estates (Red Circle) in the north eastern region of South Kodagu, in relation to protected areas (both green shaded areas) and Asian elephant distribution in Southern India (See also Figure 1.4 and 2.5).

[24] The process of capturing the twenty five elephants in this area was underway at the time of the writing of this thesis and is now complete. Elephants have been kept captive for training at various forest camps scross Karnataka State



(b)

Figure 3.2(b) Location of the study estates (Red Circle) in the north eastern region of South Kodagu In reference to the three *taluks* of Kodagu.

Prior to start of my field work, I wanted to establish multiple study sites across the district but both *taluks* differed in the nature of human-elephant interactions. In addition, it was not logistically practical with a small research team to monitor multiple sites across the Kodagu district. My aim was to understand how and to what extent coffee estates are being used by elephant populations in their movement patterns. I assumed that with the availability of continuous stretches of forests (comprising reserve forests and national parks; See Figure 2.4 a and b); coffee estates would be used only for movement (possibly during migration period) with opportunistic raiding. However, coffee estates are not homogenous and vary greatly in size depending on the ownership, i.e. small, medium and large owners. I classified different farmer types on the basis of their extent of land-holdings (in ha). Thus,

- Small farmer: A farmer with landholdings of less than 5 ha
- Medium farmer: A farmer with landholdings between 5 ha to 30 ha
- Large farmer: A farmer with landholdings of more than 30 ha.

In India, about 99.1% of the total land area under coffee is in the form of small to medium landholdings (<10 ha) and only about 0.9% of the total land holdings in India are > 10 ha (Reddy, 2013). In Karnataka State, the total percentage of landholdings >10 ha is about only 2.8 %, while the rest of the total land under coffee is 97.2%. In Kodagu the percentage of land holdings >10 ha is very low (1.1%).

Table 3.1: Number of landholdings across Madikeri (including Somwarpet) *taluk* and Virajpet *taluk* in Kodagu district from 2010 to 2013 (Reddy, 2013).

Name of the region	2010 – 2011 (ha)			2011 – 2012 (ha)			2012 – 2013 (ha)		
	<10	**>10**	**Total**	**<10**	**>10**	**Total**	**<10**	**>10**	**Total**
Madikeri	19,789	236	20,025	20,422	236	20,658	20,422	236	20,658
Virajpet	21,171	219	21,390	21,168	188	21,356	22,864	253	23,117
Total	40,960	455	41,415	41,590	424	42,014	43,286	489	43,775

Larger landholdings do not necessarily imply a wealthy farmer.[25] During the coffee picking season[26] (February to April), there is a continuously high density of people present, irrespective of the size of the coffee estate. However, the smaller the area, the higher the concentration of people and human activity, which results in fewer isolated areas for elephants to move undisturbed within the sea of coffee estates. With constant human presence during both the preparation period and coffee berry ripening season, especially in small holdings I assumed that the elephants would be taking advantage of the isolated areas within the larger coffee estates to take refuge. Also my previous experience working on a different project for six months in the same area, I had not encountered elephants a single time.[27] The same was suggested by Bal *et al.* (2008) during their study in the coffee estates of Kodagu district, but no detailed examination was carried out to validate their assumption. Initial information gathering on the elephants' use of areas indicated that elephants were known to preferentially use or frequent larger estates (See Chapter 5).

---

[25] Production of agricultural crops depends on the location, type of crop, crop diseases, economic value of the crop and the availability of work force. For instance, a farmer may abandon paddy rice cultivation for the fear of loss of cultivated paddy to the elephants. The presence of elephants within coffee estates discourages people from working in the coffee estates resulting in shortage of labour and leads to increasing demand for better payment by workers. Very few established farmers and large corporate owners (For example, TATA Coffee Limited) are able to bear the increasing demand for high paid-workers.

[26] Although coffee is a perennial crop, it is labour-intensive with all-year round maintenance operations like weeding, pruning, irrigation, shade cover maintenance etc., to produce a high quality yield of coffee berries. However, these works are not carried at one period throughout the estate, but in specific areas in turn. This means that the rest of the estate area is mostly devoid of human presence, providing plenty of opportunity for elephants to rest or take refuge within the coffee estates (See Chapter 6 for further details).

[27] Nature of the work involved working all day including both early morning and late evening hours. There was not a single encounter or event with elephants. Although these were different coffee estates to that of this thesis, a part of these estates were located in Virajpet in the same region as those coffee estates in this study.

3.2.2.1 Research Team

The core team consisted of the principal investigator and two research assistants (RAs, Mr. Sharath and Mr. Pratap). I had previously worked with one research assistant on a Forestry College coffee biodiversity project and he was well trained in the use of hand-held GPS, line transect survey, vegetation survey and had a fairly good knowledge of local tree and plant species. He was given additional training on dung survey techniques prior to the start of field work. The second research assistant had no prior experience in field work methods and was trained by me in GPS recording, transects, and dung survey and collection prior to the study. I provided training to both research assistants on the identification of individual elephants, handling camera trap mountings and replacing the batteries, using camcorders for video recording, and most importantly on how to document the relevant information on any sightings during field work.

Due to the nature of work and environment, all the members of the team worked together throughout the field period. In the field, both assistants counted the number of elephants and if visibility was good enough identification of elephants was noted, before cross referencing their observations to my own[28]. On occasions when I was absent, the RAs recorded how they had received information about the elephants' presence, the number of elephants seen and if possible, the identity of the elephants, as well as the location of sightings, GPS points, time and date. In addition, every event or encounter with elephants was video documented. I would then cross check[29] between

[28] This was to ensure there was inter-observer reliability among all the three team members.

[29] Most of the cross referencing and checking of data collected by the research assistants were done on an ad hoc basis.

their data and the videos or photographs recorded. I also confirmed their observations of presence of elephants with the relevant local people/workers in the study sites.

In addition, reliability in measures of the count or quantity of coffee seeds was evaluated during dung sampling in the field. This cross-checking was done to ensure that there were no discrepancies in the data collected. Networking with the local people meant that they effectively became members of an extended research team for the study, gathering information on elephant presence in the study sites, and helping us to work efficiently and quickly in locating the elephants. This local reporting provided an opportunity for the research team to visit multiple sites to survey for elephant presence and to document numbers and sex, and where possible identify the elephants. For camera traps, initial training was provided to me by the manufacturer (Centre for Electronics Device and Technology, Indian Institute of Science, Bangalore). Subsequently, both research assistants were trained on how to set up and use the camera traps in the field by me[30].

Fieldwork was conducted for the period of 13 months from the March 2011 to April 2012. At least two members of the team were present at any given time during the fieldwork. Some of the days spent away from the study site included meetings with the stakeholders like farmers, coffee company managers, and outside Kodagu to repair or replace the corrupt camera trap units and to meet the higher Forest officials[31].

[30] Training included changing batteries, downloading pictures from the memory card, checking dates and times and most important, making sure the infrared light pointed in the right direction after mounting the camera traps on the tree. Practice sessions of mounting camera traps on trees and change of batteries were done for two weeks for familiarising with the mechanisms of working with the camera traps.

[31] In August 2011, I visited Stirling University (UK) for review meeting with my supervisors about the progress of my work (for a period of one month). I took personal leave for a period of three weeks in December, 2011. On both occasions my assistants were working for almost the entire period except for few days (2 to 4 days each occasion).

3.2.3 Selection of coffee estates

Given the absence of any initial data on elephant population movement and their presence within cultivated areas, I chose large corporative coffee estates as my study sites to document elephant groups, their movements and their activities within coffee estates. These estates are located at various locations in the north eastern region of Virajpet *taluk*, at varying distances from the forest boundary. The study coffee estates are seven divisions[32] of TATA Consultancy Services (head office located in Pollibetta) (See Figure 3.3 and Table 3.2). Although another corporative estate gave permission to access their estates during field work, they wanted to maintain anonymity.

Coffee plantations require intensive management protocols. Coffee estates are connected by small roads built to provide better access within each estate for the transportation of estate materials and people. For management purposes, each estate is further divided into sub-divisions and each sub-division is further subdivided into different blocks of varying size. Between these blocks, there are small access roads. Most of the small roads are private estate roads and are deserted between 6 pm to 6 am. The large coffee estates selected as study sites also already have systems in place for gathering information on the daily presence of elephants within their estates, as a safety measure for estate staff.

By networking effectively with the managerial and estate workers, their existing recording systems greatly aided in the collection of data on elephant populations and their regular use of areas within the estates. Developing these contacts also facilitated agreement on the use of camera traps, and helped to identify the best locations to place

[32] Refer to Appendix 1 for the definition of coffee estate divisions, subdivisions and blocks.

these. The aim was to identify the elephant population that frequented these estates through photo and video documentation (See Section 3.7).

The seven study sites varied in size (ranging from 200 to 600 ha.) but are all at an elevation ranging from 2600 – 3500 feet. Robusta is the main coffee variety cultivated in all estates, while Arabica was intercropped in three estates (Anandapur, Margolly and Yemmigoondi) as these are at a lower elevation than the other estates (See Appendix 3).

Table 3.2 Study coffee estates owned by TATA Consultancy Services (Pollibetta) (See Figure 3.3).

Estate Name	Altitude (ft)	Area (ha)	Distance to Forest (km)[33]	Presence of water	Protection of Estates
Anandapur	2600-3200	373	3.5	Yes	Electric fence, Guards, mobile networks
Balmany	2619-3036	224	0	Yes	Electric fence, Guards, mobile networks
Cottabetta	2831-3300	445	2.5	Yes	Electric fence, Guards, mobile networks
Margolly	2880-3150	477	1.0	Yes	Electric fence, Guards, mobile networks
Pollibetta	2897-3429	330	3.0	Yes	Electric fence, Guards, mobile networks
Woshully	3090-3180	528	1.5	Yes	Electric fence, Guards, mobile networks

[33] Distance measured on a digitized topographic map using ArcMAP 10. Distances calculated are approximate nearest point of the estate to the forest areas. Coffee estate division are located at different places, as are some subdivisions of these. For example: Yemmegoondi has three subdivisions (Doddayemmegoondi, Chikkayemmegoondi and Chennayanakote) in one location and the fourth subdivision (Siddapur) in another location.

Yemmigoondi	3030-3420	572	4.0	Yes	Electric fence, Guards, mobile networks
Estate A[34]	-	-	-	Yes	Electric/ Solar fence
Estate B	-	-	-	Yes	Electric/ Solar fence
Estate C	-	-	-	Yes	Electric/ Solar fence
Estate D	-	-	-	Yes	Electric/ Solar fence
Estate E	-	-	-	Yes	Electric/ Solar fence
Estate F	-	-	-	Yes	Electric/ Solar fence

[34] Estate A to F – This is the estate that granted access permission but wanted to remain anonymous. I accessed these estates for better visibility in circumstances when the elephants I was observing crossed over to these estates, or if there was any information on the presence of elephants within these estate boundaries. Information on elephants' presence was much lower than the other seven study estates (TATA coffee Ltd) as it was difficult to establish larger network of people to share information without the official permission and co-operation of the management. These estates are located at varying distances from the forest (0 to 3 km approximately)

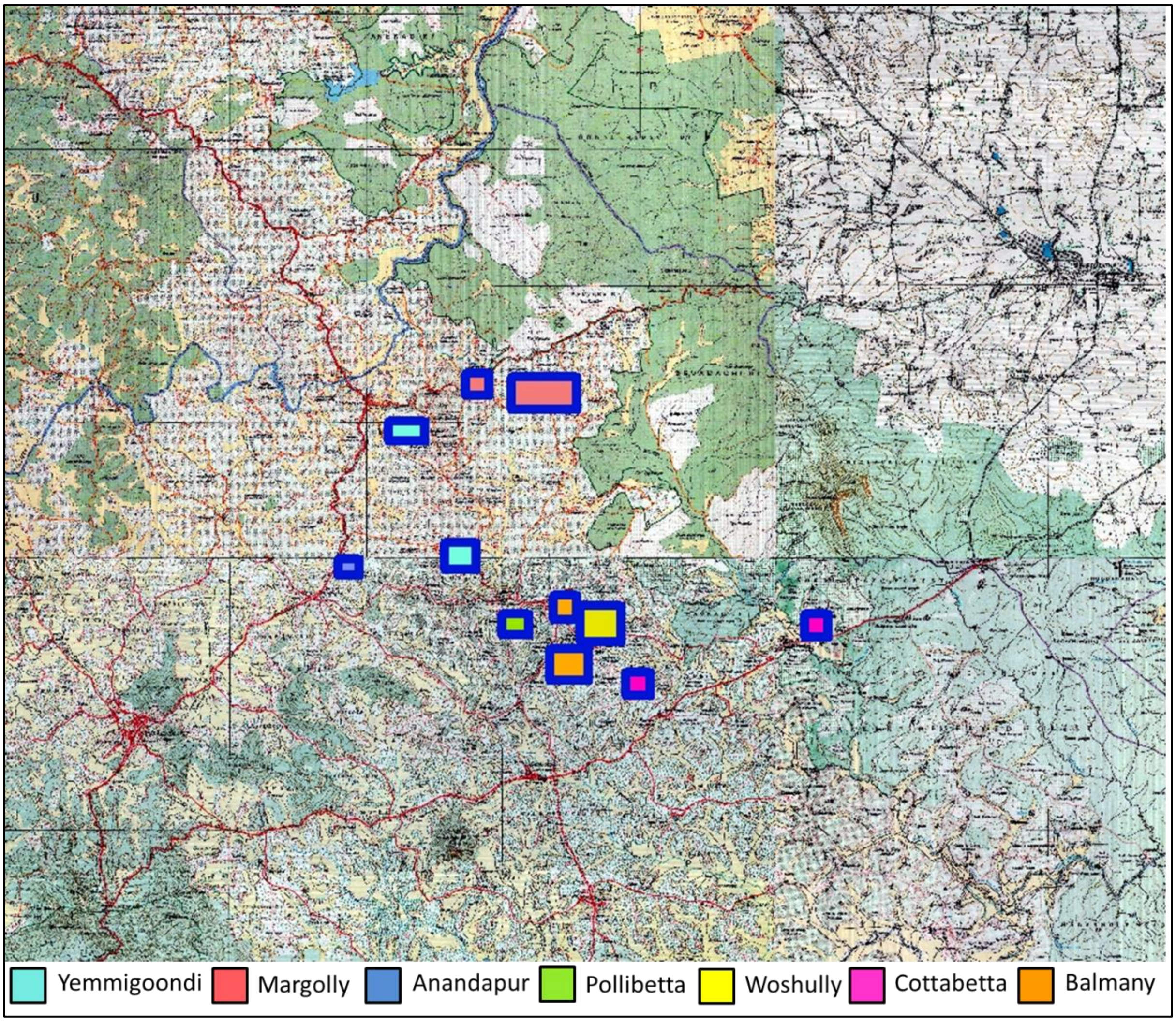


Figure 3.3: Location of seven divisions of TATA Coffee Ltd. Different colours represents each of the different coffee estate divisions. It can be noted here that some of the coffee estate subdivisions of one division are located at different locations. Estates A-F (See Table 3.1) are located between these estates, but are not represented in the map to maintain anonymity. Apart from these large corporative estates, there are also other large and smaller landholdings, both private and small corporative owned.

3.3 Methods

The study methods include both qualitative and quantitative data collection. There is a paucity of data on Kodagu's elephant population dynamics and their behavioural dynamics (Bal *et al*., 2008; Narayana, 2009). As a result, qualitative data collection was helpful in collecting initial information on the elephants' presence in coffee estates and their regular sightings within the specific study sites. These qualitative data were also used to aid in framing the research questions and to facilitate the interpretation of the quantitative analyses, in order to accommodate the study site's history, environment, setting, and socio-economic and political influences.

3.3.1 Secondary data collection to estimate patterns of crop-raiding events by elephants across Kodagu district

To understand and estimate the level of human-elephant interactions in a region, secondary data from Forest Department records on crop-raiding events, attacks by elephants on people, on-site information from local people, etc. were collected. Forest Department records are considered to be inaccurate and incomplete but are nonetheless considered to provide 'best available' (or indeed, the only) data to assess human-animal interaction through crop-damage events, especially elephant and people interaction, over time. Previous studies evaluating human-elephant interactions in Kodagu (Nath & Sukumar, 1998; Kulkarni *et al*., 2007; Bal *et al*., 2008) have also used these records for estimating ranging patterns of human-elephant interactions in Kodagu, including the extent of such interactions in different villages over time. These studies evaluated spatial trends of these events to determine the high, low and medium regions of elephant movements within the human-dominated landscape of Kodagu. I have also used similar methods to determine the spatial trend of events, including data from the available compensation records from the 1990's until recent years and prior to my field work. Results were used to identify a specific study region and sites suitable for collecting further information to determine and understand use of coffee estates by elephants.

The first phase of my field study commenced with visits to Kodagu's Forest Department across three *taluks* (Madikeri, Virajpet and Somwarpet) and Hunsur district (See Chapter 4, Section 2) to collect records on crop-compensation events, human death and injury cases caused by elephants and elephant deaths. Records are stored in two formats within the Forest Department, one is the actual application and inspection of events and the second type is the summarized version for the Forest Department's internal procedures. Different protocols in the accessibility and distribution of the compensation records at each division caused difficulty in accessing information quickly and identifying the original crop compensation records. For instance, data had to be extracted from older handwritten records, as these records were not allowed to be removed out of the Forest Department for photocopying. Digital copies of records for the most recent 5 to 10 years were accessible in a few divisions which had computerised data available. The possibility of photographing these records was considered, but for a few entries the comprehension and clarity of handwritten data had to be confirmed with the Forest Department staff in charge of these records. In addition, except for the few digitized data which were in English (only in the most recent 3-4 years), most of the entries were in local language Kannada, in both hard copy and digitized versions. However, wherever possible, efforts were made by me and the assistants to collect as much information as possible from both original and summarized records. The data collected were i) the type and quantity of crop damage, ii) the amount of compensation applied for, iii) the date of events recorded and iv) amount of compensation awarded. Updates to these data were monitored and incorporated throughout the field period.

3.3.2 GIS Data

I aimed to determine elephant movement paths across the agro-forestry landscape of Kodagu. However, with no existing information available on the elephant population of Kodagu, it would have been difficult to identify resident and migrant[35] elephants and to observe their movement paths, either through GPS-collars or following them on daily basis. Long-term monitoring is necessary for the identification of elephant individuals or groups that are frequent users of coffee plantations, and to implement radio/GPS collars to determine their movements and behavioural dynamics. It also requires the complicated and extended process of applying for relevant permissions[36] from the Forest Department for initial monitoring and the subsequent use and set-up of a radio/GPS collar system for monitoring. Logistically, this was not possible within the time frame of my field work.

Instead, I decided to follow and identify the elephant individuals or groups that were currently using my specific study sites. A hand held Global Positioning System (GPS) was used to record the locations where elephants were present, refuge hotspots (or refuge areas; See Footnote 37 or Chapter 6, Section 2.1), study area boundaries, coffee in elephant dung and its location within the estates, and also the positioning of camera traps within the study area. I used two Garmin GPSMAP® 60CSx handheld GPS devices to take GPS co-ordinates during my fieldwork. These GPS coordinates were then mapped using ArcGIS (version 10) on the digitized topographic maps obtained from Survey of India, Bangalore.

[35] The elephant population using the coffee agro-forestry landscape of Kodagu district has not been previously studied. As a result, there is no documentation of elephants using Kodagu district as their permanent home range or using the Kodagu landscape during seasonal movement.

[36] There are long delays due to the bureaucratic processes involved.

The elephant population demography and behavioural dynamics have been poorly documented across Kodagu district as compared to other elephant ranges in India. There is a lack of data on elephant movement within the agro-forestry landscape and how and to what extent they are using these coffee estates. Previous studies (Kulkarni *et al.*, 2007; Bal *et al.*, 2008) have identified elephants within Kodagu's landscape, but there is no precise documentation of the area and routes taken by elephants. These previous studies indicated that the elephants may have been using the coffee estates as hiding places during movement, but there was no systematic documentation of the frequency of use of the place or which are the elephant individuals or groups using such areas. Information was also available in the form of local people and farmers' views on elephant presence in their respective region or farm. Although communicating with local people provides unsubstantiated qualitative evidence, this method provided initial data for further follow-up study with camera-trapping, or identifying refuge hotspots, etc. This process was useful to establish baseline information to carry out further long-term monitoring of the elephant population. After establishing study sites, information was gathered from local people, managers of estate and estate workers on:

- Areas most frequented by elephants which included
    - Standing area (resting area during the day when there is high human activity)
    - Water tanks
    - Feeding areas
    - Entry and exit points to the estates (specific to study sites)
- Any known elephant individuals that the local people could identify from previous experience

Estate blocks (as categorised by estate management) were used to document these data to facilitate easy communication with local people and provided reference points for the identification of precise locations of elephant presence. I then recorded GPS co-ordinates of each site and later compared these sites with my own direct sightings of elephants within the estates. These locations were divided into two categories:

- Refuge areas[37]: These are areas considered to be resting sites of elephants within each estate according to local knowledge (See Chapter 6, Section 2.1). These areas are located within the coffee plants blocks within the estates and considered to be 'hiding' areas of elephants especially during the day-time (when there is human activity).
- Exit and/or Entry points: These locations were identified by frequent breaking points of electric fences at estate boundaries, and where elephants were thought to enter and/or exit the study sites.

Although there were many such locations, it was noted during the field study period that there were specific points where the elephants most frequently entered or exited these area. These locations were used to deploy camera traps (See Section 3.3.5). Some estates had been accessed by elephants along much of their boundaries, but observation during field visits suggested preferences for specific locations. These were expected to correlate to refuge areas documented within the estate, and movement from one estate to another, for example in relation to access to food and water resources. Thus the presence or absence of variables comprising water tanks, fruit trees like jackfruit,

[37] Specific areas within the coffee estates were considered to be frequently used by elephants as refuge areas during the day-time, as reported by local people (estate owners, workers, managers, etc). These areas were noted down and GPS points were taken during the reconnaissance field session for the study sites (coffee estates). Further, these areas were monitored during the fieldwork to check whether elephants frequented these areas and also if there were other such areas within the study coffee estates.

orange, arecanut, etc. were all noted in the immediate surroundings of refuge areas. Importantly, location preferences could also indicate the elephants' avoidance of people, who are highly active within the estates, especially during the day

3.3.3 Dung surveys

For successful management implementation in a region, knowledge about the elephants' seasonal distribution and the demography of the local population is of key importance (Dawson & Dekker, 1992; Varma *et al*., 2012). Knowledge of current Asia's elephant population is estimated by using various methods; being a forest species, it is difficult to count all elephants visually and thus various methods have been adapted and used to estimate the elephant numbers. The most common type of indirect census methods of elephants is the dung count (Barnes, 1996). Dung count methods are used for two main reasons, i.e. to calculate an index of elephant abundance or relative distribution and also to estimate the number of elephants. There are four stages to estimate elephant number: estimation of dung density piles per km^2, estimation of defecation rate of elephants, mean rate of dung decay, and all of the above is combined to estimate elephant numbers.

Dung surveys were carried out at the study site to determine coffee consumption of elephants by estimating the number of coffee seeds in the dung (See Chapter 7, Section 2). Asian elephants are known to be a dispersal agent of coffee (Joshi *et al.*, 2009; Kumar *et al*., 2010). Bal *et al*. (2008) have suggested that although there is a new trend in coffee as a novel food resource, it may be limited to few individuals in the population, with the potential to spread within the population. As an extension of previous research, the presence of dungs was monitored in relation to elephant visits to the coffee estates. Dung surveys were carried out in two phases. The first phase included a line-transect method and in the second phase, only fresh dungs were surveyed when these were available. However, the line transect method was abandoned[38] (See Appendix 5) and most of the dung surveys in the second phase were carried out only in those locations where elephant presence was observed on the previous day or the same day.

The GPS location of each dung pile was recorded when encountered. Records of dung bolus diameter, number of boli in each dung pile, weight, contents of dung, presence or absence of coffee seeds, fruits like jackfruit, mango, etc., and fibres were documented (See Chapter 7). Barnes and Jensen (1987; cited by Barnes, 1996) classification of dung piles according to the dung shape were also noted down (See Appendix 5, Table 1 Classification of dung piles). Bolus diameter is known to be an indicator of age in elephants as these is found to be positively correlated (Jachmann & Bell, 1984; Reilly 2002; Morgan & Lee, 2003; Morrisson *et al*., 2005). If there is no apparent deformation of boli due to the ground impact, then it is considered intact (Morrison *et al*., 2005). Then the measurement of long and short axes of the cylindrical shape is recorded. The mean of the two measures would be considered as the diameter of the bolus. In this study, boli were measured whenever they were found to be intact. However, due to their impact with the ground, the dung cracked or sflattened leading to a small sample of dung with intact boli for measurements.

3.3.3.1 Methods for assessment of coffee seeds, fruits and fibre in dung

Coffee berries have two cotyledon seeds and are in the form of a drupe. Estimating the number of coffee seeds in the dung of elephants should allow an estimation of the

---

[38] I have only reported the line transect method used along with the classification of dung piles according to their shape and state in Appendix 4 to provide information on the process of developing the methodology. Elephant density or dung density analysis is not considered further in this thesis due to a lack of sufficient data.

magnitude of coffee berry consumption by elephants. The dung was examined for presence of coffee seeds and these were individually counted and weighed to check the magnitude of coffee consumption by elephants (See Figure 3.3).

Figure 3.3 Boli Measurement and Research Assistants counting coffee seeds present in the dung.

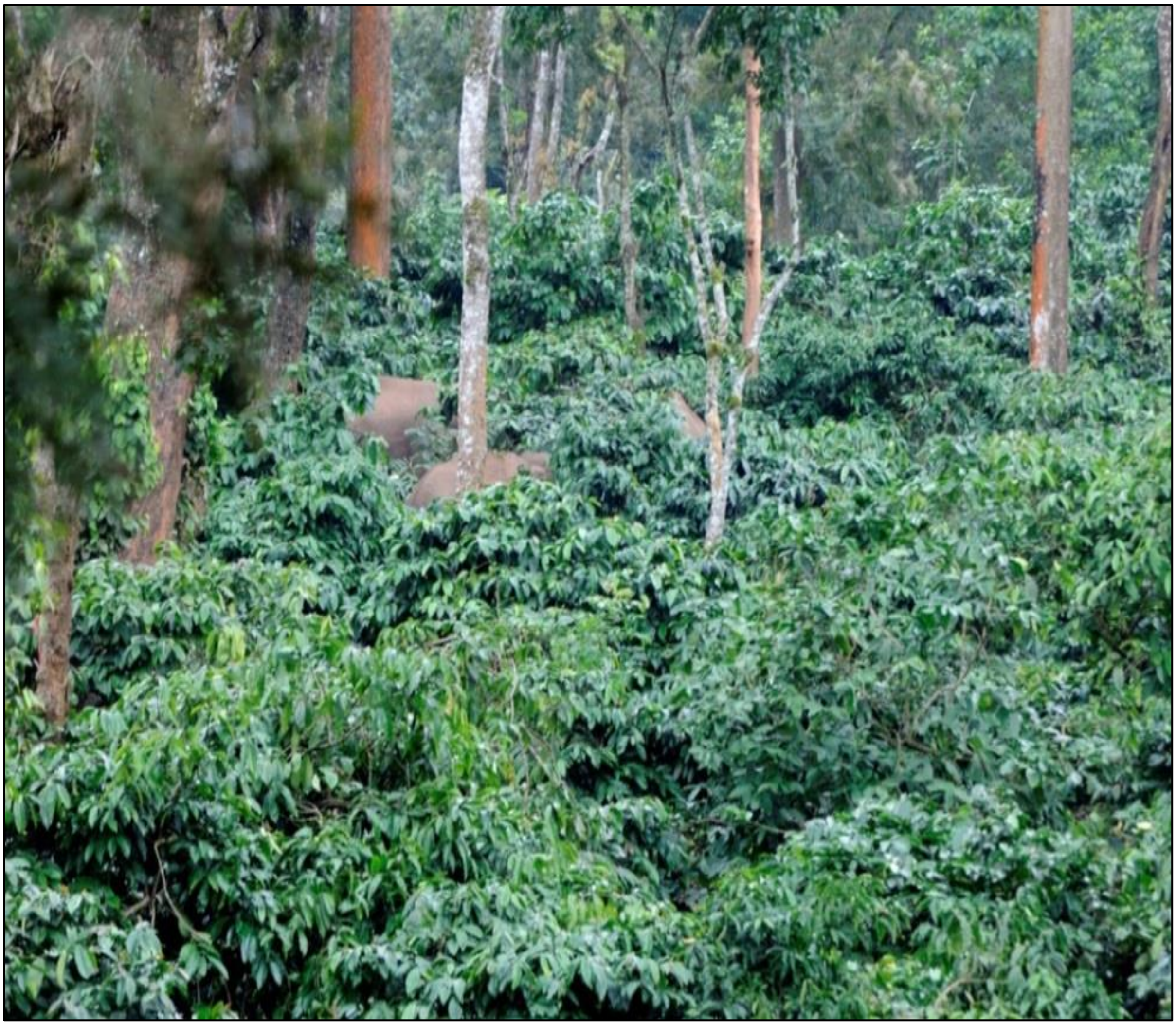
The presence of other fruits like jackfruit (*Artocarpus heterophyllus*), orange (*Cirrus reticulata*), guava (*Psidium gujava*), ramphal (*Annona reticulata*)[39] and fibres were also recorded. Coffee seeds in each dung pile were counted and weighed using the portable 5 kilogram weighing scale. All the fruit content types were also weighed together and separately for each content type (See Chapter 7, Section 2).

3.3.4 Video documentation and photo documentation

Video documentation was used to record the events and possible behavioural responses of elephants towards threats, especially people. Initially, photo documentation was the choice of method to document the identity (ID) of individual elephants and groups. However, the height of Robusta coffee plants greatly reduced the visibility of elephants making photo documentation difficult (See Figure 3.4 a, b; See Video 2 and 3 Appendix

[39] The presence of ramphal seeds were noted down whenever identified in dung surveys. However, as these seeds were small and partially digested, the possibility of finding and identifying these seeds was very low and due to a small sample these data were not used in any analyses.

12). Even with stationary elephants during the day, visibility was very poor as they would take refuge in between coffee plants (under the canopy of coffee plants). Better visibility was possible near the water tanks, during the evening and morning hours, or on small estate roads when they moved from point A to point B between different blocks on the estate. Video recording was chosen because the time was also recorded and could be cross referenced with behavioural observations. Video documentation of elephants was recorded with the aid of two hand held camcorders (Hi8 8mm cassette Sony camcorder and Sanyo Xacti digital camcorder) whereas for photo documentation a Nikon D3000 DSLR (55-200mm lens) was used.



(a)

Figure 3.4 (a) Elephants as seen in Robusta coffee areas.

(b)

Figure 3.4 (b) Elephants as seen in Arabica coffee areas.

3.3.5 Camera traps

Until recently, camera traps have not been extensively used for studying elephants and studies are still being carried out to optimise the use of camera traps for identification through a capture-recapture method. Camera traps were used as an additional support for video and photo documentation for elephant group identification. In Kodagu, most plantations cultivate Robusta (*Coffea canephora*) rather than Arabica (*Coffea arabica*) as it requires a thin canopy shade cover, maintenance is easier for the management, and it is also less prone to diseases (such as white stem borer[40]) than Arabica. However, Robusta coffee is a mid-storey tree that grows up to a height of 10m, whereas Arabica

[40] White stem borer (*Xylotrechus quadripes*) is a pest that reduces the yield of Arabica coffee plants in India to about 40%. Infested plants need to be uprooted and new plants established at a substantial loss to the coffee farmers.

is a small shrub that grows to about 1.5 to 3 meters. This proved to be disadvantageous as elephants took refuge amidst coffee pants during the day reducing their visibility. During the day, the elephants appeared to have learned to avoid people who are working in certain parts of the estates and during the coffee picking season there are more people working throughout the estate. I used camera traps to aid the identification of individual elephants and to support in video and photo identification within the study sites. Elephants took refuge within the large coffee plants, and came out in to open only in the evenings until early mornings, or when there was no human activity. It was important to document the presence of elephants within the study site and also identify these elephants.

Before installing the camera traps, it was necessary to identify those places that the elephants frequented within the study area. During the first phase of field work, my initial discussions with local people had identified those locations that were considered the most frequented by elephants, including elephant exit and entry points, provided initial locations within the study sites. Most people identified these locations based on previous experiences of incidence/encounters that they or others they knew had with the elephants. It appeared that some locations served as both entry and exit points and others either as only entry or only exit points. These areas were marked and later surveyed to examine any sign of frequent use by elephants, such as the amount of damage to the coffee plants, presence of dungs, footprints, etc. Observations were made during the first two months of the field study, whenever information about elephant presence was made available to the research team. Such locations were noted down and were crossed checked with the locations given by the people about frequently used locations and entry and exit points. The high frequency usage of certain exit and entry points could be attributed to the accessibility of boundaries for elephants (See Figure

3.5). These locations may indicate weak points of the electric fences or better conditions for breaking electric or solar fences, or an advantageous elevation level, especially when there are young calves in a group.

Figure 3.5 Fence installed at the boundary of an estate, where such locations are weak points that provide easy accessibility for elephants to enter or exit an estate.

Camera traps were initially placed in April, 2011 and continued to be used until the end of the field season (March 2012). Initially, the camera trap units were installed and mounted near the identified and exit and/or entry points of elephants into the estates. However, the low view range of in these locations the quality of the pictures of elephants was low overall. Later, these camera trap units were mounted on trees near a road junction, refuge areas and water tanks. These sampling locations were selected in relation to the identified and observed frequent usage of the areas by elephants during the first phase of the fieldwork. Since camera trap units were not used as a capture-recapture method, but only for documentation and identification of elephant individuals, these were not installed at fixed location and there was no specific duration of time for each sampling location. Camera trap units were relocated based on information of elephants' presence and movement within the estates for opportunistic documentation. Although there were many potential locations, about 22 locations were identified as the most frequent used areas by the elephants in the study sites and thus camera trap units were more frequently installed in these locations.

Camera traps were provided by Dr. André Pittet (Center for Electronics Design and technology, Indian Institute of Science, Bangalore, as a student rental). However, there were only eight camera traps available and no additional cameras were purchased because of financial constraints. To be able to utilise the eight camera traps efficiently, camera traps were moved to different locations at a given time depending on the information available on the presence of elephants. The main objective in using camera traps was to be able to get clear images to identify the individuals and thus was used accordingly, while also bearing in mind the statistical bias of locating cameras only where sightings had already occurred. All camera trap locations were also recorded through GPS.

Camera traps were placed in secure, metal cases to avoid any damage and lower the probability of theft (See Figure 3.6). The design for the metal cases was provided by Dr. Veeramani (from the Periyar Foundation) who had these cases made to avoid damage by elephants when using camera traps for the identification of tigers. These metal camera trap cases were then secured to trees (See Figure 3.7), with the help of straps, metal chains and padlocks. The batteries were changed every three to five days depending on the usage. However, it was important to monitor human activity in these areas because the camera traps were triggered if there was any work occurring at that location and the memory card would be filled with photos of people at the end of the day[41] (See Figure 3.8).

Figure 3.6 Design of metal case to secure camera traps from elephant damage and theft by people.

[41] The photos taken by camera traps of people could be of those instances where (i) people were working in the area where the camera traps were mounted (ii) when the people were curious of the camera traps and spend time in front of the cameras resulting in many pictures filling up the memory.

Figure 3.7 Mounted camera trap on the tree (the red circle) and example camera trap images.

Figure 3.8 Example location of the camera trap mounted on a frequently used area by the elephants and instance of people photographed during work (Boundary between Gattadhulla Estate and neighboring estate).

3.3.6 Identification of individuals, groups and age-sex classification

There is a lack of long-term systematic data on the elephant population using the agro-forestry landscape in Kodagu, necessary to determine if the population is transitory or resident elephants. During my field work, I tried to identify at least some elephant individuals using areas within my study sites (See Chapter 5, Section 3.5). To cross reference the elephant individuals identified, additional data collected through photo and video documentation data were used. Age-sex classification of the elephant individuals and groups were estimated according to the field key for Asian elephant age and sex classification (Dawson & Dekker, 1992; Varma *et al.*, 2012; See Chapter 5, Table 5.1 in Chapter 5, Section 3.4 for details). In addition, males were classified into tuskers (including single tusks) and Makhnas (tuskless bulls) (See Table 5.2 in Chapter 5, Section 3.5.1 for further details). Any unidentified adult or sub-adult or calf elephant which it is not able to categorize as male or female were recorded as Unknown.

3.3.7 Qualitative Data Collection and Descriptive Analysis

A pilot study was conducted in the study area over two months (May - June, 2009; submitted as a thesis in partial fulfilment of an MSc degree, See Chapter 8). I interviewed local farmers across the district to understand and evaluate the attitudes of people towards and their interactions with elephants. Questionnaires and semi-structured interviews were used to collect data on people’s perception and attitudes (See Appendix 12). I used a snowballing sampling[42] method where certain criteria were established prior to the study but respondents were sometimes contacted via the social networks of the respondents in the first few interviews. Demographic information about respondents was collected using a questionnaire, whereas the semi-structured interviews helped in engaging the respondents in a discussion, to be better able to understand their

[42] Respondents were recruited through a network of contacts of the existing respondents

perceptions and attitudes towards elephants and towards conservation and wildlife in general. Respondents' consent for participation and permission to record the interview were confirmed orally prior to the interview (See Chapter 8).

During the current study, this approach was also used in terms of informal and semi-structured interviews conducted with the estate managers, estate workers, and Forest Department officials to understand their perceptions and attitudes towards the presence of elephants in coffee estates, and also to identify the strategies they used to cope with their presence. Interviews were recorded using the Olympus WS560 and SONY MP3 (ICD-UX60/S) record players.

3.3.8 Behavioural Observations

Understanding behavioural responses are crucial for the management and mitigation of a human-elephant interface (Kumara *et al*., 2012). Whenever there was an opportunity to observe the elephants in good visibility conditions for more than one minute, I noted down their activity and also tried to video record their behaviour. Behavioural observations were also made whenever possible during interactions between people and elephants, including the encounters between the elephants and the research team. However, there were few observations of interactions between people and elephants and these data were limited and not robust because the elephants were overwhelmingly observed in coffee estates either before or after the working day. Elephants preferred to take refuge during the day-time and came out of their hide-out only when humans were absent or their numbers were extremely low. Elephant responses to the research team (either on foot or vehicle) are also biased as obvious reactions by elephants to the team were stimulated by the constant presence of the team. Overall, the resulting sample size from this opportunistic sampling method was too small to conduct reliable analysis on the data collected. Nonetheless, I recorded each elephant’s response as *ad-libitum* data and I will refer to these data in my discussion of people’s perception about elephants and their interactions (See Chapter 8).

3.4 Data Analysis

Statistical analyses and graphical representations of data were carried out using the SPSS statistical package (IBM version 19) with some basic analyses conducted in Microsoft Excel (2010). Probabilities were two tailed and were considered significant when p<0.05. The main tests used throughout the thesis were:

3.4.1 Chi-square

Most of the data in the study are categorical frequencies or events and thus chi square (X2) tests were used. For binomial or one-sample X2 tests, categories were considered to be equally probably, thus the expected values were considered to be the same. During the study, I collected data on the presence of elephants within the coffee estates, their group size, age-sex class and identification of individual elephants whenever possible. The lack of information on the elephant population across Kodagu made it difficult to expect any kind of pattern in group size, or in the composition of the elephant groups, and their presence within the estates. It was also impossible to predict which elephants and how many elephants I would be observing on any given day and lower visibility also made observations more challenging. Thus, to analyse the significance of the data, expected values were considered equal between cells. One of the assumptions of the chi-square tests is that the expected frequencies have to be greater than five, with an expected value of 5 occurring in less than 20% of cells and with no expected frequencies occurring below one (Field, 2005). However, the small sample sizes of sightings resulted in expected frequencies less than five occurring in more than 20% of cells, as reported in the analyses included in chapter 4.

3.4.2 Univariate Analysis

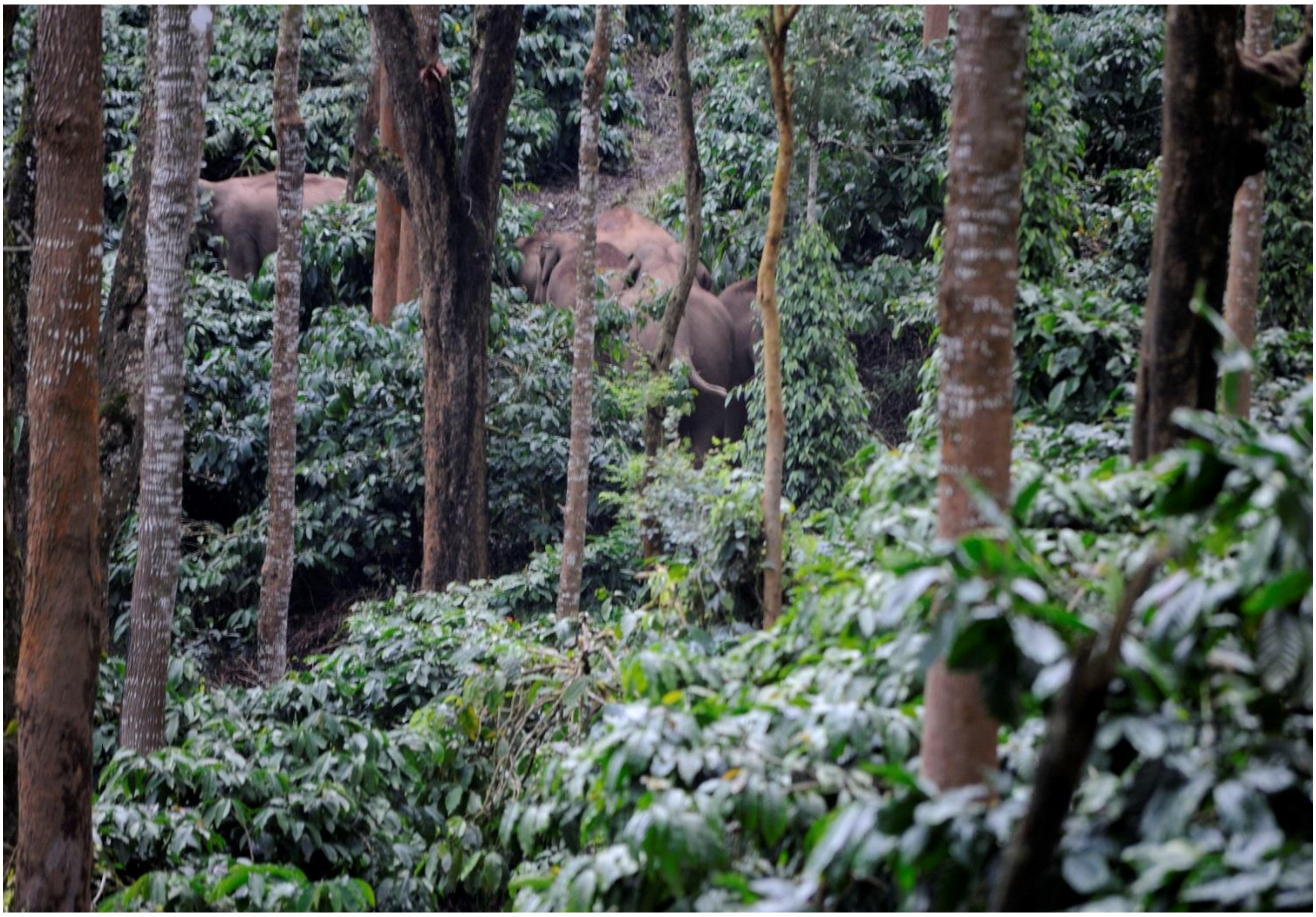
Univariate Analysis of Variance (Anova) was conducted to determine which of the variables were affecting elephant visits to estates and their use of coffee estates as Refuge areas (See Chapter 5 and 6). The dependent variables in these tests were elephant numbers, group sizes, or group type (mixed sex, male or female), while the independent variables were fruit presence/absence, season, refuge area presence/absence, human presence/absence and distance to primary forest in metres. All variables were entered together in a hierarchical model, and only the significant factors or interactions are reported. Details of the variables and tests are provided in the relevant chapters.

3.5 Summary

In this chapter, the sampling methods and techniques used in my field work were outlined, including an evaluation of these approaches and their limitations in this particular research context. A broad range of techniques were used to try and identify the best means of monitoring elephant presence and activity (transects, dung surveys, qualitative reports and structured interviews, camera traps) but not all of these provided adequate sample sizes or data or sufficient quality of data for inclusion in analyses. Due to small sample size, there is a lack of statistical power to enable clear conclusions to be drawn from the data collected. However the diverse range of methods used provide a valuable insight into the challenges of studying human elephant interactions in this context, and taken together these data do provide an initial overview of elephant activity in this region that can be used to inform future research effort.

Chapter 4

REGIONAL PATTERNS OF CROP DAMAGE



CHAPTER 4: REGIONAL PATTERNS OF CROP DAMAGE

4.1 Introduction

The interaction interface between wildlife and people has resulted in damage to crops, property, livestock and a relatively small number of injuries and fatalities to both species (See Chapter 1). When charismatic species like elephants, tigers, leopards are involved in these encounters, people may display more hostility to such species rather than towards those animals, such as rodents or birds that cause more actual damage to crops. Animals like snakes or scorpions may not cause damage to crops or property but are a threat to life. However, this threat does not necessarily result in negative perception or attitudes of people towards wildlife, for example to snakes. Villagers or farmers in rural India worship snakes as 'Gods' and they are considered to be a boon as snakes keep rodents from destroying agricultural crops. Also, it is common to find snakes in village homes; when detected they are either caught to be relocated or killed. Recent awareness and conservation campaigns have encouraged people to develop tolerance towards snakes in the cities and provide support in relocating snakes to forest areas which are mostly located in the outskirts of the city limit.

Large species are easily visible, are threatening and leave behind tell-tale signs of the damage that they have caused. As discussed in Chapter 1, human-elephant hostile interactions are measured by damage caused to crops, houses, properties, human injuries and casualties and elephant deaths due to people (Barau & Bist, 1995; Balasubramanian *et al*., 1995; Sukumar, 1989; 2003; 2011; Zhang & Wang, 2003).

Crop damage by wildlife and especially elephants is not a new phenomenon, but rather has been in existence from the advent of agriculture (See Chapter 1, Section 4.3). The extent of crop depredation by elephants varies across its ranges both in Africa and Asia (Sukumar, 2003). Crop-raiding incidents have been documented at high intensities in fragmented landscapes with low-density elephant population as in northern West Bengal and at low levels in an area with prime elephant habitat and a high density population as in Nilgiri Biosphere Reserve, South India (Sukumar, 2003). The extent of damage is suggested to be higher when there is closer proximity of cultivated lands to elephant habitats.

4.1.1 Interface intensity level in Kodagu – Crop-raiding

Elephants are known to consume most human food plants and thus feed on almost all cultivars that people grow (Sukumar, 1989; 2003). Elephants are also generalists in their feeding choices. Agricultural plants are often more nutritious, having higher palatability and less toxicity than wild elephant foods (Sukumar, 1989; Sukumar & Gadgil, 1988), and are easy to access in large quantities. These traits allow these generalist feeders to readily adapt to consuming human food resources. Elephants are thus directly in competition with people’s food resources and indirectly by using the same resources as livestock.

Crop-raiding can be explained in terms of proximate and ultimate causes (Sukumar, 1994). Expansion of cultivated lands and increased movement of people into elephant habitats (Blair *et al*., 1979), compression of elephant populations (Hoare, 1997; Graham, 2006), rainfall patterns (Hoare, 1997; Graham, 2006) and preference for agricultural crops by elephants (Sukumar, 1989; Webber *et al*., 2011) are considered to be proximate causes of crop-raiding. Crop-raiding seasonality is associated with the close proximity of cultivated lands to protected area boundaries (Naughton-Treves *et al*., 1999), seasonal reductions in natural grass availability and quality (Osborn, 2004) and to specific harvesting crop cycles (Sukumar, 1989, 1990). Sukumar and Gadgil (1988) attributed the ultimate cause to social organization and the "high-risk, high-gain" crop-raiding strategy to increase fitness (Sukumar, 1991; Chiyo *et al*., 2012) and reproductive success in the context of male-male competition. Solitary male elephants or group of bulls are considered to cause most of the raids in India (Desai & Bhaskaran, 1996) and in Sri Lanka (Fernando *et al*., 2008b).

As mentioned above, crop-raiding is suggested to occur due to attraction of elephants towards high nutrient quality and palatability of crops along with reduced chemical defences and high water retention ability of cultivated crops compared to wild vegetation (Sukumar, 1989; 1990; Chiyo *et al*., 2005). In Kodagu, observations of feeding behaviour suggest that some individual elephants are consuming coffee berries (Bal *et al*., 2008; See Chapter 7); a potentially chemically defended food. However, no studies have been carried out to understand whether there is any nutritional advantage to elephant from coffee consumption. Thus, we are not certain if coffee consumption is an adaptive behaviour of elephants in a coffee-rich habitat, if it is opportunistic sampling or by choice. As coffee is the main cash crop for farmers in Kodagu District, the records of crop loss in terms of coffee berries or plants could indicate whether there was an increased interaction of elephants and people in human-dominated landscapes resulting in the perception of 'conflict of interests' between the two parties. The potential for social learning aids in the development of novel behavioural repertoires (Galef & Laland, 2005) suggesting that coffee consumption is a novel behaviour that may have been learnt slowly by the other individuals of the herds and passed on to other resident elephant populations (See Chapter 7).

At the landscape level, crop raids are thought to represent opportunistic forays by a segment of males in the population; thus the intensity of the encounters between elephants and people is likely to be dependent on the behavior and ecology of these individuals (Hoare, 1999a; Chiyo *et al*., 2012). In Kodagu, coffee is the main cash crop grown in the region. Coffee plants are not planted annually, but only replaced when the production of a plant becomes low or if it is infected by disease. The wide extent of coffee plantations and their high productivity makes them a potentially easy source of food for elephant; how often do raids occur and where? Is the raiding seasonal and associated with coffee availability? Do the elephants come to the plantations to raid, or are raids opportunistic (See Chapter 5)?

Crop growth phase and harvest timing may influence the availability of food for elephants and thus underlie temporal variation in raiding frequency. In Kodagu, seasonal patterns have been suggested by other studies of 'human-elephant conflict and intensity of crop damage' (Nath & Sukumar, 1998; Kulkarni *et al*., 2007; Bal *et al*., 2008). Similar results were also seen in crop-raiding events in Cambodia (Webber *et al*., 2011). Monthly variation in crop raid frequency was suggested to be a function of planting, ripening and harvesting of crops (Webber *et al*., 2011). Raids in Cambodia peaked during October to December, with the lowest frequency in the months of March-June (Webber *et al*., 2011). Raids on rice fields were positively correlated to rainfall, but there were also some negative or no correlation with a few crop types in relation to rainfall. Since coffee ripening and harvesting are also seasonal, like paddy rice, seasonal raiding may be reflected in seasonal patterns of crop damage records.

Studies of the human-elephant interface begin with an understanding of the site-specific incidents and their level of intensity. Information on when, where, and what elephants raid is significant to enable our understanding of their behavioural and feeding dynamics (Sukumar, 2003; Kulkarni *et al*., 2007); allowing us to understand the "why" of crop-raiding. Greater understanding is necessary in order to encourage human co-existence with wildlife. Understanding elephant preferences for cultivated crops, their temporal patterns of raiding and choice of areas for raiding provides significant information for people to reduce and mitigate crop damage by elephants (Webber *et al*., 2011).

As discussed above, the increasing use of agricultural landscapes by elephants has intensified the human-elephant interaction interface, along with loss of crop and property damage. Elephant encounters are more common for people living closer to the forest areas. This increase in interaction of people and elephants has resulted in greater threat to life for both parties. In India, about 400 people are killed by elephants annually (Rangarajan *et al*., 2010). As a result, Forest Departments have monetary compensation schemes for people injured or for the family of the deceased, if fatally injured.

Elephant deaths and injuries are also caused by people as retaliatory measures for crop damage or for poaching. Across India, an average of 41 elephant deaths have been recorded annually due to human-elephant confrontations with poisoning (25) and electrocution (16) (Bist, 2002). About 53 elephants died between 2002-2003 due to electrocution and poisoning in India (Project elephant, 2009) which represented 36% of elephant deaths for that period (Basakaran & Venkatesh, 2009). Elephant death and injury events are also recorded by the Forest Department.

This chapter presents an analysis of crop compensation cases to demonstrate the extent of damage occurring across Kodagu district. Data on human and elephant injuries and deaths have also been presented to understand the level of risks that are experienced as a result of elephant and human confrontations.

4.2 Methods

<u>4.2.1 Assessing Crop damage incidents</u>

Annually, elephants damage about 10,000 to 15,000 dwellings and 800,000 to 100,000 ha of crops (Bist, 2002; Kulkarni *et al*., 2007). Both the Central and State Government spend about INR 150,000,000[43] as ex-gratia payments for crop damage, to victims and for protection and control measures (Bist, 2002; Kulkarni *et al*., 2007).

Assessment of damage due to human and elephant interaction is possible through records of payments made to complainants in respective districts and state Forest Departments of elephant range areas. For compensation amounts to be calculated, crop damage in the field had to be inspected by forest officials. This sanctioning of payments was an important part of compensation schemes as it is thought to ensure that the reported damage was not exaggerated and the claimant received an appropriate compensation amount.

Forest Department records are the only large-scale data on reports of events as there are no data yet available which have assessed all the actual events in the study area. In some areas where long-term research has been established, the researchers have been attempting to record as many crop-raiding events and cases of human injury or death of elephants (Sukumar, 2003). There are therefore limitations to using compensation

[43] INR 10,000,000 (INR 1 Crore) = £ 97,601.28

records for the study region which are widely acknowledged by researchers throughout India (Nath & Sukumar, 1998; Kulkarni *et al*., 2007; Bal *et al*., 2008; Gubbi, 2012), especially as people may not report all damage events or claim compensation. Thus, if a minor raid or field invasion occurred but was not reported, it would not be recorded and the analysis of compensation records reflects a bias towards only those events that were sufficiently serious for the landowner to make a claim for compensation. It is evident from the compensation records that majority of claimants were for elephant damage and there were no or very few reports of damage due to other wildlife species damage like wild pigs (*Sus scrofa*). There is thus a bias in incidence (crop-raiding event) reporting specifically for elephant damage. This bias would probably make elephants appear as the most 'problematic agricultural pests' relative to any other wild animals. While elephants may not be the animal causing the most damage by comparison to rodents, birds or even livestock (Hill & Webber, 2010) they are perceived as the greatest pest (Lee & Graham, 2006; See Chapter 8 for further details). Elephants trample crops or consume large quantities of them and the signs of such destructions are obvious. This makes reporting the causes of damage for compensation to the Forest Department easy. It is also easy for the Forest Department to conduct relatively straightforward surveys to assess and estimate the damage caused by elephants.

Records of compensation events usually consist of three or four different dates, which were (1) date of application to Forest Department, (2) date of official event entry by Forest Department, (3) date that the amount was sanctioned, and (4) date of cheque issue. I used the date of application to Forest Department for analysis as this date may be closest to the date that the event occurred. Compensation cases were seldom up to date in the Forest Department records book, which contained only a reference to the year of occurrence of crop-raiding events. Some compensation applications were carried forward to the following year due to limitations of sanctioned ex-gratia payment in the annual monetary budget. This system of carrying forward of compensation payment resulted in incomplete records of crop-raiding events which were then updated and allocated to the subsequent year. This system of accounting created a time lag of 1-2 years in the total number of compensation claims for the most recent years providing incomplete records of current crop-raiding patterns. Thus it was important to monitor and update the records from the Forest Department in order to understand and assess the intensity of human-elephant interactions in a given area[44]. Also, it was important to note that compensation claims were paid based on the state's available budget for the specific financial year. The fiscal year of the Forest Department was the annual financial year, which starts from the month of April in one year and ends in the following year in the month of March. In the case of shortage of funds for compensation, as mentioned above the compensations owing were carried forward into the following year and then updated in the records. Since the Forest Department financial year starts from the month of March for each year and ends the following year in February, the terminology 'fiscal year' was used to include both consecutive years (For example, year 2007-2008, which consists of March 2007-Feb 2008).

Also, there is a lack of concordance between events, claims, payments and elephant sightings. If an elephant individual or groups were sighted, it does not imply that the crop-raiding events occurred at the same day or period of visit. Data from Forest Department records thus indicate a series of dates recorded with respect to crop-raiding events, from dates of when the actual events occurred, complaint date and/or Forest

[44] This is applicable to Table presented in Appendix 5. For my MSc thesis I had collected the overall crop compensation records for Kodagu in 2009. For the purpose of the current study, I resampled all the data along with more detailed records of the compensation data from Forest Department throughout the region. There was a difference in the total number of events for 2007-2009. This was probably due to the lag in the data updated annually depending on the approvals of compensation applications.

Department record of the events, compensation application date and the actual payment date were recorded as noted above. No firm date other than a month of report can be assumed for many events, and thus seasonal trends need to be interpreted with caution.

The preferred method for evaluating elephant crop damage events is through third party enumerators (IUCN-AfESG, 1999). As mentioned above the Forest Department records on crop damage may not represent the actual number of events. In addition, prior to 2007, there were no registered cases of events of elephant damage in the settlements within the forest reserves as they were not considered to be legitimate settlements prior to Forest Rights Act (31st December, 2007). However, if the records are assumed as a reasonable "sample" of events (Gubbi, 2012), then this will allow us to determine the intensity of damage caused by elephants. This will give an overall view of the extent of 'negative' interactions of elephants and people in Kodagu. Crop compensation cases and the number of human injury and death cases are reliable indicators for the general extent of damage caused by wildlife across a region (Nath & Sukumar, 1998; Kulkarni *et al*., 2007; Bal *et al*., 2008).

Wildlife damage claims were made by the affected farmers to the relevant Forest Department. When wildlife damage occurred, the concerned plaintiff submitted an application to the Forest Department. The relevant division officer then carried out a site inspection and estimated the amount of damage that had occurred. This compiled report was then sent to higher officials in order for a Range officer, the Assistant Conservator of Forests and the Deputy Conservator of Forests to approve the estimated amount of compensation. If the monetary claim was high, the Range Officer visited the site for inspection. This usually occurred when an individual elephant or group of elephants took refuge at a particular place for longer than a single event (personal observation). Forestry officials with Range Officers and on a few occasions the Assistant Conservator of Forests visited a site to examine the damage.

I collected the total number of crop damage incidents reported for all three *taluks* in Kodagu, i.e. Madikeri, Somwarpet[45] and Virajpet, along with Hunsur district (where some of the villages near Nagarhole National Park fall under the jurisdiction of Hunsur Forest Divisions[46]; See Figure 2.1; Appendix 4) from their respective Forest Department offices[47]. Virajpet Forest Division had records dating from 1992, whereas for Madikeri Forest Division the compensation claims have been recorded from 1990. This difference in time frames may be because during the initial years all compensation claims were made at Virajpet Forest Division but later were assigned to villages corresponding Forest Divisions (See Section 5 - Discussion). A total of 17723 events were collected from both territorial and wildlife forest divisions of each *taluks*. These 17723 events were translated from the original languages and coded by event date and payment amount within each of the regions. This coding of the written, longhand records allowed for a temporal and regional analysis in four divisions.

These events have been assessed by earlier studies (Nath & Sukumar, 1998; Kulkarni *et al*., 2007; Bal *et al*., 2008) to determine the pattern of crop-raiding events in Kodagu. As mentioned earlier, Forest Department Compensation records were the only documentation available for wildlife damage in Kodagu. So, for my study the same data sources were accessed but with the updated record of events up to (and during) the study period. This chapter consists of the analysis of these data to understand the

[45] Somwarpet and Madikeri data are recorded in Madikeri Widlife division. Thus, the data are merged under Madikeri Division in Table 3.1.

[46] Hunsur Forest Division is under the wing of Mandya District, Mysore Circle Forest Department. With only one subdivision, i.e. Hunsur subdivision, it has three Forest Ranges, i.e. Hunsur Forest Range, Periyapatna Forest Range and K. R. Nagar Forest Range.

[47] See Chapter 2, Section 2.2.

current pattern of crop-raiding events in Kodagu and the effect of elephant and people interaction in Kodagu. In order to assess the temporal patterning of damage events, given the inaccuracies and issues noted above, one time series analysis was conducted on the number of reported events per month in each fiscal year. This time series analysis used the data of compensation events recorded in the Virajpet Forest Divisions to examine if there is any trend in the number of events occurring across the years. Analysis was done in SPSS (IBM SPSS Statistics Version 19).

4.2.2 Records of death and injury

Although in terms of frequency of raids, elephants in general are not one of the most important crop pests (Naughton-Treves, 1998) they do kill and injure people. Data on people killed by elephants were collected from the Forest Department Records from original files. I collected data on the time, date, location, circumstances of human death due to elephants. The data collected are from the years 1992 to 2011, across the different divisions of Kodagu.

Thus, I obtained details on the circumstances and time of the lethal event between elephants and people (See Section 4.2). I was able to get such detailed information for 36 cases. I categorized the time of the day into five categories:

1. Morning (5.00 am to 10.00am) - . In coffee estates, workers (both women and men) usually have an early start on most working days as they have to report to work either by 7.00 am or 7.30 am. This category comprises early morning duties, both personal and work, until the mid-morning break at 10.00am.
2. Afternoon (10.00 am to 3.00pm) - comprises the rest of the morning work hours including an hour lunch break and the first part of the afternoon work.

3. Evening (3.00pm to 8.00pm)[48] - comprises activities of late afternoon work period, working overtime, returning home from work and personal work.
4. Night (8.00pm to 12.00am) - includes very few work activities except for occasional guarding.
5. Mid-night (12.00 am to 5.00am) – every minimal people activity period except for occasional late-night travelers or intoxicated people.

These categories were related to the daily activities of most of the people especially estate workers. These four categories have the same number of hours (5) in each time block, except the 'Night' category which was a four hour block.

4.3 Results

4.3.1 Trends in compensation overall

Compensation records were analysed to assess the extent of crop-raiding damages by elephants for the entire Kodagu district. There was a low number of reports of crop-raiding events across the district between 1992-1996 (See Figure 4.1). In the fiscal year 1999 – 2000, a slight peak in the number of incidents reported was seen, followed by lower and more uniform variation for the reporting period until 2005-2006. Figure 4.1 indicates that there was no clear trend over the very long term, but we can see a marked peak in 2007-2009 (See also Appendix 6). Time series analysis of the crop-raiding events (See Appendix 6) indicates a presence of significant time signal of events occurring across the years but there is no consistent trend for an increase or decrease over time.

[48] Sunset in India usually occur between 6.00 pm - 6.30 pm and is dark by 7.00 pm.

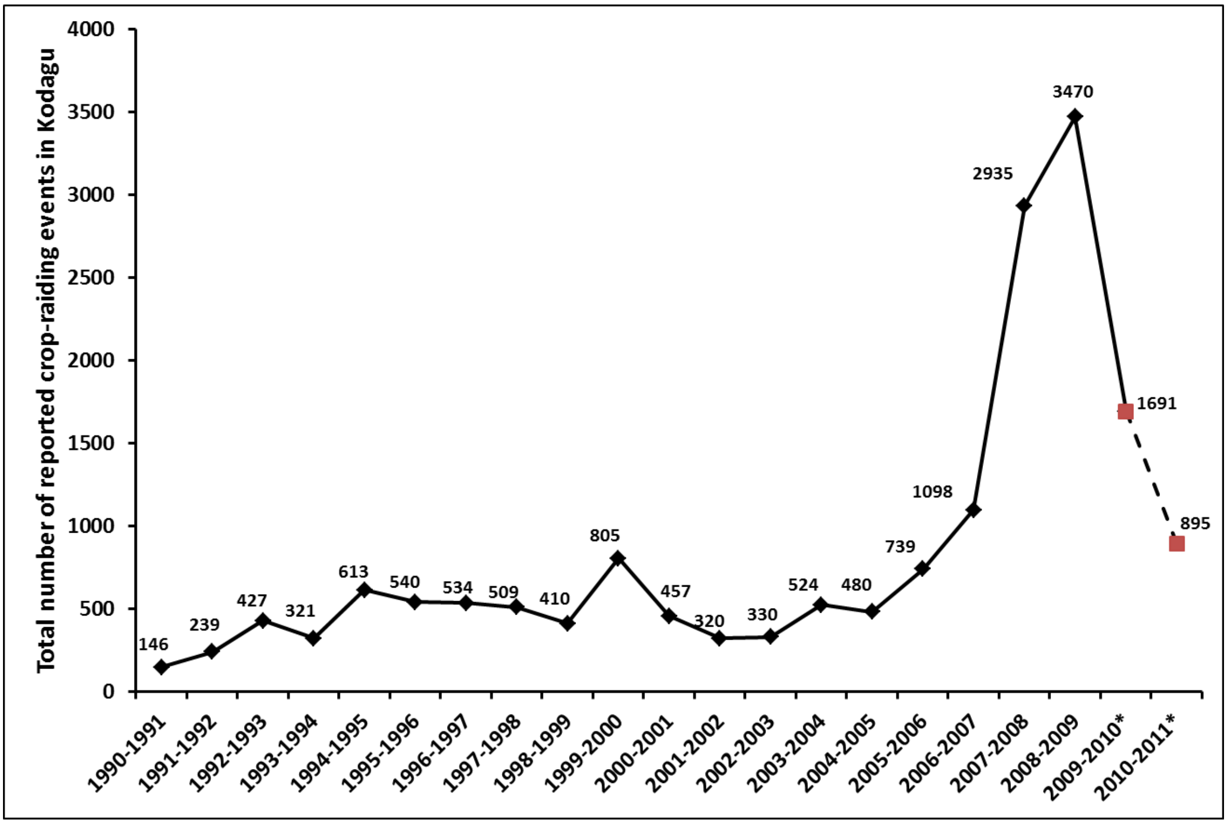


Figure 4.1: Total number of reported crop-raiding events (compensation claims) in Kodagu district during 1992-2011. The symbols * and dotted line represents years with incomplete records of crop-raiding events. The 'red square' represents the total number of incomplete raiding events.

Figure 4.2 indicates that crop-raiding events were spread across Kodagu during the period of 1990-2011. But, a peak in report of events was recorded during the fiscal years of 2007 through to 2009. There is a similar trend in the increase of reporting of events after 2006 when we examine each Forest Divisions of Kodagu district separately (See Figure 4.2). Hunsur Forest Division saw a sharp decrease in the number of reported events, but increased in the year 2008-2009 (See Discussion for further details).

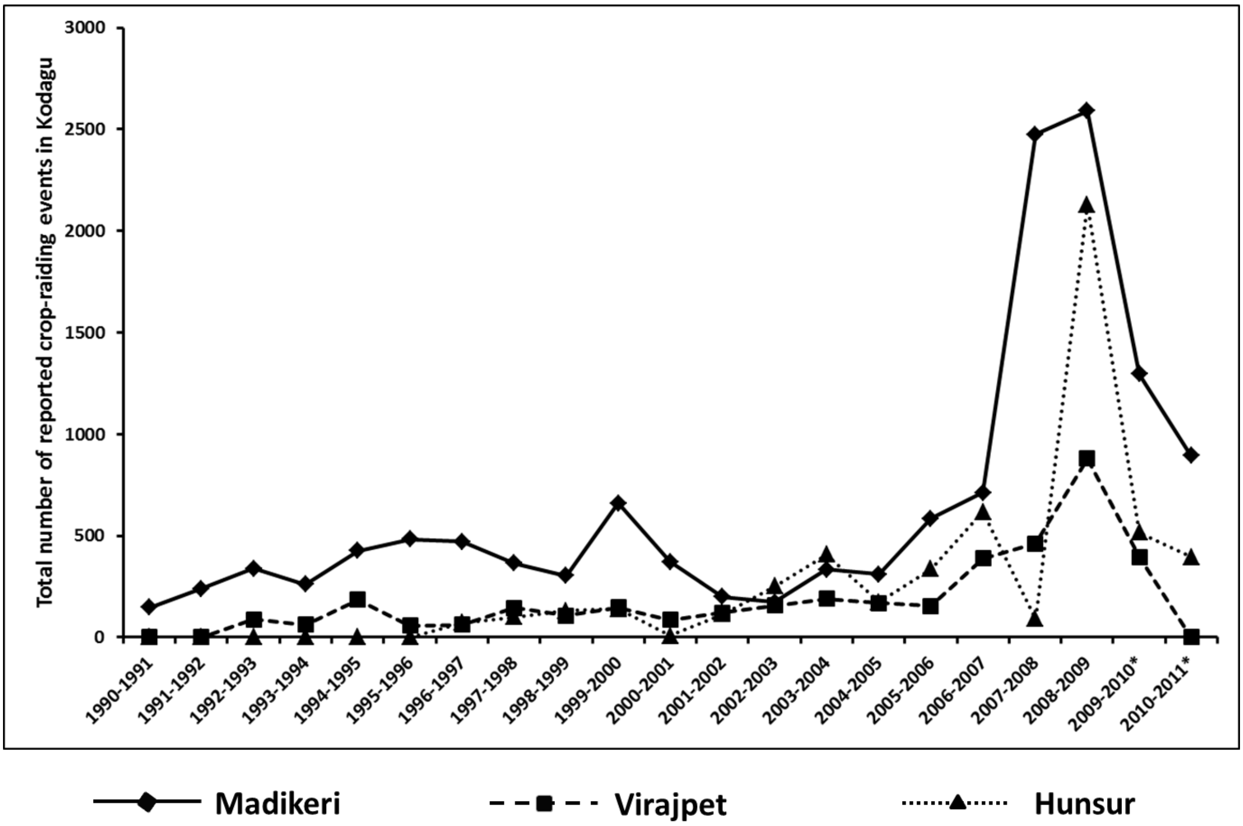


Figure 4.2: Crop-raiding compensation records of Madikeri, Virajpet and Hunsur Forest Divisions during 1990 – 2011. Years with incomplete data have been indicated with the * symbol.

After a peak in 2007-2008, the number of reported crop-raiding events appears to have slowly reduced in numbers. In 2010-2011, the numbers of events were low as the records had not been updated and the files were not accessible at the completion of my field season[49].

4.3.2 Trends in compensation in Virajpet Forest Division

Since my focal study estates were located in Virajpet Forest Division, I will concentrate on the compensation claims reported of this Forest Division. Virajpet Forest Division

[49] I hope to return to the field site to collect and update more recent data on crop damage and other related information.

has four different Forest Ranges: Virajpet Forest Range, Thithimathi Forest Range, Ponnampet Forest Range and Mundrotu Forest Range (See Chapter 3, Appendix 4). There were only three cases recorded in Mundrotu range over all the years sampled and so it was not included in the analysis. Virajpet Forest Division crop damage events also showed similar trend in increase in crop-damage events after fiscal year 2006-2007 (See Figure 4.3). Damage seemed to be at a peak in 2008-2009 and to have decreased the following year.

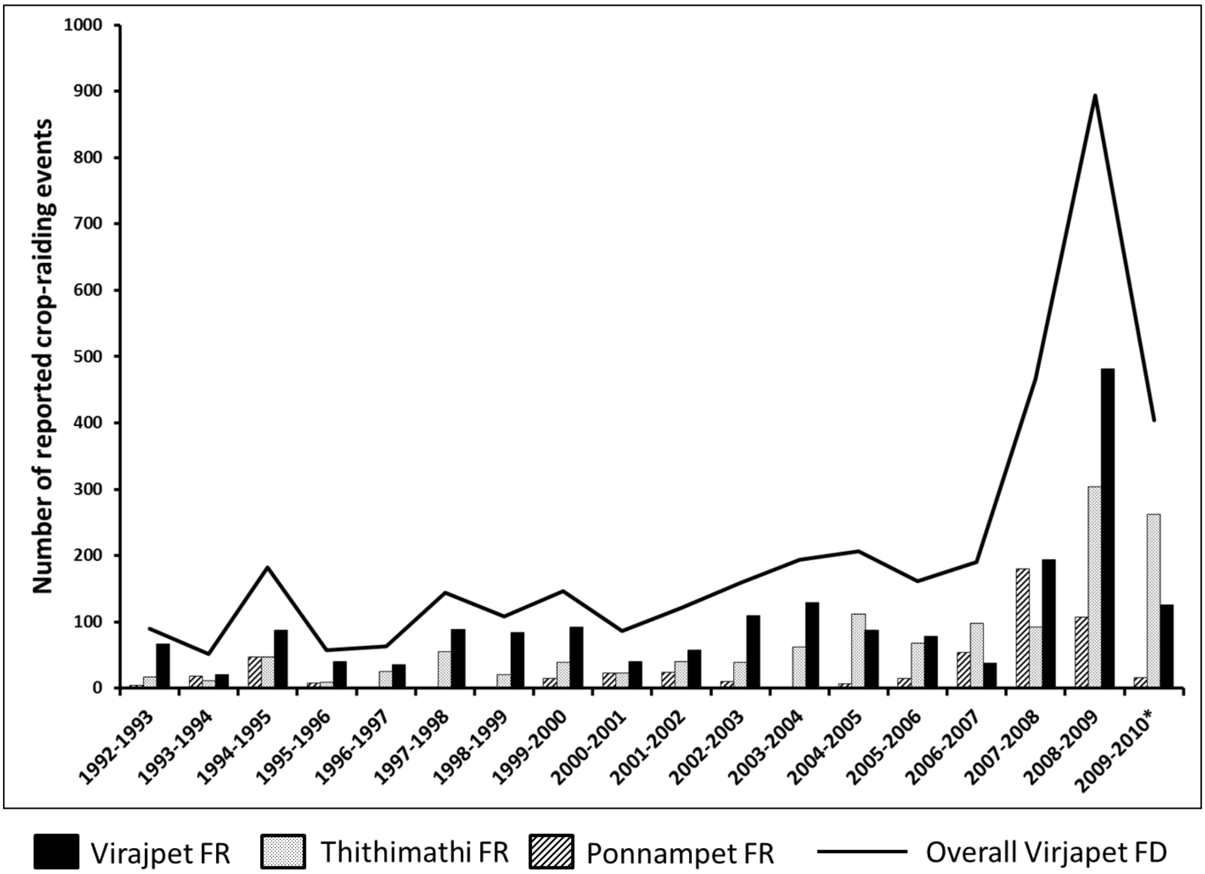


Figure 4.3: Crop damage events reported in three Forest Range (FR) of Virajpet Forest Division (FD) during the fiscal years 1992 to 2010 (N=3724[50]). The three Forest Ranges are Virajpet FR, Thithimathi FR and Ponnampet FR. * represents the year with incomplete record of crop-raiding events

[50] N= 3724 as opposed to N=3727 as with only three entries, Mundrotu Forest Range has not been included here.

4.3.3 Seasonality in crop-raiding

Annual distribution of Virajpet Forest Division (See Figure 4.4) crop-raid events was not evenly distributed and indicated an increase in the number of the crop-raiding events in 2006. During the period of 2007 through 2009, there was a significant increase in the number of crop-raiding events reported. Also, reported events suggested a difference in the number of reported events of crop-raids between months (Figure 4.5)

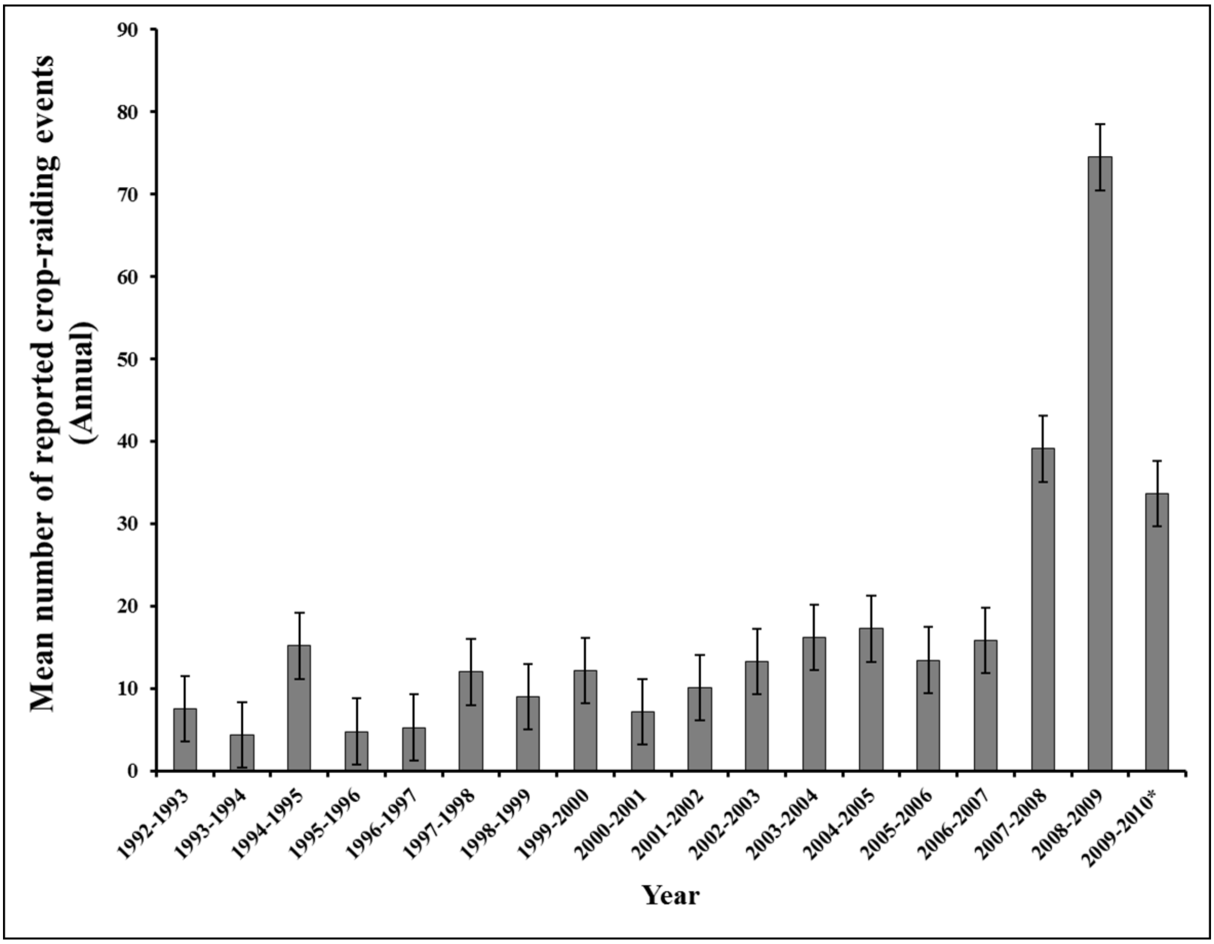


Figure 4.4 Annual trend in Virajpet Forest Division crop-raiding events (N=3727).

*** represents the year with incomplete record of crop-raiding events.**

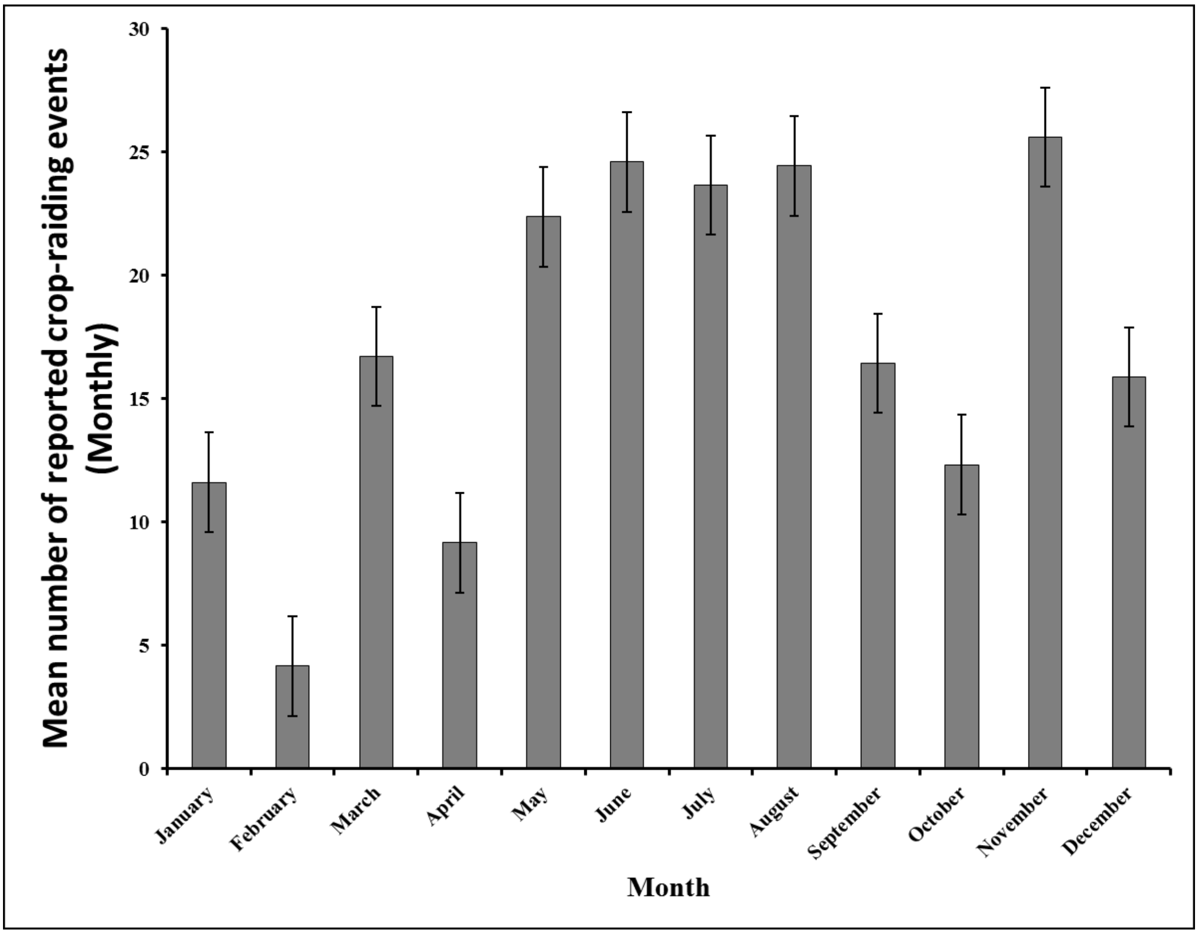


Figure 4.5 Monthly trends in Virajpet Forest Division crop-raiding events (N=3727).

The peak and dip in crop compensation records across the years suggested a higher interaction frequency between elephants and people (or their crops) during specific months. In Hosur (Tamil Nadu state), the monthly damage to cultivated crops suggested that damage by elephants was a year-round occurrence (Baskaran & Venkatesh, 2009). However, the number of people affected varied across the year with an increase in reported events from October until February with a peak in the month of December. Permanent crops like banana (*Musa paradisiaca*), arecanut[51] (*Areca catechu*) and coconut (*Cocos nucifera*) were reported to be damaged by elephants during the first

[51] These are the seeds of areca palm. Commonly referred as a *betel nut*, these are drupes.

peak season (See Appendix 10 for edible species list). But, this peak was also the season for jackfruits (*Artocarpus heterophyllus*), and thus there was a suggestion that elephants' main reason for venturing into estates was to feed to on jackfruits.

4.3.4 Monthly variation in crop damage cases in Virajpet Division

Earlier two studies reported two peak seasons for elephant visitation to coffee estates corresponding to the first (June-August) and second (November-January) monsoon seasons (Nath & Sukumar, 1998; Kulkarni *et al*., 2007; Bal *et al*., 2008). They also reported that these peak seasons corresponded to the seasons of fruiting trees and paddy rice ripening. Applications for crop damage payments for 2006-2007 indicated that coffee damage was mostly reported for the first peak season, and the second season was found to correspond to the paddy-ripening season.

I used the data on crop compensation records from 2007 up to 2011[52] to see if this pattern in raiding events persisted (See Figure 4.6). Records showed a clear indication of a peak between June-September, but there was no indication of a second peak of events between November-January. This lack of a seasonal distribution to raiding events could be due to the overall high reporting of events in the fiscal year 2007-2008. The most frequently reported damaged crop is that of coffee across all the months irrespective of the frequency of crop-raiding events. Damage to coffee plants can result from various elephant activities like during moving through the estates, resting in refuge spots at specific locations, accidental damage when being chased or driven by people (personal observation). Some of the damage was also the result of coffee plants being uprooted during play (See Chapters 6 and 7).

[52] Virajpet Forest Division gave me permission to access to only the recent five year data of crop-damage records. I was informed that the older records were sent to shore house, where it is difficult to access the old records. I was not given permission to access the store house.

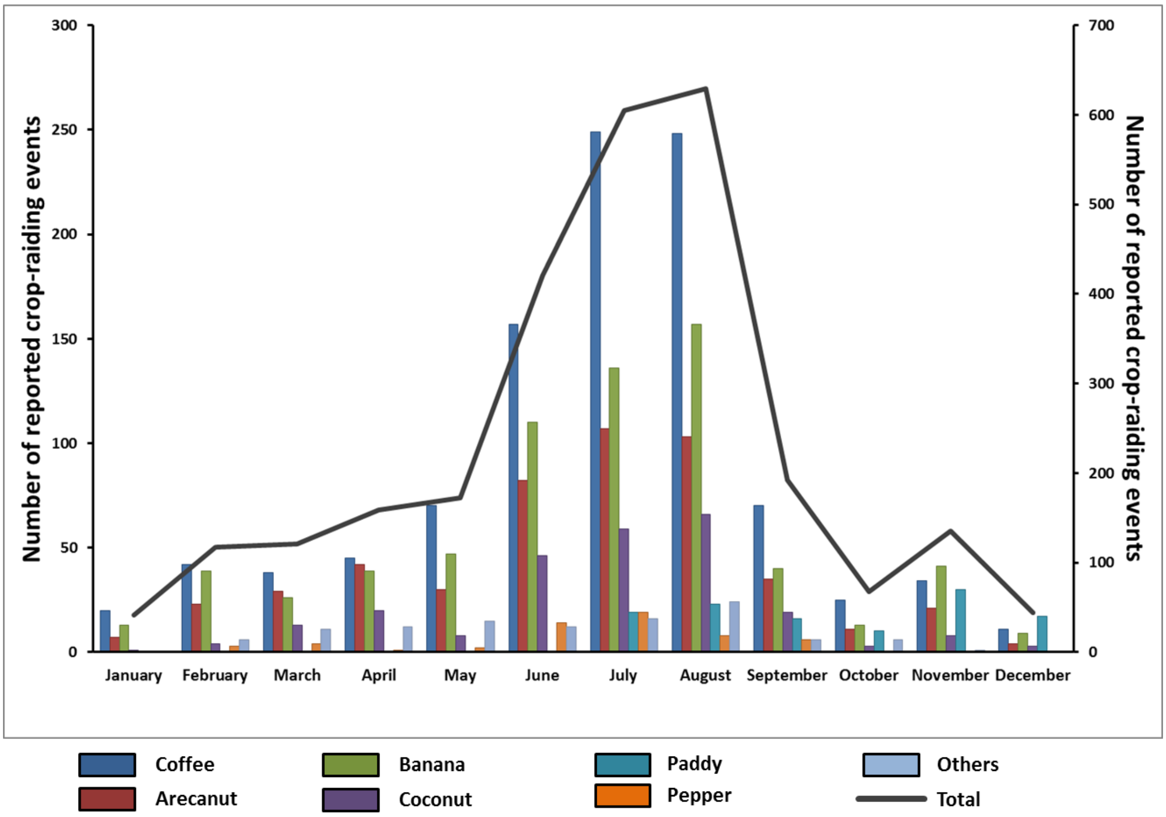


Figure 4.6 Mont hly number of Crop-raiding events reported in reference to major crop-types across Virajpet Forest Range during fiscal years 2007-2011 (N=2704).

<u>4.3.5 Variation in relation to coffee ripening season</u>

Coffee was reported to be the most damaged crop, followed by banana, arecanut, coconut, paddy, pepper and other plants like jackfruit trees, mango trees, bamboo, oranges found within the estates (See Figure 4.6 and 4.7). Damage to seasonal crops like paddy rice occurred exclusively during October-January. Coffee, although seasonal, showed similar patterns of damage with two peaks but with an exception in February when it peaked for the second time.

Damage to perennial crops like banana, coconut and arecanut indicated a similar pattern of two peaks. There was also occasional damage to irrigation pipes, property damage like gates or fences around estates, which for the larger farm owners was a small expense but for small subsistence farmers, was a relatively huge cost.

Coffee damage during the month of February coincided with the coffee-ripening season, which suggested that coffee could be acting as an attractant (Bal *et al*., 2008). Coffee seeds found in dung (See Chapter 7) emphasized the fact that at least a few individuals were ingesting coffee berries. This observation was first reported in 2008 (Bal *et al*., 2008) and was not mentioned in other previous studies. There is no prior information about elephants feeding on coffee. This could be because damage to coffee plants was negligible and thus it was never reported or it is indeed a novel feeding behaviour, which may have been developed as recently as the last decade. This suggestion coincides with the farmers' belief that elephant visits to the estates have increased over the last 10 years (Bal *et al*., 2008; Narayana, 2009).

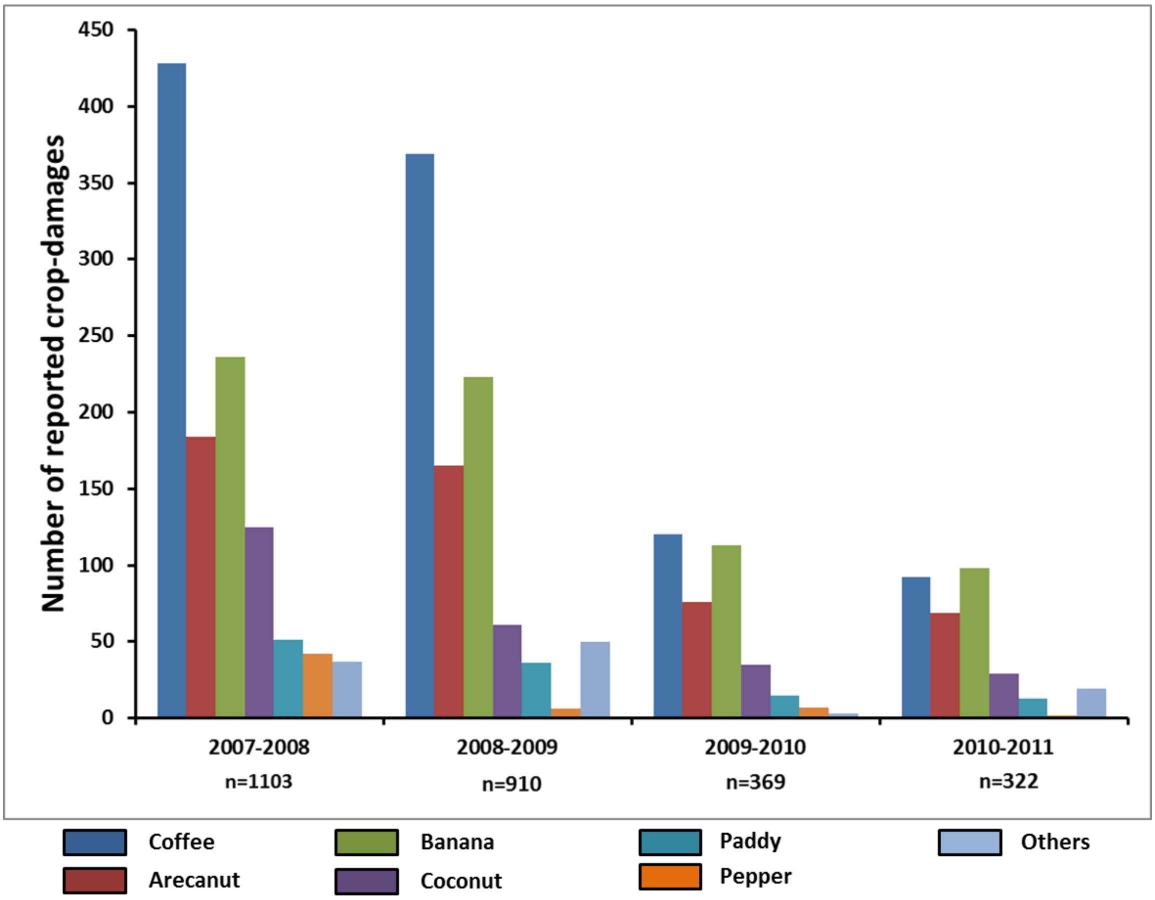


Figure 4.7 Total annual number of Crop-raiding events (Annual) reported in reference to major crop-types across Virajpet Forest Range (N=2704).

4.3.6: Seasonal trends in events recorded

Rainfall could have also influenced the patterns of human-elephant interaction. It has been suggested that low quality and reduced availability of natural foraging during the late wet and early dry season results in an increase in elephant crop-raiding (Osborn, 2004). During informal interviews and meetings with various estate farmers and workers, they mentioned that the annual rainfall during the years of 2006-2008 was relatively low when compared to previous years. However, district rainfall data indicate that there was an overall increase in annual rainfall from 2005 until 2007 with an average of approx. 3000mm, with low rainfall in 2008 and an average annual rainfall of

2,448 mm. In 2010-2011, there seemed to be a reduction in total rainfall with a late and short monsoon season (See Figure 4.8 and 4.9). However, reported numbers of crop damage events were low during 2010-2011 as I had limited access to complete records by the end of my fieldwork period.

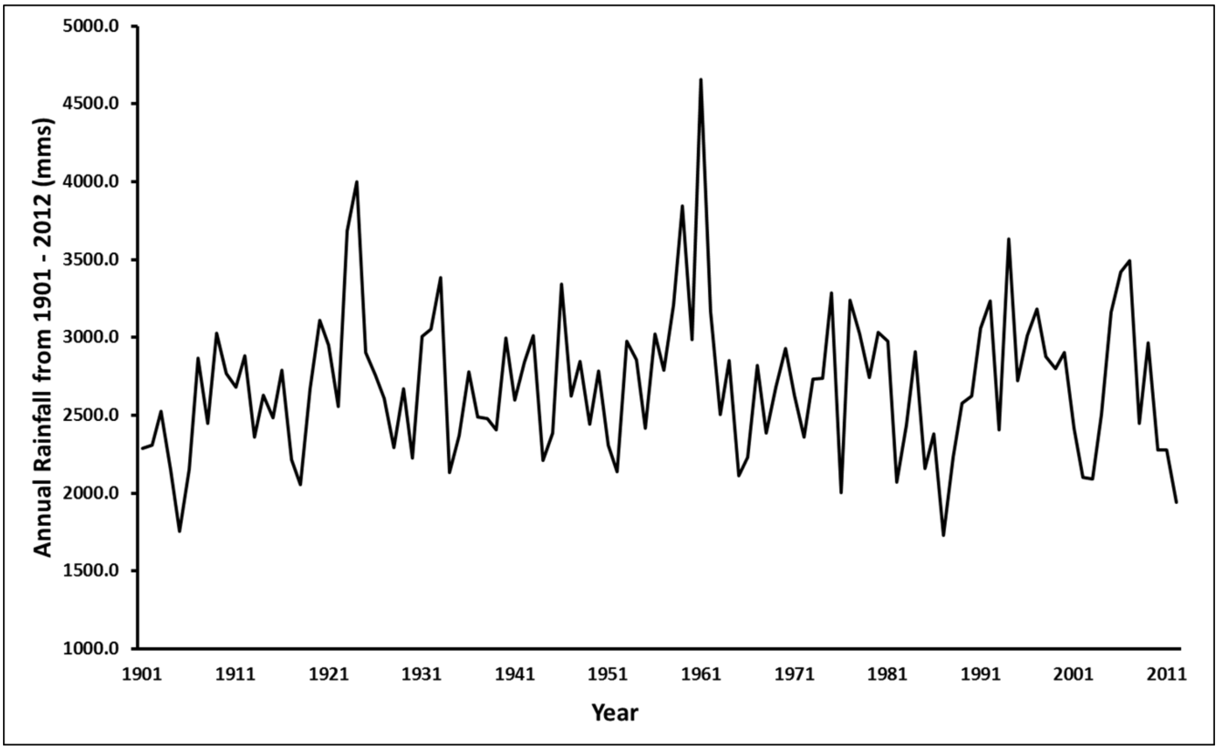


Figure 4.8: Annual Rainfall (mms) of Kodagu District from 1901 to 2012 (Source: India Meteorological Department[53]; The Official Kodagu District Website[54] and Kodagu Zilla Panchayat Website[55]).

Crop growth phase and harvest timing may also influence the availability of food for elephants and thus their temporal variation in raiding frequency. In Kodagu, associations with crop-raiding patterns have been suggested by other studies looking at

[53] 100 Years (1910 – 2000) Monthly Rainfall Data Series for Districts, States, met-Subdivisions and all India. Hydrometeorology Section, Office of the Additional director General of Meteorology (Research), Pune. India Meteorological Department, Ministry of Earth Sciences, Government of India.
[54] http://www.kodagu.nic.in/pages/menu/depts.asp.
[55] http://www.kodagu.nic.in/zp/pages/about/glance/rainfall.html.

the ‘human-elephant conflict and intensity of crop damage’ (Nath & Sukumar, 1998; Kulkarni *et al*., 2007; Bal *et al*., 2008).

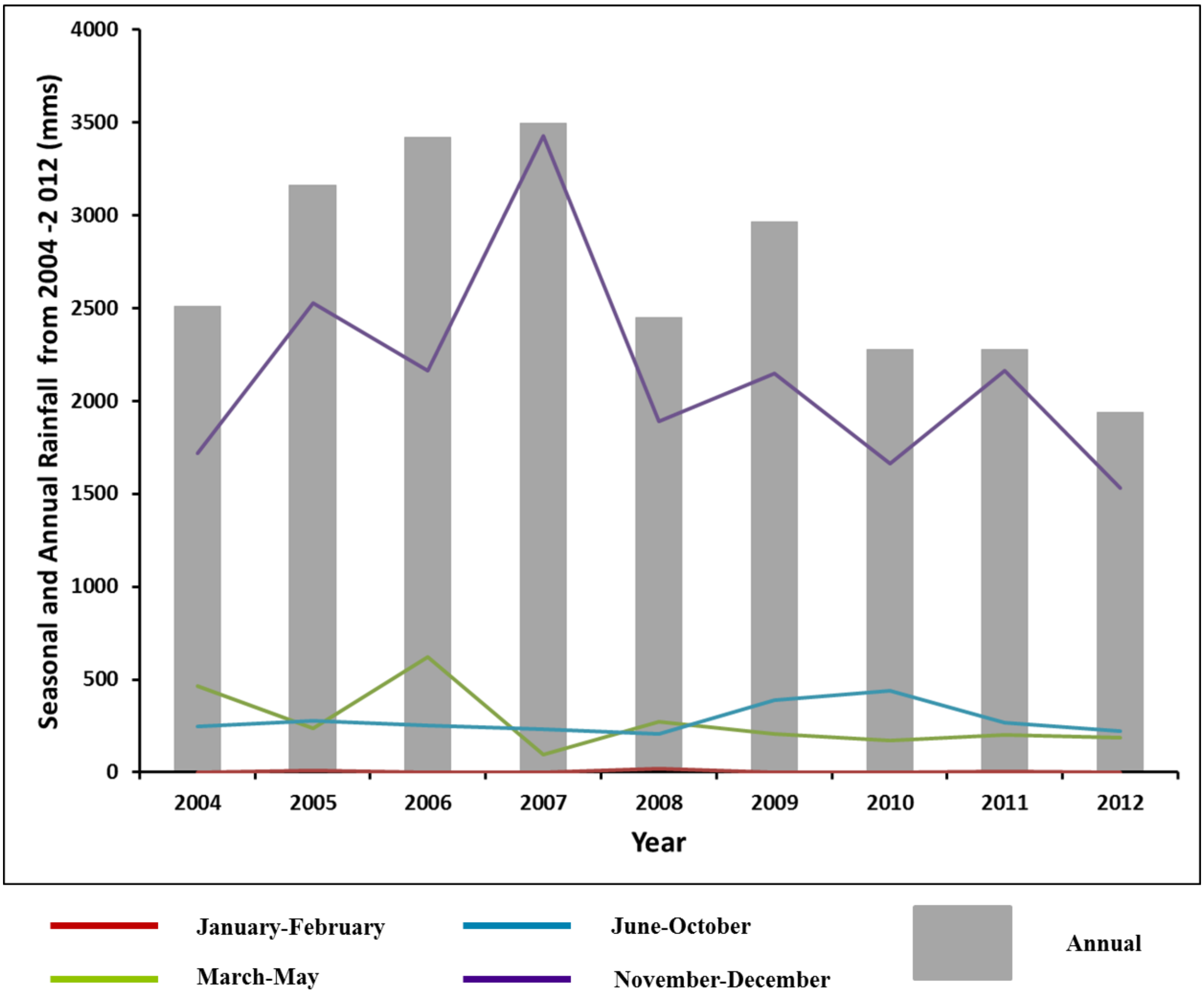


Figure 4.9: Seasonal and Annual rainfall of Kodagu District from 2004 – 2012 (Source: India Meteorological Department; The Official Kodagu District Website and Kodagu Zilla Panchayat Website).

Seasonality of crops may result in temporal correspondence of a number of different crops being raided at the same period. For instance, in Cambodia (Webber *et al*., 2011), elephants raided rice and cassava at the same time where damage to cassava could have been the result of an incidental damage or trampling while moving to reach preferred rice crops.

Jackfruit tree or fruit damage was not reported in compensation records, as they were grown as native trees providing shade for coffee. In Kodagu, elephant feeding on jackfruit was however reported by farmers to be one of the main reasons for elephants entering coffee estates (Bal *et al*., 2008; Narayana, 2009). Coffee plants were also reported to be damaged at this time although this was not the coffee ripening season. Farmers also suggested that elephants may feed on leaves of coffee plants, but this has not been recorded or observed yet during this study or in the earlier studies (Bal *et al*., 2008; See Chapter 7).

4.4 Elephant and human death events

4.4.1 Elephant deaths

During 1992 to 2011, a total of 152 elephant (See Figure 4.10; Appendix 7) deaths were recorded in Kodagu with an average of approximately 8 elephant deaths per year. I have combined the data of both Madikeri Territorial and Wildlife Division as the wildlife division had only recently started recording compensation data and the sample size was too low to be considered separately for this analysis.

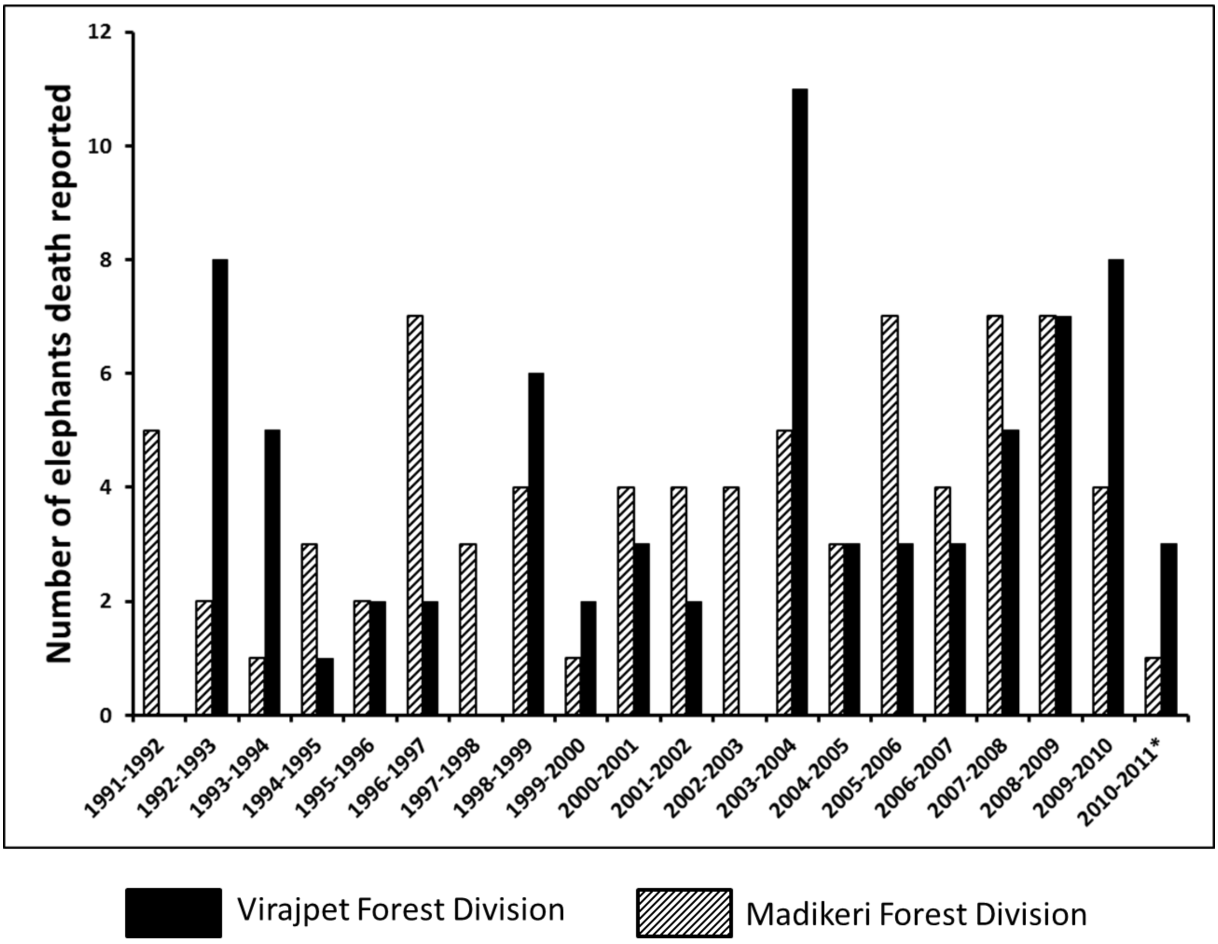


Figure 4.10: Number of elephant deaths recorded by fiscal year in both Virajpet and Madikeri Forest Divisions (N=152).

A total of 91 deaths reported were of male elephants which is about 60% of the total deaths recorded (See Table 4.1). Female elephants were 45 (29.6%) and calves were 15 (9.9%). Sex of the elephant was indeterminate in only one case as the carcass was completely degraded and no advanced scientific method (e.g. genetics) was available.

Table 4.1 Gender of elephants reported dead during fiscal years 1992 – 2011 in Kodagu district (Territorial Division = TD; Wildlife Division =WD).

Gender	Madikeri TD	Madikeri WD	Virajpet	Total
Calf	13	-	-	13
Calf M	2	-	-	2
F	18	4	23	45
M	41	-	50	91
Unknown	-	-	1	1
Total	**74**	**4**	**74**	**152**

The number of natural and unnatural (anthropogenic) deaths from the forest department's records was 110 and 41 respectively, combining all the divisions. Only one report of elephant death was inconclusive (for unknown cause). Of the 41 anthropogenic records of elephant death, electrocution (14), gunshot wounds (14) and poaching (2) were mentioned as the cause of death. Injuries and untimely death from unknown causes were recorded as unnatural deaths. Natural elephant deaths report included accidental deaths like falling from steep hill, predators (tiger kills), injuries caused by fights with other elephants, deaths thought to be due to illness, deaths during birth, and old age were recorded as natural causes. There was no significant difference in the number of deaths across months (combining all data across years; $X^2 = 91$, df = 84, p = .282, Cramer's V = 1, Phi = 2.646) (See Table 4.2).

Table 4.2: Kodagu Forest Departments records on the number of elephant deaths (all causes) from 1991 – 2011 (month-wise).

Month	Madikeri	Virajpet	Total
January	4	6	10
February	5	10	15
March	9	5	14
April	10	5	15
May	7	9	16
June	2	8	10
July	8	7	15
August	7	6	13
September	6	5	11
October	5	3	8
November	6	8	14
December	9	1	10
Unknown	0	1	1
Total	**78**	**74**	**152**

Not all elephant deaths were recorded. If any elephant died within the natural and extensive forest areas, unless the carcass was found by a forest patrolling team, the death went unreported. Retaliatory killings by farmers through poisoning and gunshots, sometimes also went unreported as it is punishable by law to kill a national heritage animal of India. Retaliatory killings of elephants have been increasing in the recent years (See below).

4.4.2 Human deaths

A total of 121 people were killed by elephants during 1992-2011 in Kodagu district. The neighboring Hunsur Forest Division reported about 54 human deaths during the same period (1998-2011). In Kodagu district, about 79% of the victims were male (96) and 23 (19%) were female. Information on two victims was missing and I was informed that the original files were not accessible at that time. The highest incidents of deaths appeared to occur during the months of March-July (See Figure 4.11) which coincided with the first peak season of the reported crop-raiding incidents.

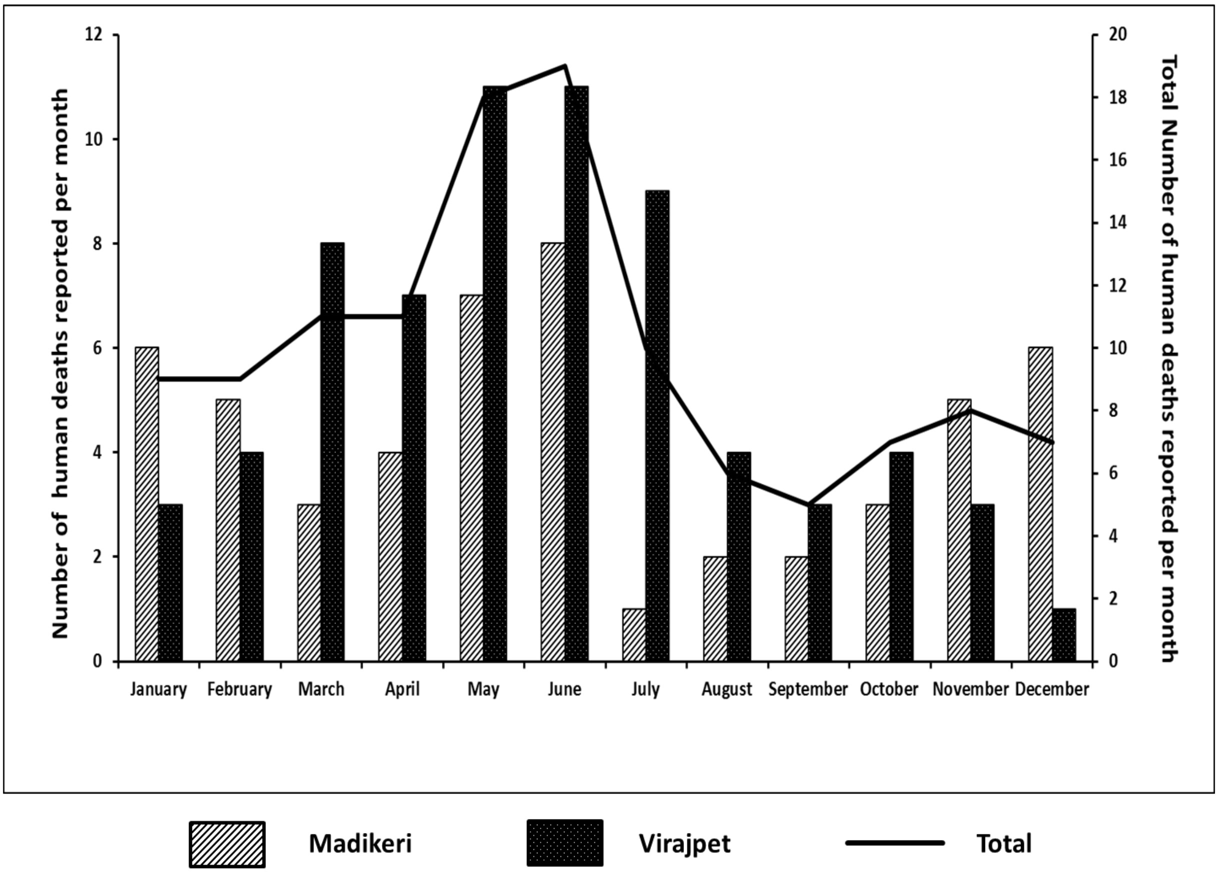


Figure 4.11 Kodagu Forest Department monthly records of human deaths by elephants in Kodagu district during 1992-2011 (N= 121).

Most of the lethal incidents occurred in the mornings and evenings (See Figure 4.12). One-way chi-square analysis (X^2 = 20.24, df = 3, $p \leq 0.05$, N=36) of the time of day when people were fatally injured by elephants indicated that there was a significant difference in the time of occurrence of the fatal encounter. I assumed an equal availability of opportunities for elephant contact during the day, and ignored the events occurring during night (N=4) and midnight (N=1) for further analysis. One-way chi-square tests ($X^2 = 17.5$, df = 2, $p \leq 0.05$, N=31) indicated a significant difference in time of lethal encounters with elephants by people during the day.

This may be an accurate representation of incidence occurrence; it clearly indicates the time when people are more prone to lethal elephant encounters. Elephants are known to use the coffee plantations and other agricultural lands during early mornings and late evenings (personal observations; See Chapter 5 and 6). Such adaptation of movement pattern by elephants is most likely due to generally low levels of human activity at these times. Nine incidences occurred in coffee estates while working during the day time and most events occurred in large coffee estates.

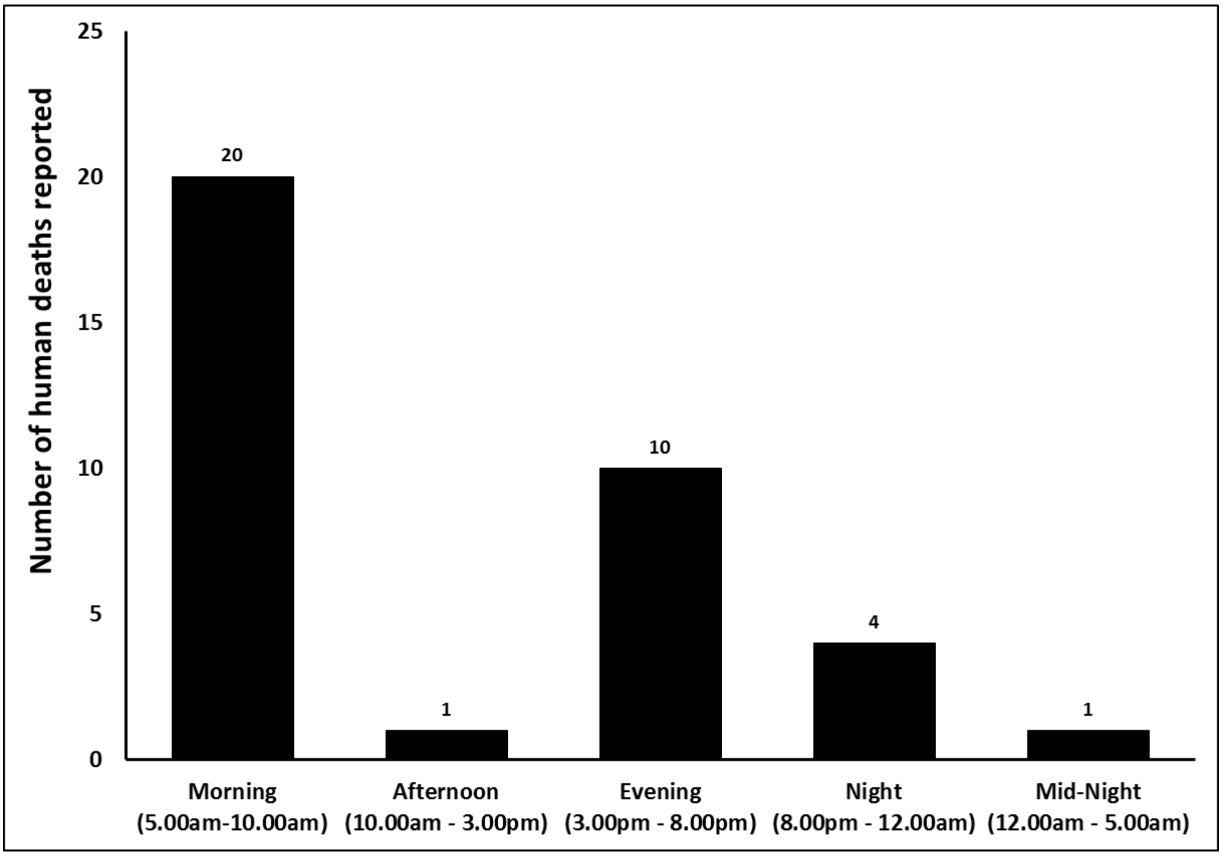


Figure 4.12: Time of day of lethal interactions leading to human deaths with elephants (N=36).

Recorded circumstances of human death cases are shown below (See Table 4.3). Most of the events seem to occur when people traveled to work or while they returned from work, school, town etc. Also, in coffee estates, working in the thick coffee bushes, it was sometimes difficult to notice elephants nearby as elephants are remarkably quiet (personal observations). Even if there is any noise, it may be masked by other workers and their noise. If the wind direction was towards you from an elephant's location, then there was a possibility of detecting elephants that may be approaching. People who return home from work, especially women workers in estates, often stay back to collect firewood, while the elephants start moving when most people have left the vicinity and thus they may encounter a lone woman worker. In few events, people were travelling at night when they are drunk or were not in the state of mind to neither detect an elephant's presence nor escape if it was startled or became aggressive.

Table 4.3: Examples of circumstances when people were killed by elephants

Circumstance of human death	Number of cases
Cattle grazing	1
Drunk state	1
Guarding paddy field	3
Went out to check the source of sound	1
When attending to nature's calls	1
While on work	2
While going to work	13
While coming back home from estate work	4
Travelling	7
While going to school	1
While looking for cattle inside forest	1
While walking on road	1

Reports of human death indicated that men were more prone to being killed by elephants than were females in both Madikeri and Virajpet Forest Divisions (See Figure 4.13). Of the total 124 human deaths recorded in the Kodagu district[56], 96 of them were males and 23 were females. Five events did not have any records of the gender of the victims.

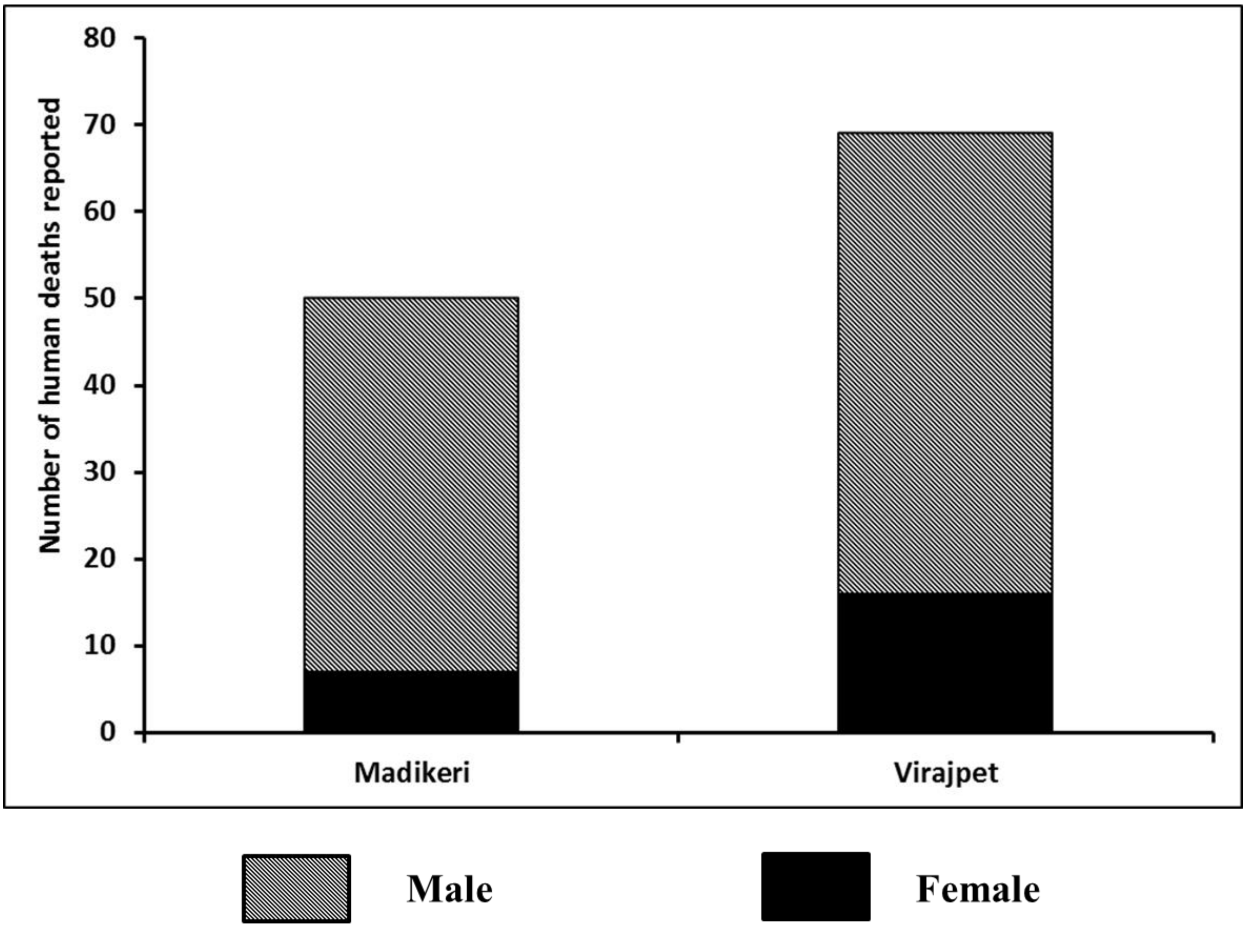


Figure 4.13: Gender of people killed by elephants in Madikeri and Virajpet Forest Divisions (N=124).

[56] Forest Department records of human death from the beginning (accessible/available) up to this study period.

Forest Department records of people killed by elephants indicated that female victims' age ranged mostly from 29 – 59 years old (See Table 4.4)[57], except for two female victims who were 10 years old and one other victim's age which was unknown. Male victims ranged in age from 16 to 80 years old. Considering the circumstances of elephant direct interactions with humans, it is evident that adults were more prone to lethal elephant encounters. All of these tragic events raise the question of intent on the part of the elephant. Given the density of the human population, and the frequency with which elephants are present alongside people, the number of events was low and suggestive of accidental encounters which startle or alarm the elephants (and the people) and where neither party could retreat uninjured. Hence I have avoided the term "elephant attack" in these analyses.

Table 4.4: Kodagu Forest Department Records on number of human deaths as a result of elephant encounters in Kodagu during the period from 1992-2011.

Age	Female	Male	Total
0-10	2	0	**2**
11-20	0	2	**2**
21-30	1	3	**4**
31-40	0	4	**4**
41-50	4	12	**16**
51-60	4	10	**14**
61-70	0	12	**12**
71-80	0	2	**2**
Unknown	1	4	**5**
Total	**12**	**49**	**61**

[57] The accessible records were incomplete and some of them were missing information like the age of the person, location, timings, circumstances, etc. The data and the analysis presented here are based on the available of this information. For example, a total of 124 human deaths were recorded across Kodagu district but the information on the age of the people killed is N=56.

4.4.3 Monetary value of compensated lethal cases

Compensation for human death has been recently raised to 5,000,000 lakh Indian Rupees[58] (£5000 approx.) from 25,000 Rupees (£250 approx., 1992). Injuries (including injuries causing permanently disability) caused by wildlife are now provided with financial support of 50,000 thousand Indian Rupees (£500 approx.). The first increase in the compensation paid to the family of a person killed by elephants was made in the fiscal year 1997-1998 (1, 00,000 lakh Indian Rupees., i.e. £1000 approx.) and then increased again in 2007-2008 to 1, 50,000 Indian Rupees, i.e. £1500). While perceived as an enormous threat to rural lives and livelihoods, elephants have also been suggested to cause fear psychosis and mental illness among people living in elephant ranges (Naughton-Treves *et al*., 1999; Jadhav & Barua, 2012). This effect is debatable and has yet to be substantiated by research showing that a threatening interaction alone can be a major cause of severe psychological illness to a person.

4.5 Discussion

Globally, the patterns of human-wildlife interactions across a specific region are first examined through the existing documentation of the consequences of such interactions; for example crop loss, property damage, threats to the lives of both people and wildlife and to people's livelihoods. In Kodagu, studies on human-elephant interactions first explored the existing Forest Department compensation records of crop-raiding events. The first two studies did not find any increase in the cases during the period of 1992-2004 (Nath & Sukumar, 1998; Kulkarni *et al*., 2007; See Footnote number 43, page 104). However, Bal *et al*. (2008) suggested that there seem to be a non-linear increase

[58] As per the Government Order No. FEE 143 FWL 2010 dated: 03-08-2011 with effect from June – 2011.

in the reported cases of elephant damage events and high inter-annual variability (See below) which they found to be correlated to the local rainfall patterns (Bal *et al*., 2011).

An overall increase in crop damage cases after fiscal year 2006-2007 was evident, which correlates with the results found in earlier studies (Bal *et al*., 2008) (See Figure 4.1). In 2006, the Government of India announced a new G.O.[59] increasing the ex-gratia payment rates for damage to plantation crops. This could be one reason for the increase in the reporting of cases in 2006 and 2007 as the financial incentive for making a report was now higher. Similar trends associated with an increase in payment rates were also found in Sindhudurg district in Maharashtra (Mehta & Kulkarni, 2013). Of the three ranges, Virajpet range appeared to be affected by more crop damage events, followed by Thithimathi and Ponnampet. Most of the large co-operative owned coffee plantations were situated in Virajpet Division and were also in close proximity to the major reserve forests that formed a continuous stretch into Nagarhole National Parks and Wildlife Sanctuary.

Kodagu Forest Department compensation records indicated that Madikeri Forest Division was the first to document the compensation claims for the crop-raiding events in 1990. Virajpet Forest Divisions records commence from the year 1992 and access to records of Hunsur Forest Divisions compensation claims was from the fiscal year 1996. When the compensation schemes were introduced, many people were not necessarily aware of such schemes and this may have been one of the main reasons for low recording of crop-raiding events. Interviews and discussions with the local people (See Chapter 8, for further details) confirmed this perspective, especially in areas with few reports of elephant presence or few accounts of interviewee's interaction with elephants

[59] G. O.: Government Order

within the coffee estates. However, it is important to consider that these are only assumptions mostly based on people's report of the presence of elephants and their perceptions of increased interaction within the coffee estates. In earlier days, factors like less indiscriminate human encroachment on forest lands, higher tolerance of wildlife and lower density of human populations may have been the reasons for fewer interactions with elephants in the now human-dominated landscapes (See Chapter 8). These are only assumptions as to the possible increases in human-elephant interactions and their negative consequences. It is essential to next examine the historical use of Kodagu landscape by elephants so as to understand its current use by elephants and to enable the development of a better management tool to reduce negative interactions at the interface between elephant and people.

Also, these reported compensation events are in no way a complete record of elephants' use of coffee agro-forestry landscapes. During my fieldwork in Kodagu, I observed that although elephants were present in larger estates, there was no documentation of damage on a daily basis. It may be that on these large estates production is target-oriented and a little damage to coffee plants and surrounding vegetation will not affect their overall production. Concern is raised only when there is extensive damage by elephants to coffee berries and coffee plants which are at their prime yielding phase. This effect was evident especially in one of the estates (Gattadhulla TATA estate, Margolly Division), where a large elephant group had taken refuge for more than a month during high coffee-picking season. Eventually, a managerial decision was taken to collect all coffee berries that had fallen to the ground (during the first round of coffee-picking season or while being consumed by the elephants) to remove any temptation from the presence of ripe berries, while elephant dung was also collected to obtain coffee seeds from them. I was told by the managers that the coffee seeds from dung would be measured separately, and processed only if it was considered to be of good quality[60].

Thus, while the records of crop compensation events of elephant damage do suggest evidence of elephants presence in those specific areas, it is however only indirect evidence of their presence and does not imply that the elephants were actually sighted unless specified in the records of crop damage events. Single compensation events could be a record of one single event or of crop damage spread across several days by the same individual(s). The number of compensation events recorded depends on many factors, of which the amount of compensation payment for the damage, duration of the process of application and time to receiving compensated amounts are all relevant as well as the rates of crop damage events by the elephants. These are all key factors that influence the individuals' decision for reporting and applying for compensation for the events/damage. For example, in the year 2006 – 2007 compensation records showed an increase in the number of recorded events which could be a result of drought which then led to an increase in the number of elephants venturing into agricultural lands in search of food and water; alternative this rise could be due to an increase in the compensation payment rates by the Forest Department in that year. However, there are no data or studies that have explored the above factors as explanations for the rise in compensation records of crop damage events. Future studies could conduct long-term study comparing at least two drought periods or two independent increases in compensation payment rates to distinguish between the possible increase in rates of elephant events as opposed to changes in Forest Department recording rates or remuneration. Also, compensation records have to be compared with ground data of crop-damage events occurring in each specific area to evaluate the actual level of crop

[60] Note that this made my dung sampling (Chapter 7) difficult.

damage caused by the elephants in Kodagu. This requires long-term monitoring across the entire area to be able to establish a pattern of crop-damage and also for better understanding of overall type of crops damaged. This monitoring would enable researchers to assess and understand the use of coffee estates by elephants in relation to the type and patterns of crop-damage for better management in order to reduce negative human-elephant interactions. This would enable us to enhance our understanding on the actual cause of negative interactions between people and elephants in Kodagu.

4.5.1 Spatial variation in crop damage

High incidences of crop damage were recorded in the villages of north eastern part of Virajpet, close to Devamachi, Dubare and Maukal Reserve Forest boundaries. There was a band of distribution of high to low and then to medium events areas across north-eastern part of the district to north western region close to Brahmagiri Wildlife Sanctuary. There is no information on the migration or seasonal movements of elephants of the region, but the band of varying incidents might be a basis to determine movement patterns and to understand if these are routes traditionally used by elephants for travelling between areas of their home range or if there are other factors influencing crop damage in these areas. It is evident that most of the high and medium number of crop-raiding events zone is closer to the forest boundaries at approximately 10 to 15 km (See also Chapter 6). However, in few villages which were in close proximity to forests and high event areas, there were very few or no incidents of crop damage.

4.5.2 Comparative seasonality of crop-raiding

In Cambodia, data on crop-raiding events suggest that rice (*Oryza sativa*) was the main crop that was raided most frequently, followed by banana (*Musa paradisiaca*), *C*assava (*Manihot esculenta*), sugar cane (*Saccharum officinarum*) and papaya (*Carica papya*)

(Webber *et al*., 2011). Also elephants were found to feed on and damage fruit crops like coconut (*Cocos nucifera*), jackfruit (*Heterophyllus artocarpus*), mango (*Mangifera indica*), etc., but in lower frequencies. Webber *et al*. (2011) proposed that there was a positive linear relationship between the frequency of raids and area to be harvested.

Primary research in the north western region of Sri Lanka suggested that elephant's raid both during the harvest and post-harvest seasons (Campos-Arciez *et al*., 2009). During the harvest season, especially at the final stage, crops like paddy rice are raided. Home gardens were also known to be raided, especially those consisting of fruiting trees like jackfruit, wood apple (*Limonia acidissma*), tamarind (*Tamarindus indica*), coconut, mango, papaya, banana and other plants like corn (*Zea mays*), eggplant (*Solanum melongena*) and green chillies (*Capsicum annum*). Post-harvest season, elephants were said to raid store houses and kitchens of homes for stored grains and salts and thus causing damaging to property as well as eating the harvested and stored food. In Kodagu, seasonality of coffee ripening, harvesting and other production of fruit trees used as shade species on coffee plantations may have influenced elephant use of these areas as illustrated by recorded raiding events; these issues of seasonal resource presence are explored in greater detail in Chapter 6 and 7.

Buffer zones like growing chili and garlic which contain volatile irritants are suggested to deter elephants from entering the paddy fields (Osborn & Parker, 2002). Cultivation of tea, tobacco and possibly coffee as alternative crops to be grown in buffer zones has been suggested as another mechanism to reduce raiding of cash or subsistence crops (Chiyo *et al*., 2005). However, in order for effective implementation in preventing elephants from entering rice fields, these unpalatable crops have to be cultivated in larger areas with high yield and most importantly should be economically valuable (Parker & Osborn, 2006; Hedges and Gunaryadi, 2010; Webber *et al*., 2011). The value of such crops, for example honey, may rise if they actually function to deter elephants (King *et al*., 2007; 2009; 2010; 2011). In Africa, many communities (For example: Kenya, Tanzania, Uganda, Botswana, Mozambique) have effectively implemented bee-hive fences as deterrent for crop-raiding African elephants. This has ensured reduced crop-raids; decreased negative encounters of elephants and people and also by cultivating bee-hives, communities receive additional income through sale of honey and other bee products.

However, coffee is a cash crop in Kodagu and if elephants are now observed to consume coffee berries this would question its effectiveness as a buffer zone crop. Bal *et al*. (2011) suggested a possibility of coffee becoming a novel food resource for elephants. They were not able to ascertain if the entire elephant population in Kodagu has started to feed on coffee or if it is only prevalent amongst few elephant individuals. They suggested that within a few years, through social and cultural learning, coffee berries could become an established, if novel, food resource (See also Chapter 7).

4.5.3 Elephant and human death reports

Interactions between people and elephants have resulted deaths and injuries for both parties. The Elephant Task Report (Rangarajan *et al*., 2010) suggests that India makes the best effort to document the Asian elephant poaching incidents across Asia. About 36.4% of total elephant deaths recorded in a five year span from 1997-2001 was natural and about 63.6% were reported unnatural deaths. Causes of unnatural deaths recorded were due to ‘poaching, conflict-related deaths and electrocution’. In Africa poaching is one of the main causes for elephant population decline and so it is in India, where poaching constitutes about 37.4% of unnatural deaths recorded; a rate which marginally higher than that of the natural deaths of elephants.

India is reported to have the highest occurrence of hostile human-elephant interactions in relation to other Asian elephant range countries (Doyle *et al.*, 2010). That study examined news media reports of human-elephant interactions across Asia and found that India has higher reported mortalities of people and of elephants as a consequence of hostile human-elephant interactions. With 60% of the total Asian elephant population and the second highest human population, the consequences of human-elephant interactions might be greater than in any other Asian elephant range states (Doyle *et al.*, 2010).

In 2014, the Forest Department reported 101 deaths of elephants across India mostly due to poaching and bullet wounds and a few deaths from electrocution, illness and old age (Vattam, 2014). There was an increase in elephant mortality representing 206 deaths during the drought period of 2012-2013, of which about 17% were reported to have died due to low water availability. An annual average of 35 elephants was reported to have been killed by electrocution between 1998-2004, mostly in the states of Karnataka, Tamil Nadu, Kerala, Orissa and Assam (Bist, 2006). Whereas elephant deaths in Coimbatore Forest Division were found to be mainly due to diseases or other natural causes, followed by electrocution and accidents (slipped on slopes, train collision, etc.; Ramkumar *et al.*, 2014). People have also resorted to the use of poison, illegal live electric wires attached to fences, shotguns, nail boards as foot traps, and automatic weapons (Haturusinghe and Weerakoon, 2012) for protecting their crops, property and indirectly protecting themselves from accidental encounters leading to injuries and fatalities.

In Kodagu, guns have been used against elephants for safety purposes from earlier days and thus when in danger, there is a possibility of people shooting at elephants during an encounter or when the elephants are causing severe damage to the farmer's crop. In India, it is now estimated that about 130 to 140 elephant death occurs annually (Vattam, 2014). In Sri Lanka, with an average of 150 elephant deaths recorded every year, about 40% of these deaths are due to illegal retaliatory killings occurring mostly in the north-western region where there is an increase in infrastructure developmental activities causing fragmentation and shrinkage of protected forest areas for elephants (Haturusinghe & Weerakoon, 2012). Continuous fragmentation and shrinkage of natural habitats have resulted in elephants venturing into new areas for food and water. As elephants have adapted to consuming cultivated crops for their high nutrient value and availability (Sukumar, 1989), there are more crop-raids. In Kodagu, there is evidence that indicates that increased elephant populations have resulted in higher rates of interaction with people, but such perceptions are certainly leading to people becoming hostile and intolerant towards elephants and wildlife in general.

For people, fear of life and restrictions on their daily activities has resulted in animosity towards elephants and conservation in general. People living closest to elephant habitats are more prone to be killed and injured. Doyle *et al*. (2010) indicated that news media reports of hostile human-elephant interactions were mostly produced outside the geographic range of Asian elephants, suggesting that such interactions may be more frequent where individual or remnant elephant populations are frequent users of human-dominated landscape.

In India annually, an average of 350 people are killed by elephants (Bist, 2002; Lenin & Sukumar, 2011), where as in Sri Lanka about 50-70 human deaths are recorded every year. In Southern India alone, an average of 50 people is reported to be killed by elephants every year (Arivazhagan & Ramakrishnan, 2010). In Karnataka, about 23 people (a region of 3-4 millions of people) were killed by elephants during the period from April to November, 2013 (Vattam, 2014). People killed by elephants are mostly farmers or workers employed in the agricultural lands (Rangarajan *et al*., 2010). Human injuries and deaths are sporadic compared to crop-damage, but they are the most severe manifestation of the hostile human-elephant interaction interface.

About one third of the identified elephant corridors are known to be private lands owned by (individuals and communities mostly for coffee and tea estates) (Bist, 2006). In Coimbatore Forest Divisions, human deaths by elephants outside the forest (outside the boundary of forest areas) were reported to have increased compared to those occurring inside the forest areas after the year 2010 (Ramkumar *et al*., 2014). Month-wise analysis of human deaths due to elephants was found to be higher in December to February and July to September. Most of the deaths occurred between 2000 hours and 2200hours, with second highest between 1800 – 2000 hours and 2200hours – 2400hours and the rest during 0600 – 0800hours. They found that the men were more prone to encounter elephants than were women; however, both male and female causalities occurred outside the forest. The age-category of the people killed by elephants suggested that the adults between the age of 41 to 60 followed by 61 to 70 years old were more prone to encounter the elephants.

In this study, most incidences also occurred during evening and mornings when people were travelling to work or coming back home. On Kodagu coffee estates, work starts early and ends in the late evening when elephants are most active. To avoid such events, the work timings and ethics of the entire district have to change, which would be difficult. To ensure their livelihoods, people have to continue their daily activities irrespective of elephants' presence or not. Most coffee estate workers live within the estate premises where the public transport is almost non-existent. There are private vehicles which transport people during the day, but they stop working by late evening. People who have gone travelling for different reasons would have to walk back or take a motorcycle and may encounter elephants on their way back. Efforts to reduce such incidents have been implemented with very low success as people have become intolerant and frustrated of restricted movements and being confined to their homes and immediate surroundings by the fear of elephants.

Annually, elephants in India cause damage to 0.8 to 1 million hectares of agricultural lands (Bist, 2002). In Kodagu, the majority of farmers are small land holders, so if we consider on an average each family holds one to two hectares, then at least 500,000 families are affected by crop-damage by elephants (Rangarajan *et al*., 2010). Damage to crops and property by elephants are compensated as ex gratia payments by the Government of the respective administrative State Forest Department where the event occurred. Each crop type and property type is allocated a set compensation amount and after careful investigation by the concerned officers, this set amount is paid to the affected person. Human injuries and deaths by elephants are compensated immediately to help the families of the wounded or killed.

4.6 Conclusions

This chapter described the overall regional pattern of crop-raiding incidence in Kodagu using data collected from the Forest Department Compensation Records across the district and from 1992 until 2011. It was clear from these analyses that Virajpet division in southern Kodagu has events of crop damage that have varied over time and as well between months.

Lack of extensive analysis of crop-raiding events in relation to planting and harvesting cycles of crops is the major limitation of this chapter. Such an analysis would have probably helped in understanding patterns of crop-raiding and to predict the vulnerability of crops (Webber *et al*., 2011). Such information could aid in effectively applying mitigation strategies in reducing crop losses. Also, designing effective management methods across elephant ranges, it is important to assess the site-specific crop-raiding behaviour of elephants; monitoring and mitigation strategies can be targeted at a local level for effectively tapping the most efficient resources and outcomes (Sitati *et al*., 2005).

Chapter 5

USE OF COFFEE ESTATES BY ELEPHANTS

CHAPTER 5: USE OF COFFEE ESTATES BY ELEPHANTS

5.1 Introduction

Pressure on an ecosystem from the expansion of human activities results in fragmentation, reduction of protected area sizes, and increases the likelihood of wildlife using human-dominated landscapes. For conservation of ecosystems and biodiversity, it is important to understand how animals, especially large mammals, meet their needs for space in these fragmenting ecosystems (Douglas-Hamilton *et al.*, 2005). If the animal population is relatively stable then animals may explore new areas for enhanced resource availability, decreased predation risks, and critically, for mobility and connectivity between resource patches. Such problems are particularly marked for mega-fauna like elephants. Elephants, both resident and / or transitory are known to use a diversity of landscapes including agricultural lands as movement paths or for resources. The frequency of use of different landscapes across time has been related to seasonal resource availability or the need to move between resource patches safely (Graham *et al*., 2009; Pittiglio *et al.* 2014). It is important to examine and determine the extent to which habitats are connected in order for populations to be able to respond to changes and adapt to new environments (Henderson *et al*., 1985; Henein & Merriam, 1990; Wegner & Merraim, 1990).

In Kodagu, recent expansion of human agricultural activities and populations has led to an increase in elephant-human interactions across the region (Nath & Sukumar, 1998; Kulkarni *et al*., 2007; Bal *et al.*, 2011). Most of the coffee estates are located in close proximity to the forest boundaries with many estates sharing boundaries and thus with limited or no buffer zones between the agricultural landscape and forest areas. Workers thus work close to forest boundaries for various activities on the estates from coffee berry picking to the preparatory period of coffee production. Also, as mentioned earlier (See Chapter 3, Section 2.2), the food and water resources abundantly available in coffee estates may attract elephants to venture into the estates or it may simply be that these estate areas were previously movement paths or established home ranges of the elephants using the area. This use of estates creates more opportunities for human-elephant interactions which can result in negative consequences for both people and elephants. However, in the absence of systematic data on behavioural and population dynamics of elephant populations in Kodagu, the above mentioned reasons for the use of coffee estates are only speculations. Thus, it is important to determine and estimate the elephant population of the region and assess their relative usage of different habitats.

Geographically, Kodagu is located in an important position in Western Ghats (See Figure 2.4 a), which harbour the largest wild elephant population in India. Elephants appear to use the regions in Kodagu as a transitional area during movements between forested areas in the Western Ghats (Nath & Sukumar, 1998; Kulkarni *et al*., 2007; Bal *et al*., 2008). However, it is not evident which individuals or groups of elephants use these areas for migration or which use Kodagu as a part of transitory, seasonal ranges or as new home ranges. This lack of information on the elephant individuals and populations in Kodagu means that tracking methods cannot yet be used effectively to understand how and why elephants use agro-forestry coffee plantations.

5.2 Identification of elephant individuals

Individual identification within an elephant population is important to understand the group composition, dynamics and their demography (Moss, 2001; Fernando *et al*., 2010). Which elephant individuals or groups are using an area frequently or not using an area? What are the social group dynamics? These questions require identifying individual elephants to be able to understand and distinguish different ranging patterns among individuals and groups and to detect behavioural dynamics between and within groups. Also, understanding how and why elephants use agricultural lands requires a comprehensive knowledge of which part of the elephant population is using these regions; who are those individuals and what are their original ranging patterns in order to understand the baseline determinants of why elephants raid crops. Are the male elephants of the population venturing more into the agricultural lands? Is people's hostility due to the presence of male elephants or family herds, or both? Which elephants take on more risks with their raiding, causing increased tensions with people and finally, which elephants have behaviourally adapted to avoid people within human-dominated agricultural lands? All these questions require identifying individuals. Furthermore, once individuals are reliably identified, long-term research can be established so as to determine ranging patterns through GPS collars on the identified individuals in the region; these would provide information on elephants' usage of an area and aid all the stakeholders, including elephants, in developing management strategies to minimise negative encounters between humans and elephants.

If the elephant population is too large (for a short study period) or the habitat makes it too difficult to observe and thus to identify elephants, then it is important to evaluate the importance of working at the level of individual elephants. In Kodagu district, elephants are known to frequent coffee estates and cause crop damage (See Chapter 4); occasionally people are killed due to encounters with the elephants. There has been a recent public outcry to capture the elephants using these regions (Chandra, 2014) and the people's perception is that because the elephant population has increased above the optimum capacity of the landscape, elephants are thus venturing into agricultural lands. Lack of knowledge about the elephant population and their use of agricultural landscape in Kodagu has resulted in considerable speculation about the number of elephants, and misidentification of elephants that use the agricultural landscapes frequently.

Population and demography of elephants across Kodagu district have yet to be comprehensively studied compared to the other elephant ranges in India (For example Baskaran *et* al., 2011; Joshi 2009; Joshi & Singh, 2007; Sukumar 1998, 2003; Venkataraman *et* al., 2005; Williams *et al*., 2009; Williams *et al*., 2001). Information is lacking on whether these elephants are resident or merely transiting across the district. Also, there is no information on the overall or seasonal use of these coffee estates leading to speculations and assumptions about the nature of elephant-human interactions in Kodagu. This chapter presents the data on the elephant individuals and groups that were using the coffee estates in the study area and their frequency of estate use during fieldwork.

5.3 Methods

Determining the range of individuals and populations of animals is vital to understanding how they try to meet their energetic, reproductive and social needs within a given habitat. The most common methods used to study and observe elephants are the direct observation methods and the indirect sampling methods. Recently, the use of tracking by global positioning system (GPS) technology has been of immense help to determine ranges, especially for wide ranging, highly mobile mammals like elephants (Douglas-Hamilton, 1998; Blake *et al*., 2001; Douglas-Hamilton *et al*., 2005). Although GPS collaring is logistically expensive and may be high risk for elephants[61] during the collaring process, it is useful for monitoring elephant populations within agricultural areas without engaging with people (e.g. Graham *et al*., 2010; Bhoominathan *et al*., 2008). However, this approach first requires an extensive ground survey and knowledge of the elephant population that is frequently using these areas.

In India, two major methods have been used by researchers to monitor elephant population and demographic rates (Goswami *et al*., 2007); i.e., indirect methods and sampling using technology. Population estimates can be obtained by distance sampling methods (both direct and indirect signs, for example block count methods or line-transect methods; Buckland *et al*., 1993), but this does not give any data on demographic rates of the population (Karanth & Sunquist, 1992). Population estimation is also determined by mark-resight method and through population surveys (Sukumar, 1991; Ramakrishna *et al*., 1998) which probably also provides data on variables related to abundance like density and sex-ratio but again does not provide any data on reproductive rates. To overcome these limitations, radio telemetry and satellite transmitters have been used but they are expensive for monitoring and instrumentation and also adequate sample sizes are difficult to obtain (Desai, 1991; Joshua and Johnsingh, 1993; Venkataraman *et al*., 2005). All the above mentioned methods do not take into consideration the detectability parameters (Williams *et al*., 2002) which are important considerations for forested habitats.

[61]GPS collaring of elephants require tranquilizing and capturing of the individual animal. This process may involve the risk of causing death to the animal and also monetarily is an expensive method.

Incorporating a capture-recapture (C-R) framework (Williams *et al*., 2002) is probably the best method to estimate both population size and demographic rates of elusive wild species (Karanth, 1995; Karanth & Nichols, 1998; Karanth *et al*., 2006; Goswami *et al*., 2007), especially elephants. Similar methods have been used by Goswami *et al*. (2012) by incorporating the photo-recapture methods through an automated process of rapidly identifying individual elephants from photographs. I used similar methods to identify the elephant individuals in my study area.

5.3.1 Habituation and visibility levels

Robusta coffee plants greatly reduce the visibility of elephants in coffee estates and with no prior information on the possible places for visibility, the research team first established contacts with the local farmers and workers who provided details about frequent locations of elephant sightings. Each coffee estate had "estate guards" who were responsible for locating elephants and assessing elephant presence in the coffee estates every day before the main work commenced (See also Chapter 8, Section 4). The Estate Guards provided invaluable information about elephant locations for the research team. After the initial period , the research team observed that the elephants in coffee estates appear to avoid encountering people by limiting their movements in the estate to those hours with the least human activity (See Chapter 6 and 7). Although elephants are aware of the presence of people in the coffee estates, they are also wary and intolerant of people. They are known to either move to a new isolated place, to mock charge people, or sometimes to cause serious injury and death to people and livestock. The research team tried to maintain a considerable distance of 20 to 50m from elephants whenever possible, depending on the visibility level. Although elephants were aware of people around them, they were not habituated to the extent that they would allow people to approach at close proximity. However, there was one exception which was a male elephant referred as 'Oldie'[62]. However, during the study, this individual seemed to become more wary of people and mock charged if anyone approached at close proximity.

Elephants were either encountered directly (after a report from a plantation or farm owner) or captured on camera traps placed in the coffee estates (See Chapter 3, Section 8). Within the coffee estates, the level of visibility was generally very poor. The Robusta coffee plants are tall enough (up to 10m) to cover an elephant completely or leave only their backs visible making detection and identification very challenging. Although the general protocol for encounters was to maintain a distance not less than 20m, on occasion the research team had to get as close as 10m to improve visibility sufficiently to document the size and type of elephant group and the age and sex of individuals. Initially, I tried to categorise the activity of the elephants during each encounter. However, elephants were known to take refuge[63] at one location for the entire day with little or no movement and the visibility was so poor, it was extremely difficult to record activities (such as sleeping, feeding, standing, etc.) during the day (See Video 4 Appendix 12). These refuge areas within the coffee estates were defined as those areas used by elephants to rest, sleep or hide from potential threats (For example people, dogs, See Chapter 3.5 footnotes). This use of refuge areas with poor visibility was the case throughout the entire field period within the coffee estates. To record the activities of the elephants during the day, the research team would have

---

[62] Also called *Muduka* in Kannada language meaning 'old man' and he was known to accept fruits from people. Locals reported two versions of this individual's background, i.e. he was a temple elephant before he was set free or that he was captured and tamed by Forest Department. Due to management issues few elephants are ever returned to the wild, and neither version of his background could be validated.

[63] During the day, elephants were found to be using areas with no or low presence of people and were mostly found amongst impenetrable Robusta coffee plants (Personal observation and information from local people).

needed to approach within 5m of the elephants in the understory of Robusta coffee plants. This was not considered as an option for various reasons:

- People are working throughout the estate during the day from 7 am to 6 pm. They are made aware of elephants in the morning and measures are taken to shift the work place to another area of the estate and not to disturb the elephants. If the researchers startled the elephants by approaching too closely, the elephants might either attack the research team or move away from the place. Movement of elephants may put the other people on the estates at high risk.
- One can never be sure of the number of elephants present within the area initially. The thick vegetation of coffee plants hinders the visibility and there is a high chance of another elephant being present within a short distance which may put the research team or plantation workers at high risk.
- We also travelled within the estates on foot mainly to ensure least disturbance to the elephants. Frightening or surprising the elephants would endanger people working on the estates. Also, most of the elephants' known resting locations (See Figure 6.1) within the estates were not accessible by vehicle-friendly roads and travelling by foot was preferred.

For video and photo documentation, it was necessary to get as close as possible for better visibility. Estate roads are not straight and there are numerous curves, and elephants seemed to prefer being in proximity to a bend when moving from one block to another block of coffee plants (Personal Observation)[64]. We therefore focused our efforts at these locations. However, safety measures were taken to ensure that the

[64] Width of the estate roads is smaller at the bends providing an opportunity for elephants to cross the roads quickly and thus to avoid any encounters with people or vehicles. This is only a personal observation and further examination is necessary to evaluate elephants' preference for crossing points within coffee estates and in general within human-dominated landscapes.

elephants did not get close and if any possible danger was detected, the research team withdrew from the location.

As mentioned earlier (See Chapter 3, Section 3.5), I networked with local community to gather information on elephants presence within the study coffee estates. Estate workers including estate guards provided information on daily basis about elephants presence within coffee estates. Estate managers also provided information regularly through mobile network (SMS or calls) for their respective estates and also sometimes in other estate divisions of the company. Such messages were provided to the research team mostly by 8.00 or 9.00 in the morning or as soon as they had received information of elephants. This gave me the opportunity to manage my team's day field work to document the elephant population within the coffee estates. Sometimes, estate managers would get to know about elephants during the day which they would try to communicate immediately to me through mobile network. Information on elephants presence were tried to confirmed by the research team on most occasions (See Chapter 3, Section 2.2.1) Thus, these established networks with local community gave the research team (See Chapter 3, Section 2.2.1) an opportunity to be informed on daily basis about presence of elephants in the study sites.

5.3.2 Encounters

The primary data analysed in this chapter come from "elephant encounters". Encounter here is defined as those events where we (the research team) had either personal direct sighting of elephants or for some, camera trap photos. For each encounter, data were recorded on the number of elephants present, age-sex categories, group type (single male, family, male group), time of sightings, location, activities, along with video documentation and wherever possible photo documentation. Every encounter was considered as ‘new’ and recorded separately. For the analysis of the data on each elephant encounters, I have referred to them as ‘sighting events’.

5.3.3 Time of sightings

Sightings of elephants were mostly during early morning and evening. Elephant observations were seldom possible when there were people working in close proximity. Reasons for sightings to be carried out during morning and evening were:

- To avoid any possible interactions between elephants and estate workers, it was not appropriate for the study to be conducted at all times with possible risks to others’ lives.
- Choosing the times of least human activity ensured higher elephant sightings in the open areas like water tanks, swamp areas, and estate roads. The family groups were known to come to open spaces during periods with the least human activity and this gave me the opportunity to collect data on group composition and types.

Although this method of observing elephants at certain period causes biases in the data, these are practical constraints that needed to be accommodated when observing elephants on agricultural lands.

5.3.4 Age-sex categories

It is fairly straightforward to estimate the age of elephants of less than 20 years with accuracy up to age (x) ± 1 to 2 years for calves and young adults respectively (Shrader *et al*., 2006). In African elephants, the age of adult males and females, can also be estimated with experience as they are known to continue to grow with age (Lee & Moss, 1995). Male age can be assessed using increases in body shape and proportion, tusks circumference, and head size, whereas female African elephants grow slightly (but not noticeably) in shoulder height, but their back length increases with age and this dimension has been used as guidance for age estimation (Laws, 1969; Croze, 1972).

In Asian elephants, the ageing of adult male elephants that are more than 20 years and female adults of more than 15 years is more difficult as the height of the elephants is known to reach an asymptotic value at around this age (Sukumar, 1989). Thus, buccal depression, temporal dent and ear turnover for wild elephants have been suggested to be better predictors for placing adult elephants in age-classes (Sukumar, 1989), characteristics which in African elephants are also indicative of age rather than physical condition (Albl, 1971). Sukumar's (1989) age-classes for Asian elephants were estimated on the basis of characteristics used for ageing African elephants. He used a photographic method to estimate the height and the age of elephants and the results were compared with the captive elephant known-age and shoulder height. When there are no tusks present, it is important to distinguish between tuskless male (*Makhnas*) and females through their body characteristics and the shape of genitalia (Varma *et al*., 2012). Thus, the features for identification of elephants depend on descriptive attributes and these also depend on the field conditions and individual researchers' experience in categorising and identifying elephant individuals as well as communicating the data accurately with other researchers.

In the current study, age-classes of the elephant individuals and groups were estimated according to the field key for Asian elephant age and class classification (See Table 5.1; Dawson & Dekker, 1992; Varma *et al*., 2012).

Table 5.1: Age-class classification and size measures for elephant identification (Varma *et al*., 2012).

Age-classes	Male Shoulder Height		Female Shoulder Height	
	feet	cm	feet	cm
Calf (<1 year)	Up to 4	Up to 120	Up to 4	Up to 120
Juvenile (1 to 5 years)	4 to 6	120 to 180	4 to 6	120 to 180
Sub-adult (5 to 15 years)	6 to 8	180 to 240	6 to 7	180 to 210
Adult (15 years and above)	Above 8	Above 240	Above 7	Above 210

Furthermore, I also classified males into tuskers (including those with single tusks) and Makhnas (Tuskless Bulls). Any unidentified adult, sub-adult or calf elephant which could not be categorized as male or female was recorded as Unknown sex.

5.3.5 Individual Identification

Elephant identification involves a combination of morphological characteristics or traits. Identification methods have evolved from anecdotal recordings to robust methods that ensure low misidentification of individual elephants. Age-class of elephants has been assessed through various methods from rough estimates to precise information by recording birth of individuals (e.g. Moss, 2001). The study objectives and duration determine the methods used to classify the age of elephants. Age estimation for both African and Asian elephants is based upon morphometric measures such as their shoulder height (Laws *et al*., 1975; Lee and Moss, 1995; Sukumar, 1989; 2003; Varma *et al*., 2012), back length (Laws, 1969; Croze, 1972), foot print length (Western *et al*., 1983; Lee and Moss, 1986; 1995), and by teeth (Laws, 1966; Moss, 2001). Rough estimates of age categories can be made by experienced researchers from a visual estimate of the height of the elephants.

5.3.5.1 Methods of identification

The first identification method was to assess whether the encountered elephants took the form of a single male, a group of male elephants, or family unit (cow-calf groups) (Sukumar, 1989; Moss, 2001; Moss & Poole, 1983). Family units were identified from the adult females of the group and then the calves associated with these females. The individual identification process begins with detecting and recording various morphological characteristics. In this study, I have classified the groups into Family, Single Male, All Male Group and the fourth category as Unknown. Confirmed sighting events were also based on both visual sightings and auditory cues (distinctive elephant vocalisations). Confirmed sighting events of Unknown category were coded when I heard elephants within the reported locations but there were no visual sightings to confirm identities. Thus, when the presence of a group of elephants was known but not their composition, I have grouped them into a confirmed but Unknown group of elephants. Any unverified sighting of the reports of presence of elephants in the estate were categorised into unconfirmed sighting events[65]. However, there were a few exceptions to these unconfirmed sighting events where an individual elephant or a

[65] During the fieldwork, networking with the local community (estate workers, guards, managers, other stakeholders) provided information on presence of elephants and their location within the study sites. The research team would then visit these locations for confirmation and if possible record identity of the elephant individual or the group. If direct sighting was not possible, but there were other indirect signs of elephants, then the sighting event of elephants would be recorded as confirmed. Whereas, if there were no signs of elephants being present then the information was recorded as Unconfirmed sighting event.

group of elephants was known to the local people, for example Oldie (See Chapter 5 Sections 3.1 and 5; Appendix 9) and female Swing group (See Appendix 9).

Moss (1996; 2001) identified individual elephants using body configuration, tusks and ear holes, notches, tears, scars and bumps along with individual body deformities and scars (See Table 5.2). She also made associations between suckling calves and known mothers. Douglas-Hamilton and Douglas-Hamilton (1975) and Sukumar (1989) for Asian elephants used similar features but also additionally used the fold of the upper ear as another trait. Other features like shape of the ear lobe, tail length, and tail brush type variations have also been used.

Moss (1996) also used vein patterns of the ears which are considered equivalent to finger prints in humans. However, in Asian elephants it is difficult to detect the venation patterns in the ears, as they have smaller ears than that of African elephants and are mostly found in dense forests where visibility is very poor. Identification of elephant individuals through natural markings becomes difficult with their elusive nature and due to poor visibility in the thick vegetation, whether in natural forests or coffee estates.

Therefore, elephants can be reliably identified using multiple morphological features, such as ear and tail shape, body scars and tumours, and when present, tusk shape and size (Douglas-Hamilton & Douglas-Hamilton, 1975; Sukumar, 1989; Moss, 1996; Goswami *et al*., 2007; Varma *et al*., 2012). In one study on Asian elephants, Goswami *et al*. (2007) used about 16 attributes to discriminate among individual tuskers. These large sets of descriptive physical attributes are liable to change over time, making the observation and identification of individual elephants challenging. I have used similar categories to identify male Asian elephants (Goswami 2006; 2007; 2012). This method is based on a thorough list of each trait documented as characters, and with every character placed into different subcategories (See Table 5.2). For instance, the character "ear lobe shape" has categories depending on shape; these are V shaped (margins of lobe are at acute angles), L shaped (margins of lobe are perpendicular to each other) or U shaped (margins of lobe are round).

The characters and categorical features of the key were also accompanied by additional descriptive data on specific behaviour of the individual elephant, overall description, any specific characteristic of the individual, scars, whether in '*musth*' (heightened sexual state; Sukumar 1989; 2003) or not, description of scar of mark locations, tail length, tusks length, ear description, etc. if the visibility was good.

Table 5.2: Field Key of Characteristics for identifying elephant individuals.

Character	**Categories**
Tusks present	Absent / Both / Right only / Left only
Tusk arrangement	Parallel / Convergent / Spread out
Tusk length in feet*	> 3 / 2 - 3 / 1 - 2 / < 1
Tusk thickness*	Thick / Normal / Slender
Ear fold*	Absent / L-shaped / U-shaped
Ear lobe shape*	L-angular / V-acute / U-rounded
Ear tear*	Yes / No
Ear hole*	Yes / No
Tail length	Below ankle / Below knee and above ankle / Below penis sheath and above knee / Stump (above penile sheath) /No tail
Brush type	Absent / Inside only / Outside only / Both-discontinuous / Both-continuous
Presence of scars	Yes / No
Tusk angle*	Straight ahead / Intermediate / Downward pointing/ Upward

*Recordings for right and left ear were separate

Tuskless males and females were distinguished depending on the shape of their genitalia (Moss, 2005; Verma *et al.*, 2012) which are mostly visible from behind and this character is especially difficult to use when there is low visibility. Females were also distinguished by their mammary glands between their front legs (Moss, 1996; 2001).

Breasts of male and female elephants look the same until females become pregnant for the first time, making it easier to identify adult female elephants (Moss, 1996; 2001; Sukumar *et al.,* 1988).

5.3.5.2 Video/photo Documentation and Camera traps

Camera trap photographs (See Chapter 3, Section 3.5) and video footage (See Chapter 3, Section 3.4) were analysed frame by frame for identification of elephants within the study estates and to verify the age-sex categories recorded during field sightings wherever possible. Photos of male elephants were categorised according to the morphological traits listed above: tusks (presence/absence), tusk length and thickness, tail length, brush type, ear lobe shape and tear, other individual traits like body scars. Tusk presence was further categorised into both or only right/left tusks. Tusks angle was not able to be defined as it was difficult to get clear frontal shots in most cases and thus it was not included in the traits for identification of elephants. However, where available, tusks angle estimated from direct sightings and photographic evidence was documented. Tuskless males (*Makhnas*) were identified in photos (as explained in the age-sex categories, See Section 2.4 above). Elephant groups were identified based on information available for one or more identified members of the herd.

5.4 Analysis and Results

5.4.1 Overview

Observations were made through reports of the presence or absence of elephants and verification of those reports, as well as prior knowledge of elephant presence within an estate. Each encounter or sighting of elephants was considered to be as a single 'sighting event' for the day and all the analyses are based on each sighting event, irrespective of repeated observations of the same elephants on different times of the day. There will be some dependence between sightings on different days when the same individuals took up "residence" on an estate for several days[66]. However, irrespective of their identities, the group size and its use of a specific estate were the variables of interest in this analysis.

The results are based on a total of 408 sighting events during March 2011 to March 2012; across the seven coffee estates study sites (See Chapter 3, Section 2). Of the 408 sightings, 182 (44.6%) sighting events were confirmed by auditory and/or visual contact. Figure 5.1 shows the number of events recorded by month and suggests that elephants were present within the coffee estates throughout the year. However, the months from January to June had more events than the second half of the year. The highest number of events was in the month of March (N=106, 26%). However, the number of elephant sighting events in the coffee estates during the month of March is a sum of two consecutive years, 2011 (N=24) and 2012 (N=82) respectively. If we exclude the events recorded in the year 2011 for the month of March (in order to consider one year's consecutive data from April 2011 to March 2012), the highest frequency was still observed during the month of March, 2012 (N=82, 20%). The next highest frequency was recorded to be during the months of February (N=75, 18.4%), May (N=55, 13.5%) and January (N=53, 12.9%). The number of sightings differed

[66] An elephant individual or group would take refuge within a specific area of the coffee estate for several days before they on moved to a new location. During refuge and movement, elephants cause damage to coffee berries and plants and occasionally injure or kill people causing negative attitudes towards elephants.

significantly between months (One-way X^2 = 327.353, df =11, p<0.001, N=384[67], Figure 5.1).

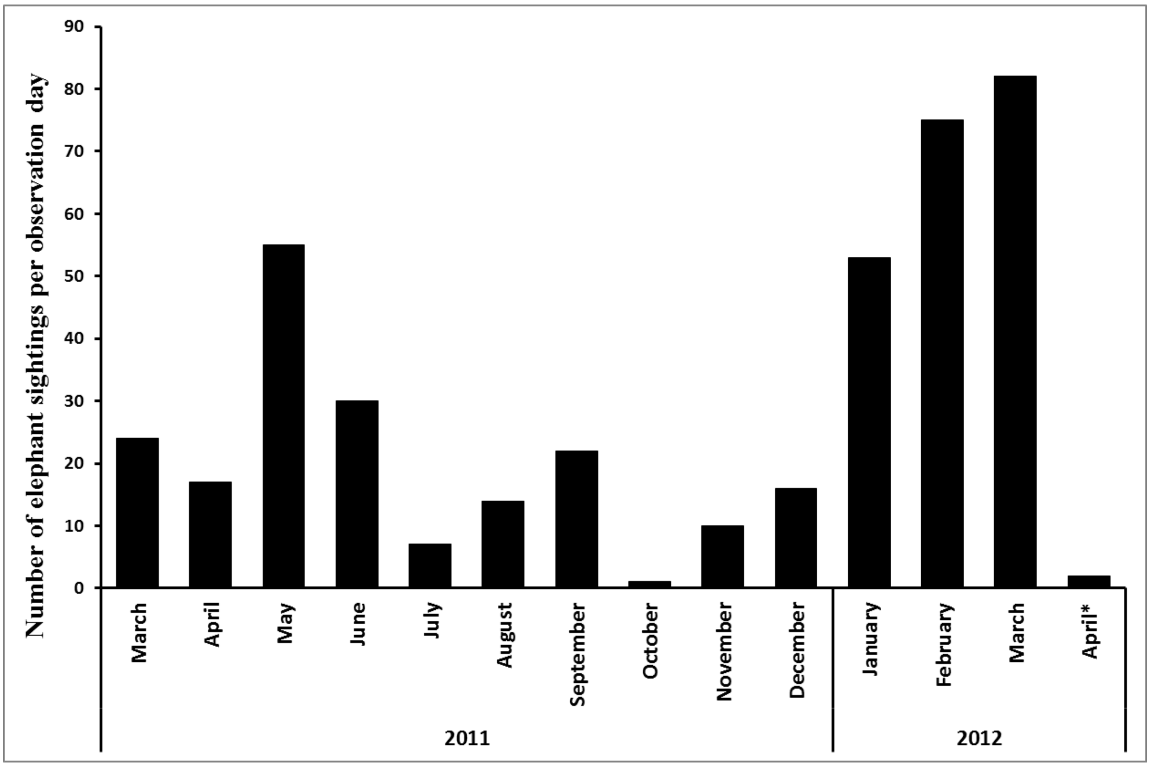


Figure 5.1: Reported number of elephant sightings per observation day by month from March 2011 to April 2012. * indicate that only first week of April 2012 was included as that was the last week of fieldwork (N=408).

5.4.2 Elephant Identification

I was able to identify a number of individuals accurately using different morphological characters detailed above, with additional support from camera trap images and video footage. Making an effort to visit places of reported elephant presence provided more opportunities to sight (encounter) elephants for visual identification verification.

[67] For the one-way chi-square analysis, I have considered only March 2012 (N=84) sighting events of elephants, thus giving a total of N=384 sighting events for one consecutive year.

Individual elephants confirmed to match the descriptors for a previously identified individual were assigned the same ID (See Appendix 9). In total, I was able to reliably identify approximately 20 individual elephants out of some 400 sightings and 339 animals which could be aged and sexed. The low level of individual identification either suggests a high population turn-over in the estates, or more likely, represents the extreme constraints on visibility. I was therefore unable to use re-sighting data to calculate population sizes or rates of reproduction (see below). As there is no established identity of elephant individuals and groups prior (IDs), rest of the chapter is based on general characteristics of elephants recorded.

5.4.3 Group type and size

Table 5.3 shows that more than 50% of the reported events were confirmed by direct sightings of elephants within the study sites. Elephant group size in the study sites were also recorded, and categorised into single elephants or groups of 2-4 (small), 5-10 (mid) and >10 (large) elephants. Precise counts were not used due to general problems with visibility and a lack of confidence in the detection of all individuals present. Individual elephants and groups of 2-4 were sighted relatively equally and totalled approximately 32% of events, suggesting similar presence of individuals and small groups in the use of coffee estates (See Figure 5.2). Groups with 5 to 10 individuals and more than 10 individuals were sighted for 20% and 15% of events respectively. In contrast to some studies, the most frequent reports and sightings were of groups, at least suggesting moderate female engagement in potential raiding of coffee plantations.

Table 5.3: Group size of reported and sighted elephants from March 2011 to March 2012 (N=385)[68].

Group	Number of reported elephant events	Number of confirmed sighting events	Percentage of confirmed sighting events (%)
1	118	62	52.5
2 to 4	128	64	50
5 to 10	78	39	50
>10	61	29	47.5
Unknown Group Type	23	0	0
Total	408	194	50.4

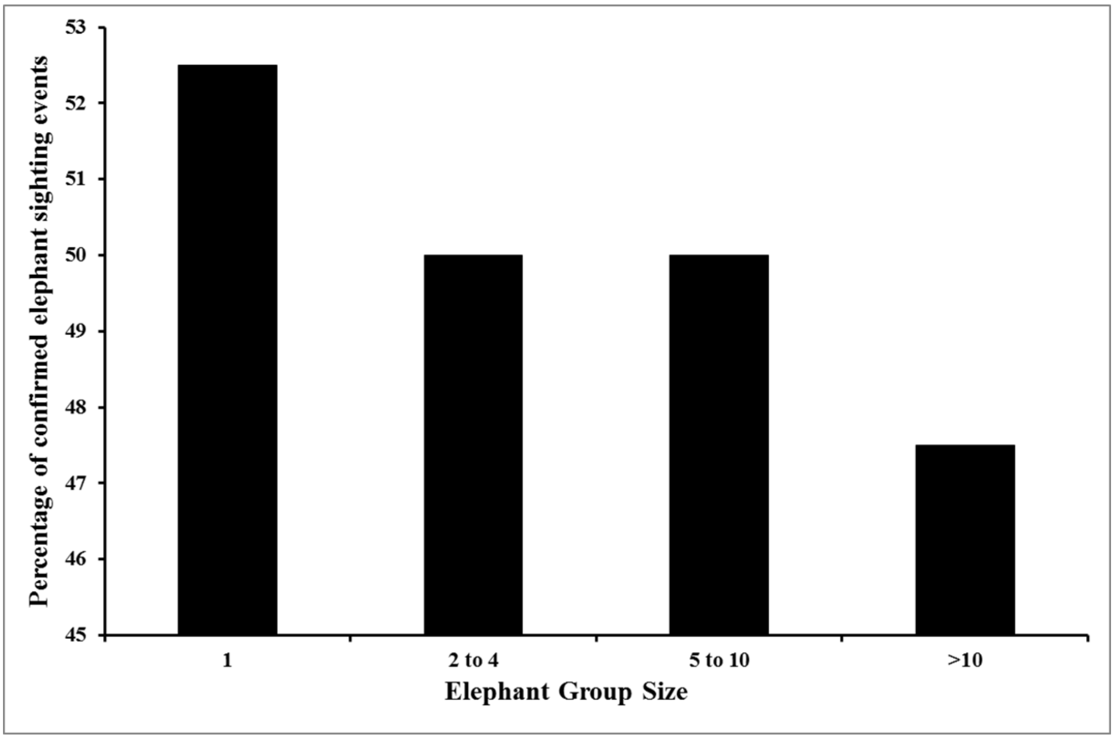


Figure 5.2 Percentage of confirmed sighting events of elephants at each group size (N = 194).

---

[68] Reported events include both confirmed and unconfirmed elephant presence.

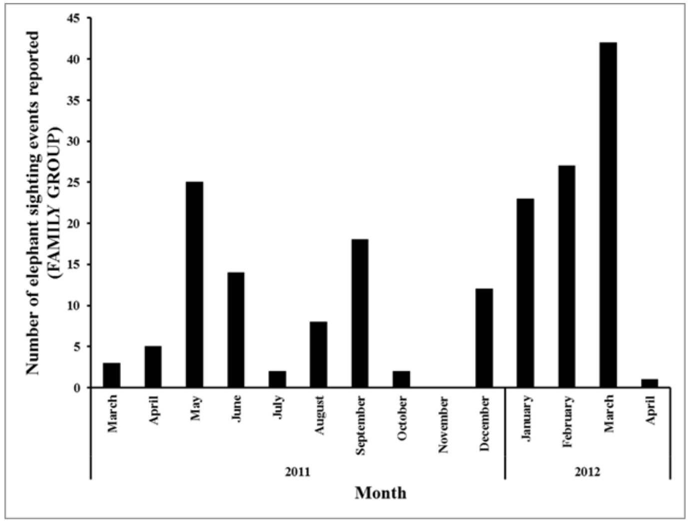
Total N=385 as the information on number of elephants are missing in the 23 sighting events (Unknown).

Data on the group type of elephants using the coffee estates (See Table 5.4) were categorised into groups of family, single male, all male group. When the visibility was poor and there was more than one elephant, the group was categorised into Unknown. Of all reports, 46.9% of elephants present were found to be family herds (N=182), of which 53.3% were confirmed through direct sightings. Lone male individuals were the second highest proportion of reports of elephant presence (22.9%) and about 12.1% of all male groups were documented. The Unknown group type was found to represent 18% of all events documented during the study.

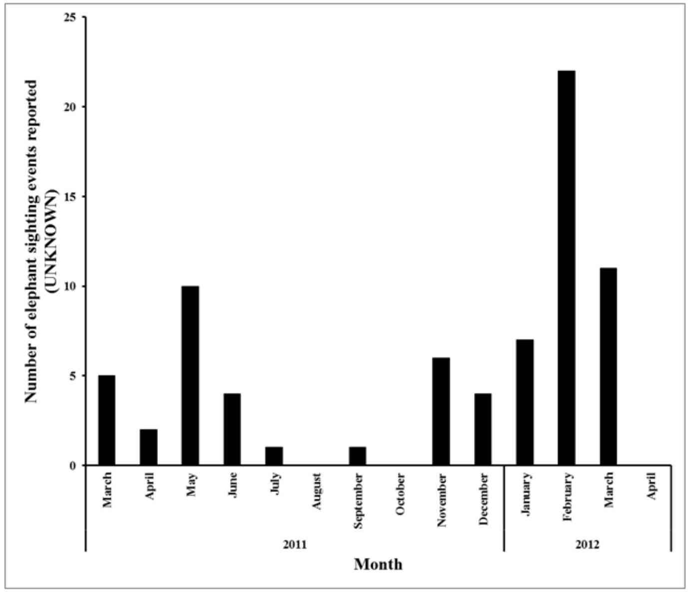
Presence of family herds appeared to be highest during the months of January to March and May (See Figure 5.3a). Presence of all male groups (See Figure 5.3b) also coincided with that of the presence of family, especially during March.

Table 5.4 Group type of elephants reported to be present in the study sites.

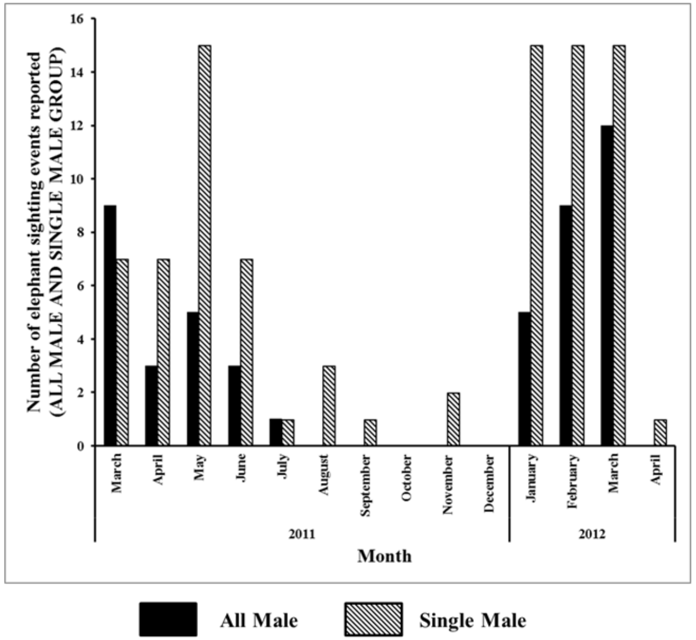
Group Type	**Confirmed reports**	**Unconfirmed reports**	**Total reports**	**Percentage of confirmed sightings**
Family	97	85	182	53.3
Single Male	54	35	89	60.7
All Male Group	37	10	47	78.7
Unknown	6	64	70	8.6
Missing data	0	20	20	0
Total	194	214	408	50



(a)



(b)



(c)

Number of elephant sighting events for groups (a) Family (N=182) (b) Unknown (N=73) and (c) All Male (N=47) and Single Male (N=89)

5.4.4 Study sites (coffee estates) and the frequency of sightings

The study sites were mainly seven estates of TATA Consultancy Private Ltd and other estates (name withheld) (See Chapter 3, Section 2.3). As mentioned earlier (See Section 4.1 above), the 'sighting events' were considered to be a single event irrespective of the number of times that the same individual was seen throughout the day, but as different 'sighting events' for each day if these occurred over a period of several days. Thus, it a sighting event does not imply the presence of different individuals on successive days. The aim of this analysis was to determine the frequency of presence of elephants within the coffee estates irrespective of which elephant individual or groups were sighted. The presence of elephants was documented primarily in three of the estates (See Figure 5.4); Yemmegundi (N=167, 41.05%), Pollibetta (N=73; 18.39%) and Margolly (15.87%). These estates differed in size, were all separated from each other between 0-10 km approximately, and each varied in the extent of forest along their boundaries. Sampling intensity was a function of reported elephant presence, rather than stratified across estates as a function of their size. Therefore, these reported numbers should reflect elephant usage (as perceived by people) rather than sample intensity.

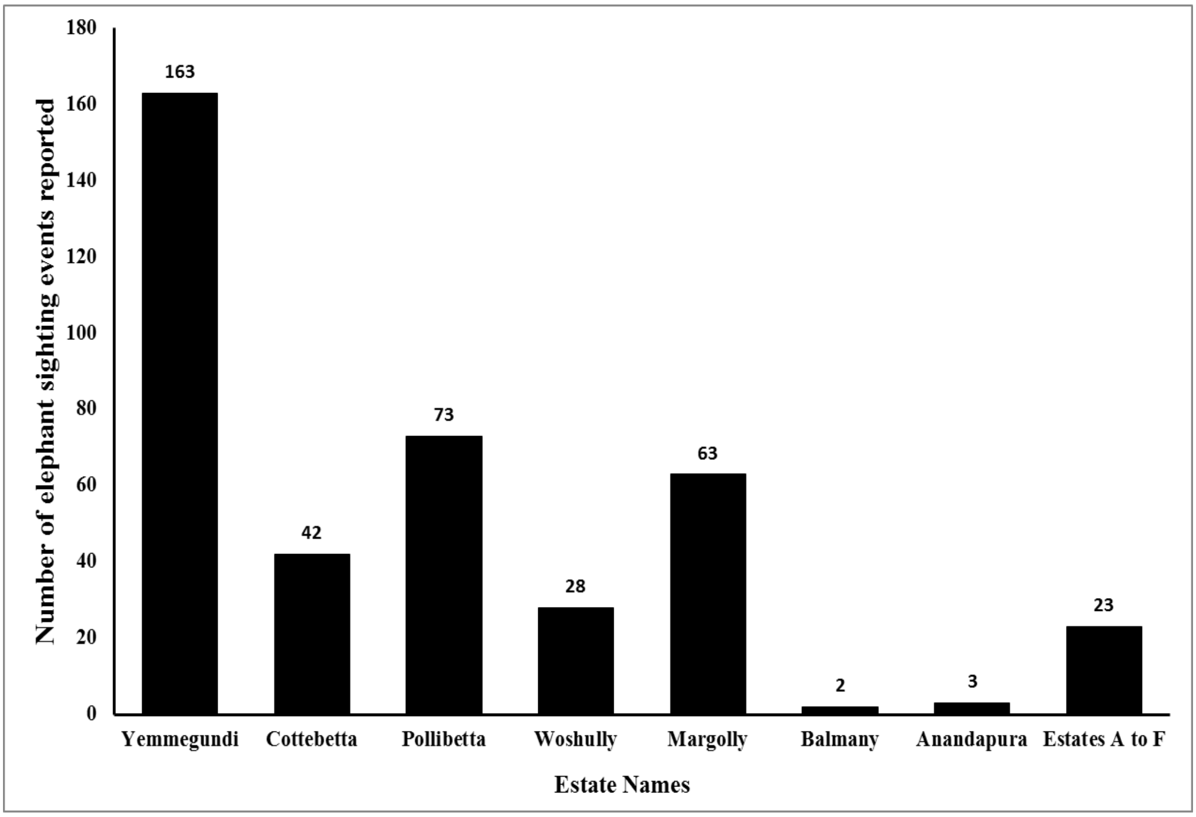


Figure 5.4 Reported number of elephant sighting events in the study coffee estates (N=397; 11 missing information on location; See Table 3.2 for estate details).

Yemmegundi estate has four subdivisions of which Siddapur sub-division was located further from the other three sub-divisions. The highest number of reports and corresponding documentation of elephant presence were mostly from the Doddayemmegundi subdivision of Yemmegundi estate (44.17%) while sightings were equally distributed across the other three divisions (See Appendix 3 for Maps). For Pollibetta division with two sub-divisions, the highest number of reports of elephant presence (71%) was in Mattaparambu sub-division. Gatatdhulla sub-division of the Margolly estate also reported high presence of elephants. Thus elephants were not evenly distributed across these estates, but rather concentrated their use on particular areas.

These reports were only from the study period when the research team was active and do not represent every event of elephant presence on estates within the region. These numbers are based on information obtained from research team's network in the region and prior knowledge of elephant presence from the previous day. The presence of elephants sometimes went unreported due to various reasons mentioned earlier (See Chapter 3), but the differences in presence between localities suggest a preferred elephant movement path and refuge areas depending on the location of all the estates (See Chapter 6).

5.4.5 Distance of sighting events to the identified refuge areas

The locations of elephant sightings in relation to identified refuge areas within the coffee estates were recorded. About 70% (N=242) of the sightings were recorded in identified refuge areas (See Chapter 6, Section 2.1). About 21.8% (N=76) of the sightings were recorded close to the refuge areas (within 500 m) and only about 8.6% (N=30) were sightings were recorded further (greater than 500 m) away from the refuge areas (Figure 5.5). Elephant presence in relation to refuge versus close or distant from the refuge area differed significantly (One-way chi-square, $X^2 = 214.4$, df = 2, $p < 0.001$, N=348).

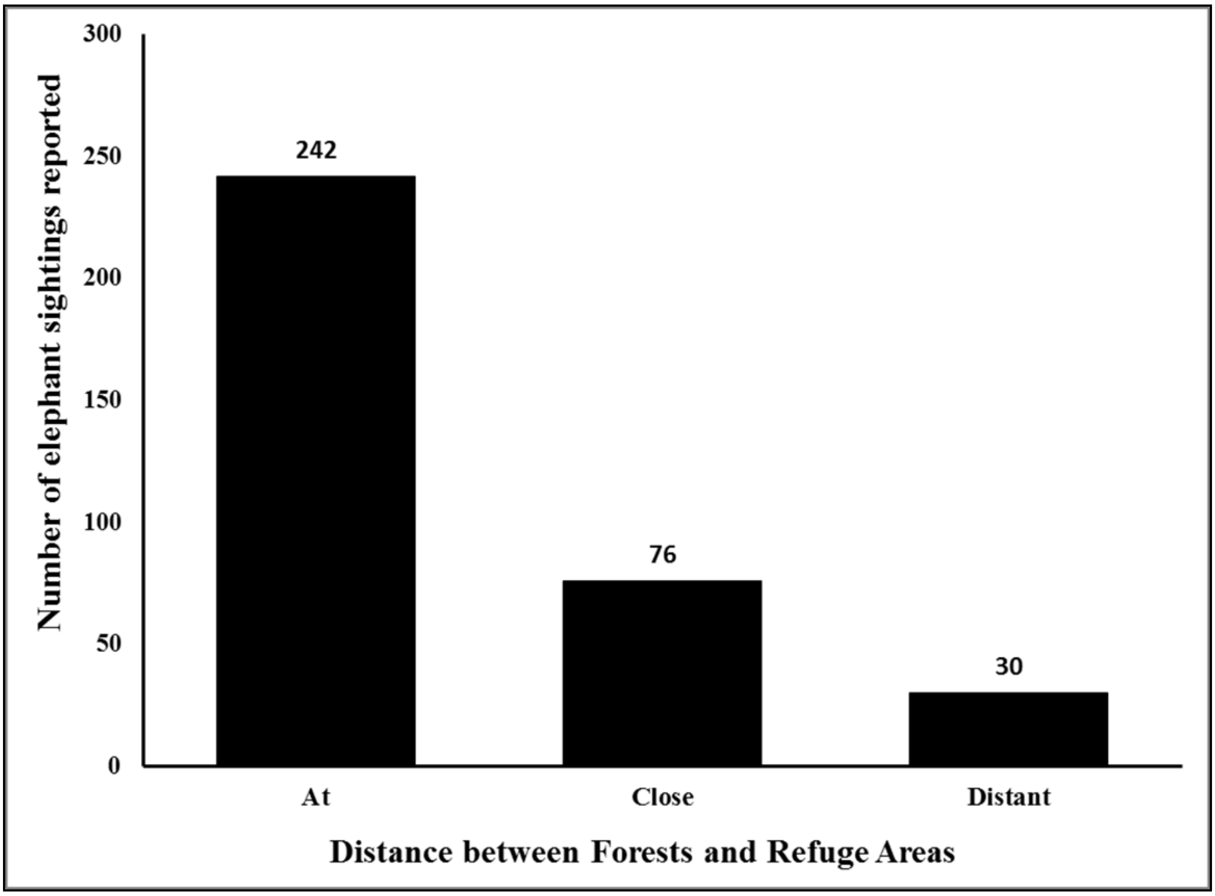


Figure 5.5 Reported number of elephant sighting events in relation to the distance between Forests and Refuge Areas (At – within 10 m radius of Refuge Areas; Close - < 500 meters radius and Distant - > 500 meters).

5.4.6 Time of sightings during sighting events

An accurate time of a sighting event was available for a total of 376 events, of which 281 were morning and 95 were in the evenings. The other 32 sighting events were reported with no definite times. Of the 376 sighting events, the number of elephants in a group was reported for 362. All group types were mostly reported and sighted during the morning. Family groups were reported and sighted in 120 morning events versus 51 events in the evening. The same trend was observed for other group types; all male group (N = 32 am: 13 pm), lone (single) males (N = 62 (am): 22 (pm)), and even the unknown elephant events were mostly reported to be in the mornings (N = 56 (am): 6 (pm)). This difference between the morning and afternoon in the number of time of reports of elephants presence on coffee estates was significant (two-way chi-square, $X^2 = 10.168$, df = 3, $p < 0.03$, N = 362; See Figure 5.6 and 5.7). Of the 186 confirmed sighting events, 117 sighting events occurred during morning and about 69 events in the evenings.

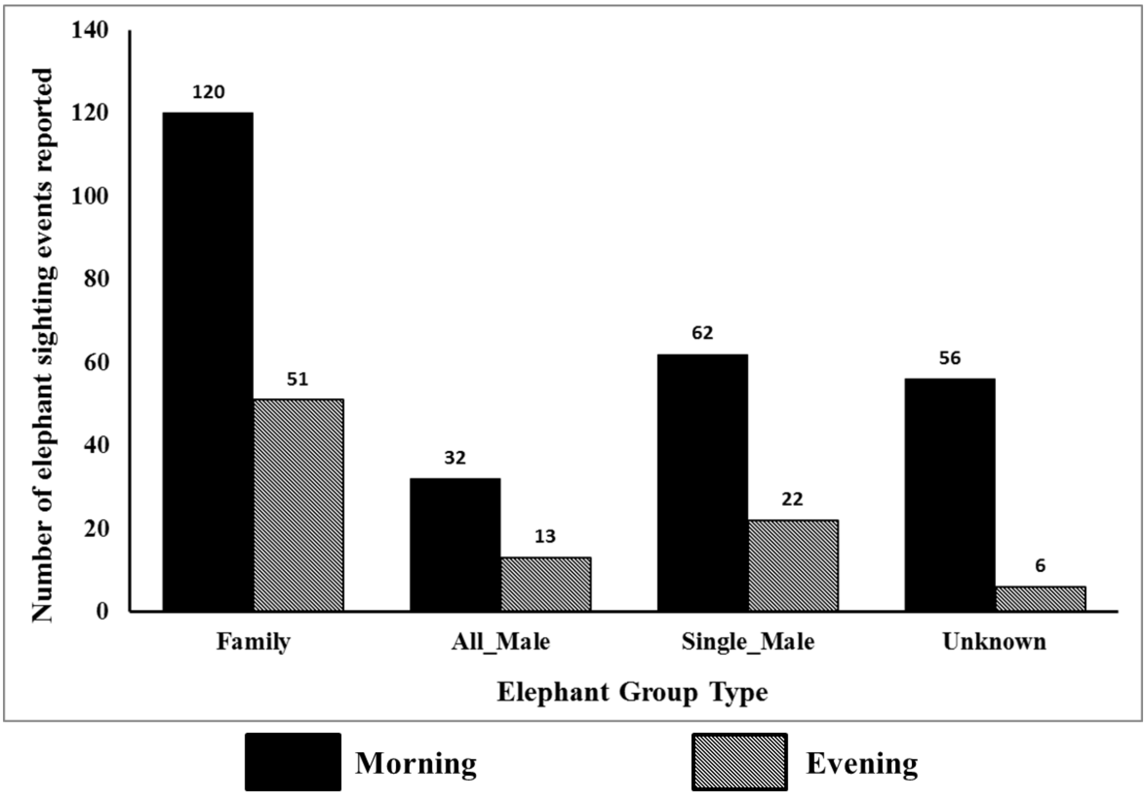


Figure 5.6 Reported number of sighting events of each elephant group type in the morning and evening hours (N = 362).

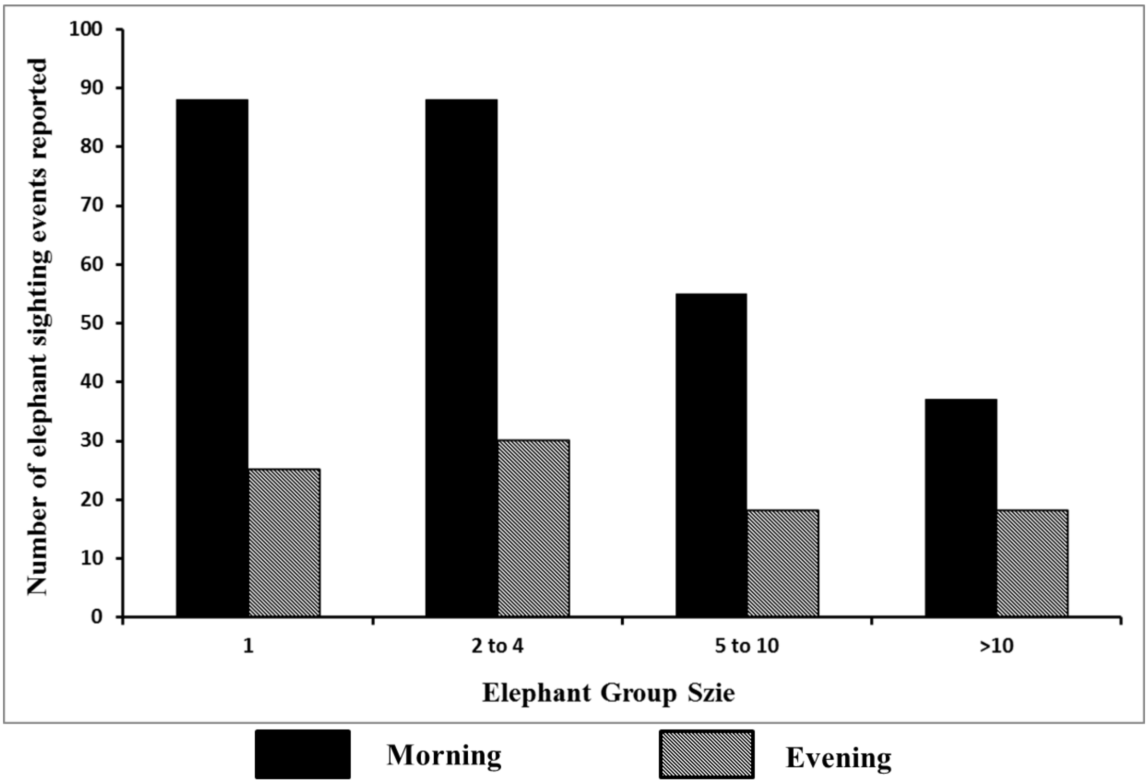


Figure 5.7 Reported number of sighting events by elephant group size in the morning and evening hours (N = 359).

5.4.7 Age-Class of Elephants in Sightings

As mentioned above (Section 3.4), elephants were classified into adults, sub-adults, juveniles, and calves with a fifth classification of 'Unknown' for those individuals which I was not able to categorise by age or sex (See Table 5.2). There were a total of 214 sighting events of adult elephants of which 127 were males, 66 females and 21 unknown. Sub-adults accounted for about 35 total sighting events of which 20 were females, 13 males and 2 unknown. Total sighting events of juvenile elephants were 40 of which 15 were females, 16 males and 9 unknown. A total of 56 sighting events of calves were observed. These data represent the number of sighting events and not those of individual elephants.

5.5 Discussion

This chapter provides the first quantitative data on the elephant population of Kodagu using coffee estates. Group composition and individual identification of the elephants has not previously been attempted in this area. However, this study specifically focused on getting to know the elephant population using the coffee estates and establishing a baseline of estate use, according to group composition, location and time of day.

This was a relatively short term study of only two years[69], and endangered and wide-ranging mammals like elephants require constant reliable monitoring to ensure their survival from threats in human-dominated landscape and to enable more effective conservation actions. The baseline data illustrated here should however contribute to defining the general patterns of estate use in relation to the overall population.

5.5.1 Identification of elephant individuals through camera traps and other methods

Identification of elephant individuals, estimates of the population through camera traps, frequency of use of the landscape at particular times and the reports of encounters or sighting events from local workers showed that there was a pattern to the elephant movements within the region (See also Chapter 6). A basic problem of monitoring elusive and rare species is that they are difficult to detect (Thompson, 2004). This problem was particularly evident in coffee estates which have been termed 'managed forests' in Kodagu. The biases and irregularities in detecting elephant presence and once detected, to be able to identify them, are very challenging. As a result, I tried to use video and photo documentation (mainly through camera traps) to corroborate

[69] 13 months for elephant sighting data collection and 3 months for reconnaissance of study sites; 8 months for secondary and qualitative data collection.

observations and provide preliminary data that can be used to establish long-term monitoring of elephants in the district.

In recent years, the use of photographic methods to identify individual animals has become one of the important ecological survey methods for population estimation and abundance. However, the process of matching a given photograph to that of a large-set of database or to create such a database is an expensive, labour intensive and challenging task. In recent years, the capture-recapture method has been considered as the most reliable method of monitoring to assess and detect animal population effectively, especially those species that are inclined to low visibility (Williams *et al*., 2002; Amstrup *et al*., 2005).

Identified elephants were mostly male elephants with only a few female elephants identified within a group. With the available camera trap pictures and video documentation, I could identify 12 individual male elephants and three female elephants and their associated calves. All identified female elephants were seen in the group of 19, the largest group observed during the fieldwork within the coffee estates. That these females were seen both in a large aggregation and in smaller groups suggests that they were resident and shared some social attraction (de Silva & Wittemyer, 2012; de Silva *et al*., 2011; Wittemyer *et al*., 2005). There were other individual elephant pictures especially for females, whose identification could not be confirmed due to poor quality or angled pictures. One of the main disadvantages of the study was that there were not enough camera traps which could have otherwise produced higher quality elephant photographs for greater identification. The lack of additional camera traps resulted in the need for an additional strategy to optimise the available camera traps to yield as many photographs as possible so as to develop the first database of elephant identification for the study region. Initially, camera traps were deployed at the identified refuge areas but later some of the camera trap locations were constantly changed, depending on elephant presence within the estates, in order to estimate the possible areas that the elephants used. This was neither an ideal nor a systematic method for the use of camera traps but for this study, this ad-libitum method was considered to be best use of the time and resources available.

Camera traps are expensive and logistically difficult to use (Field *et al*., 2005). A need for optimizing logistically field sampling strategies without compromising on statistical rigour is important (Goswami *et al*., 2012). Camera traps used for this study had only still image options and were mainly used for working out when and which the elephants visited the estates. The number of camera traps used was tiny due to financial constraints and the institution had only eight cameras available for rental. The night images were of poor quality and there were problems of missed shots, blank shots, and triggering problems. These disadvantages resulted in a loss of number of pictures that could have potentially been useful for capturing (and re-capturing) elephants within the coffee estates as they appeared to prefer to use open areas and estate roads during the night and early mornings. In capture-recapture methods, identification of individuals is crucial and most studies require identification of individuals in the field.

Visual confirmations of individuals identified through camera traps were made except for few individuals who could not be spotted or those known to be resident by people living in or near these estates. In more robust CR studies, it is suggested that any automated unsupervised method of individual identification needs to be followed up by supervised visual method as a final stage to ensure that there is no misidentification of individuals of similar morphological traits (Goswami *et al*., 2012). Even determining age-sex class through video and photographic methods is subjective and is potentially biased as it is difficult to judge physical characteristics in 2D images. But one aim of this study was to understand the group composition of the elephants using the coffee estates, and age-sex classes were reliably assessed from images.

5.5.2 Frequency of use of coffee estates by elephant individuals and groups

The presence of elephants on the estates increased through the months of January to June, just after the second monsoon season in Kodagu. Elephants are known to visit agricultural lands post-monsoon, as these agricultural lands provide plenty of food and water resources (See Chapter 6). Paddy rice season is from November to January which may account for the lower presence of elephants within the coffee estates at this time than during other months as these attractive crops were available outside the estates. The gradual increase in numbers entering the coffee estates following the paddy season suggests a regular seasonal pattern to elephant movements in this region. The jackfruit season was considered to be a main attractant for elephants visiting coffee estates even though these fruits are only available between the months of May-September (Kulkarni *et al*., 2007; Bal *et al*., 2012; See also Chapter 6). However, there are other resources available throughout the year, like grass as fresh fodder, or year-round fruit resources like coconut, arecanut, and banana, that appear to provide foraging substitutes at the end of paddy season and in the absence of jackfruit. Orange fruit is available during the months of July to September and also in December and January. Mango is a seasonal fruit available during the months of May to August. Moreover water is also a valuable resource that is plentiful within coffee estates. Although the suggestion here is that the elephants have shifted their diet from paddy rice to those resources available in the coffee estates, we still lack systematic data to test this hypothesis (but See Chapter 6). The increased presence of elephants during the months of December to June could also be due to transitory elephant populations moving between large forest blocks, or to resident elephants foraging for resources within their traditional home range, or both. It is also important to highlight that the relatively low numbers of elephants recorded during the month of July could be a result of time spent on dung-transect surveys, a lack of good visibility on estates, and perhaps an inability to respond quickly to reported sightings (See Chapter 7). Despite these biases in effort and in my data collection methods, an attempt has been made to understand the dynamics, grouping patterns and individual elephants which were visiting the study estates.

Most elephants visited estates either as single individuals or as small groups of 2-4 animals. These small groups made the detection of elephants more difficult as Robusta coffee plants were the same height as the elephants and provided good cover. The largest group size recorded was 19 individuals, which was quite large for Asian elephants (de Silva *et al.*, 2011). Family groups of elephants were more frequently present during the post-monsoon peak of elephant visit to the estates. However, overall results indicate the male elephants were present throughout the year and were the most frequent visitors to coffee estates. The possible bias in the high number of male elephants could also because of sighting the same male individual elephants; for example, 'Oldie' who preferred to use the human-settlement areas more than hiding within the coffee bushes. However, the group type data also indicated the formation of all male groups during the peak months of family group presence. This could be a period which coincides with the mating period. With the availability of paddy crops and fresh grass in the coffee estates after monsoons, this could be a period of high mating activity and may explain the increased number of male-male associations (Sukumar, 1989). Further research on the behaviour of male elephants and musth periods of identified male individual elephants would provide insights into associations of family units with males and male-male associations. Male-male associations were mostly observed between a few identified male elephants (See Appendix 9).

At this stage, we cannot easily separate seasonal estate use by small versus large groups from seasonal differences in detection probability. An increase in the reported frequency of family herds or larger group sizes during the coffee season might be due to increased vigilance by the estate guards, workers and owners concerned for the safety of their workers and protection of the coffee crop yield. Also, an increasing demand for coffee (apparent in coffee prices during my study period) may compel the famers to invest in higher vigilance, again resulting increased report of elephants within the estates. As the number of people active across different parts of the estates increased during coffee season, there was also a higher chance of sighting elephants than during non-coffee seasons; out of season estates provide isolated areas of reduced human activities for elephants to use potentially without detection. However, increased human presence should coincide with increased reports of all types of groups, and not a shift to larger group sizes. We can suggest that the greater number of people may have led to behavioral adaptability with elephants moving in larger numbers as a defense mechanism against people, although larger numbers are easier to detect than is an individual elephant or smaller groups of 2 to 4 elephants in these coffee estates. Larger elephant groups are also of greater concern since they can cause more damage to coffee berries and plants whether accidentally or deliberately. As mentioned earlier, post-monsoon high availability of resources may influence the movement of elephants from one area to the other via large estates, especially the family herds with greater nutritional requirements; these movements may coincide with the coffee ripening season in Kodagu. Future research is required to understand seasonal variation in the numbers and social dynamics of the elephants using these estates. The association of elephant numbers with resources present on estates is further examined in Chapter 6.

In India, number of male Asian elephants are in catastrophic decline, despite reports suggesting that there was 69% increase in the overall elephant population from 1980 to 2002 (Government of India, 2006). Higher male elephant mortality (resulting in skewed sex ratios) due to ivory poaching and also retaliatory deaths from crop-raiding affect the male elephant population disproportionately; female Asian elephants do not have tusks and bull elephants are considered to be more vigorous and frequent crop-raiders (Sukumar, 2003).

The data collected here indicated seasonality in the use of the landscape as well as marked diurnal patterns. Elephants were mainly observed during two particular times of the day, early mornings and evenings (See 5.3.3 above). Even if the elephants were spotted at different times, I was requested by the estate management not to disturb the elephant by approaching for observations or identification as this could have startled the elephants and led to movements of elephants during the working time of the estates, putting estate workers and coffee at risk. Thus, my times of observations were biased towards morning and evening sightings. However, this gave me an opportunity for direct sightings of the elephants and to confirm elephant resting areas within the estates during the day. This documentation of the location of elephant refuge areas/ spots over the year has shown that elephants use the coffee estates in certain patterns and appear to strongly prefer certain areas of the coffee estates over others. These preferred locations could be a function of proximity to water resources, to food resources like jackfruits, to forests, or to the neighbouring large estates, etc. (See Chapter 6). Most of the sightings were in Yemmegundi estates and Gattadhulla; however, skewed observations between estates could also be a result of differences in management or other factors impacting upon the likelihood of estates reporting to the research team. These factors will be discussed below.

Further research should focus on more robust study by deploying more camera traps with both video and still photography options in more coffee estates that are reported to be frequented by elephants throughout the year. Video options can also be a reliable substitute to direct observations of the behaviours of elephants within the coffee estates. As most of the time the elephants were hidden between the coffee bushes, direct observations of behaviours were difficult, if not impossible. Deploying video camera traps at known and identified refuge areas, would not only give us the identity of the individuals, but also information on their behaviour and activities. Informed observations on elephants' activities within the estates would give an insight into their behaviours and their adaptations to the use these coffee landscapes.

Areas of coffee estates where elephants aggregate as a group or individuals and paths used for movements would be ideal for further camera trap sites (See Chapter 3, Section 3.5). These are:

- Water tanks, especially those area that are rarely used or left abandoned by the coffee estate management or workers, would be an alternative to the water holes in the forests used by elephants.
- Swamp areas, especially with loose mud for elephants aggregate for mud baths located close to water tanks.

- Abandoned cardamom plantations, now degenerated into swamp areas, were also observed to be areas where elephants were known[70] to spend more time within the coffee estates.
- Refuge areas within coffee plantation blocks, which are large clear areas because of constant use by elephants.
- Regular paths used by elephants to enter and/ or exit the coffee estates or those paths that they used to move about within the estates from one area to the other. all

A more robust scientific study, using capture-recapture methods extended across the districts, could help in estimating movement rates of elephants under multi-state models (Williams *et al*., 2002; Goswami *et al*., 2007). The use of camera trap methods can provide comprehensive catalogues of identified individual elephants and where applicable aide estate managers and people to monitor the elephants using their coffee estates. Estate workers are excellent trackers of elephants within a familiar area and further training would provide them with skills to identify the elephants using their areas. This would yield more precise data on whether the elephants using the areas are transitory groups or resident elephants. The frequency of the individual elephants visiting a location would also provide data on home ranges of these elephants in the absence of GPS collars.

Such information could be gathered in collaboration with other stakeholders like the State Forest Department, Non-Governmental Institutions, estate owners, farmers and

[70] Elephants taking refuge in abandoned cardamom plantations were reported by the local community to the research team. This was also observed in the study estates where the abandoned cardamom plantations were ideal for elephant refuges as the height of the plants was tall enough to hide elephants. Most of these cardamom plantations are now being converted to coffee plantations across Kodagu.

other related policy makers and local people to be able to develop appropriate mitigation strategies that would minimise the negative encounters between people and elephants through better understanding and knowledge of elephants' movement within the human-dominated landscape in Kodagu. Recently, Karnataka Forest Department announced that they would be capturing about 150-200 elephants within the state as a management strategy to reduce interactions at the elephant-human interface, which have been causing crop depredation and loss of human lives (Ashwini, 2013). This elephant population resides in substantially fragmented forest areas surrounded by agriculture and human habitations. These elephants are known to use the areas between north of Kodagu district and the neighbouring Hassan district. Various mitigation measures have been taken to reduce crop loss and negative encounters with people, including the translocation of two elephants from the population (Bhoominathan *et al*., 2008). Translocation measures were a failure as the two elephants travelled back to their previous home range. With increasing human-elephant interactions, it is not possible to capture the entire wild elephant population and place them in captivity. It is thus important to evaluate and understand elephant movements in relation to specific regions and habitats, and therefore develop management strategies to reduce negative encounters in order to ensure the co-habitation of people and elephants, and wildlife in general.

5.6 Conclusions

This study has attempted for the first time to identify as many individuals or groups that are using this area, although this proved to be challenging due to a diverse range of logistical and technological factors. These results aim to serve as a baseline for future research in this area and the preliminary identities and information on group dynamics could be used to establish long-term research so as to better understand and determine elephant population's use of the coffee agro-forestry landscape and inform future conservation initiatives.

Chapter 6

COFFEE ESTATES: REFUGE AREAS

CHAPTER 6: COFFEE ESTATES AS REFUGE AREAS

6.1 Introduction

Elephants are wide-ranging mammals and are known to use regions outside protected areas substantially. It is now evident that mammals, especially such wide ranging mammals cannot be contained only within protected areas. Until recently (Ogutu *et al*., 2011) it was estimated that ~80% of African savanna elephant range was found outside protected areas (Hoare, 2000) resulting in competition for resources and space with humans (Naughton-Treves, 1998; Balmford *et al*., 2001). Elephants may take several months to cover their extensive home ranges (Fernando *et al*., 2008). Elephants travelling outside the protected areas have to use grazing or agricultural lands, settlement areas and other human land conversions which eventually increase the human-elephant interface for hostile interactions (Hoare, 2000; Sitati *et al*., 2003; Garcia *et al*., 2007; Bal *et al*., 2011). It is of crucial importance to understand an animal's ranging patterns and home range size for effective conservation planning so as to avoid negative human animal interactions at the interface. Asian elephants have smaller home ranges by comparison to African forest and savannah elephants (which average ~1400 km^2) and there are only a few detailed studies on the range of Asian elephants (250 – 1000 km^2; Sukumar, 2003; Fernando *et al*., 2008; Williams, 2009; Baskaran *et al*., 2011).

Proximity to the forest boundary has been found to be a strong predictor for the crop damages occurring by wildlife (Naughton Treves & Treves, 2005). In Uganda, crop damage occurring in villages surrounding Kibale National Park suggested that the damage was found to be highly skewed in terms of some field destroyed completely where some were untouched.

Kodagu is surrounded at the district boundaries by natural forests, and it is plausible that the elephant populations are moving from the eastern forests to those in the west, which are part of a continuous elephant range in the Western Ghats. Regional patterns of compensation records suggest that there is a band of crop depredation events from the east to the west across the district (Nath & Sukumar, 1998; Bal *et al*., 2008). This band of events may indicate that the elephant populations could be using the vast stretch of agricultural lands between the eastern dry deciduous forests and western evergreen forests as 'linking' transitory corridors. But these are assumptions based only on the crop compensation records across the district rather than observations of movements or remote tracking of elephants.

Laikipia elephants also used corridors from one core forest areas of their home range to another (Douglas–Hamilton *et al*., 2005). Such corridors outside protected areas are vital for sustaining populations of elephants and other rare mammals (Jones *et al*., 2009, 2012). Douglas-Hamilton *et al*. (2005) indicated that elephants which used such corridors moved much faster than they did anywhere else in their range. This suggested that elephants were aware of the dangers outside the protected areas and were cautious when outside the protected areas. Recent studies on elephant responses to risk (e.g. Graham *et al*., 2010; Gunn *et al*., 2014) clearly demonstrate the cognitive capacity to vary ranging behaviour in response to human risks in the landscape. Elephants are known to raid crops nocturnally when there are fewer people and the probability of detection is lower (Sukumar, 1989; 2003). In Mikumi National Park, Tanzania, elephants crop-raid less during the full lunar cycle due to the increased probability of being visible to people and to the potential predators of young animals (Gunn *et al*., 2014). The decrease in crop-raiding could be due to bright moon light which allows people who are guarding the crops to be more vigilant when visibility is high (Barnes *et al*., 2006; Gunn, 2009).

Elephants were thought to use traditional migration routes for generations well before the advent of agriculture. With increased forest fragmentation, increasing human activities and human and livestock competition, elephants may be in search of novel areas with low human activities together with greater availability of food resources. In Bénoué National Park (Mali), the elephant populations used the areas outside the park boundaries, which may be due to the presence of preferred and / or higher quality forage (Power & Compion, 2009; Granados *et al*., 2012). The authors suggested that although there was a higher risk of mortality outside protected areas, elephants traded lower predation inside the park in order to access resources of higher quality.

Elephants typically use permanent routes for repeated movements to and from dependable resources (Gautier-Hion *et al*., 1985; Campos-Arceiz & Blake, 2011), which may improve their foraging efficiency. Regions with intensive agricultural lands, such as Kodagu, cannot convert these croplands to create large connecting corridors or reserves for animals. Thus it is important to understand which paths the elephant population regularly uses within these landscapes so as to potentially manage these areas as corridors enabling elephant movement with reduced damaged to the surrounding agricultural crops and threats to the lives and livelihoods of people. The potential to establish and protect corridors is of vital importance to maintain populations of large mobile mammals.

This chapter aims to provide a baseline description of the potential role of coffee-agroforestry landscape on the locations and movement of elephants in Kodagu. Why and how are these landscapes used by the elephants? If elephants are using these regions deliberately and are not a part of the migration route, what are the attractants that influence elephants' visit to these estates?

6.2 Methods

Data used for this chapter was collected along with the data presented in Chapter 5, using the same methods (See Chapter 5, Section 3). The coffee season was defined in terms of the months of peak coffee berry production, which occur during the period between December to February. Sometimes production may extend until the end of March or early April depending on the monsoon rains. Thus the data on elephant numbers are not distributed equally for all seasons that vary in time frames.

6.2.1 Refuge areas

Coffee estates in Kodagu differ in sizes from an area of less than >1 ha to more than 100 ha owned by single coffee planters (See Chapter 3). Only about 3.24% of the coffee estates in Kodagu are estimated to be landholdings of more than 10 ha (Deepika & Jyotishi, 2013). These large estates are either owned privately or under the ownership of large coffee company co-operatives. These larger coffee estates are located at various settings across Kodagu amidst the sea of smaller coffee estates. These larger coffee estates can be close to the forest, even sharing the forest boundaries or further from the forests and closer to the towns, bordering other coffee estates or motorways. However, these large area coffee estates were thought to be used extensively by elephants as ‘refuge zones’, but until this study there has been no documentation to support this opinion. Elephants are able to use certain areas within these large estates with lower human disturbance than in other small land holdings with different ownership models. However, during the study I was able to identify certain hotspots within these large estates which elephants preferred to use as rest areas or ‘hiding areas’ which are referred to as ‘refuge areas’. The size of these refuge areas is very small in relation to the overall area of each coffee estate. The refuges areas are a small patch within the coffee estate which provides a good hiding or resting place for the elephants. Factors affecting the choice of such patches by elephants have yet to be studied in detail. Some of the possible factors are proximity to the forest boundary, water and food resources, access to movement paths, absence of close human settlements, good undergrowth and tree cover for shade and cover. These resting areas within the coffee estates thus seem to function as ‘hide-out’ areas during day time. Refuge areas were identified through information provided by local people and by recce for the first two months of the study. These refuge areas were observed to be used often by the elephants from reports and confirmed sightings, dung sampling (See Chapter 7) and camera trapping (See Chapter 5). Distance to sighting events were categorized into three categories: AT (sighting events located in the identified refuge areas); CLOSE (sighting events within 10 m radius of the identified refuge areas) and DISTANT (> 10 m radius of the identified refuge areas).

6.2.2 Location of refuge areas within coffee estates

Larger coffee estates were considered a more favorable area for elephants than were the smaller estates, as these large estates provide potential areas for elephant movements with low human presence most of the year, with an exception during coffee picking season. Bal *et al*. (2008) indicated that the tree cover alone was not a significant correlate with elephant visitation to the coffee estates. Preference of elephants for the extensive use of specific areas within coffee estates may be influenced by certain characteristics of the habitat which are discussed here as independent factors irrespective of whether refuges were located within elephant movement corridors or central to home ranges[71].

6.2.2.1 Shade cover

The identified refuge areas on coffee estates were not necessarily near high density tree canopy cover, but often located within the Robusta (*Coffea canephora*) coffee plants which provide sufficient cover to obscure visibility, especially from humans (See Figure 6.1). Elephants also seemed to open up part of the area within the blocks of coffee plant by bending the plants to create a space for standing and resting (See Figure 6.1). About 90% of the identified refuge areas were located in thicker and taller blocks of coffee plants within the study estates which provided some shade for elephants and elephants were observed lying (sleeping) under the coffee plants. This suggests that the elephants' choice of refuge areas was independent of the canopy shade of both tree and coffee plants as they altered the habitat to provide a safe resting space, while retaining shade from the higher natural forest cover.

[71] To date there is no documentation of either elephant populations frequenting the study area, their movements or their home range.

Figure 6.1 Examples of Refuge areas within the coffee estates with varying tree canopy shade cover and the clearing of refuge area for standing and or resting areas of elephants using these landscapes.

6.2.2.2 Water

Irrigation is an important part in coffee cultivation, especially when there is shortage of rainfall. Apart from annual monsoon rainfall, coffee plants require at least one session of water supply during these months, mostly through water sprinklers and drip irrigation. This water supply was important for setting of the flowers to yield good quality coffee berries (See Figure 6.2).

Water tanks of varying sizes, shapes and numbers were thus located in all coffee estates in Kodagu. Smaller areas of coffee estates mostly have one or two water tanks, whereas for larger area of coffee estate three to four, or more, water tanks existed for irrigation purposes. Thus, across the broader landscape of coffee estates that neighbor each other, water tanks were relatively evenly spread nd not concentrated in specific areas. The effect of water resources in relation to refuge areas will need to be evaluated in terms of annual rainfall, water availability in natural forests, elephant movement period, distance to water tanks in relation to each individual refuge areas, etc. At this preliminary stage, such data do not yet exist.

6.2.2.3 Presence of people

Presence of people can be discussed in terms of settlements and their activities on the estates for coffee cultivation (See Figure 6.3). Except in the main towns and villages, houses were spread sparsely within the landscape of coffee cultivation. In the smaller estates, either the farmer's house was located outside the estate or was within the coffee estate surrounded by coffee plants. In the larger coffee estates, the farmer's house and estate workers' homes (called colonies) were spread across the estates in different locations. Housing was not concentrated at one location. On the Co-operative estates, the offices, pulp house and drying yard were located at a single location but each sub-division had different units which were again spread across the estate along with the Manager's bungalow and workers' homes. Thus, in relation to human settlement areas refuge areas were approachable from all directions. Some refuge areas were further from human settlements than in the other refuge areas, but the pattern remains to be determined. Further understanding of elephant movement patterns within coffee estates and the seasonal and diurnal use of each refuge area is necessary in order to evaluate the effects of all these factors on the choice of refuge areas.

Human activity[72] in relation to refuge areas is another factor that needs to be considered. The presence of refuge areas suggests that elephants prefer to 'hide' during the day time when people are working within the estates. However, there is no specific coffee harvesting schedule and it is not necessary that work is carried out at the same place and at the same times across years. People's working patterns are determined by managerial decisions and the requirements for that specific year of coffee cultivation. Humans work the blocks containing refuge areas in the same manner as in any other parts of the estate. Thus, human activity on the estate per se may not determine the choice of specific individual refuge areas but rather a preference for refuge areas as a whole.

6.3 Analysis and Results

6.3.1Overview

Analyses were carried out on the total number of reports of elephants and then on the total number of elephants reported (N=408; See Chapter 5). For this chapter, the log normalised number of elephants reported and the number of groups reported were used in a general linear analysis of variance in order to assess the independent effects of several explanatory variables on the presence of elephants[73]. The interactions between different potential explanatory variables were also examined. These explanatory variables were months, coded as coffee season or not, presence or absence of perennial fruits (See below), distance to forest and presence of a refuge area. A total of 149 refuge areas were identified across the different study estates. Distance to refuge area was coded for each sighting as AT refuge, CLOSE to refuge and DISTANT (See Chapter 6,

[72] Working in coffee estates like applying manure, pruning of coffee plants and trees, coffee picking, irrigation, and other activities involving coffee cultivation and production.
[73] Log transformations were used to transform the data into normal distribution as initial analysis of the raw data indicated skewed distribution.

Section 2.1). As most coffee estates shared some forest boundaries and as most contained natural forests as shade trees, the proximity of elephant sightings in relation to distance to forest was categorized into ≤ 500 meters (Very Close) and > 500 meters (Close).

I have included both events verified by direct sighting ("sighted") and events reported but not confirmed ("non-sighted") in the total number of elephant sighting events reported, since at least 50% of the events were confirmed. The reasons for unconfirmed, non-sighted events was due to difficulties with visibility in dense plantations, with elephants moving into other estate areas before I or my assistants reached the sighting location or being unable to respond to sighting reports due to prior commitments in the field or long distances to travel for verification..

Perennial fruits were taken into consideration for the analysis as they were available throughout the year and thus may have had some effect on elephants' feeding behavior, especially in relation to the coffee season. It is important to look at other fruits with specific fruiting seasons that are available only during certain months of the year and understand how their presence affects elephant visits during coffee season. These fruits (See Table 6.1) were scored on a presence / absence basis, although jackfruit was scored for in relation to each sighting event and categorized here as high (more than 5 trees in one location) and low (≤ 5 trees in one location). Availability of water was not considered because of the high density of water tanks present within the estates of which at least few retained water throughout the year. Some water tanks were not considered as they were either too small to be used as a resource by elephants and were not regularly maintained.

Table 6.1 Food types and their fruiting or available months (Narayana, 2009). These months represent 'presence' in the sample and annual cycle of availability are called 'seasons'.

MONTHS	FOOD AND FRUIT TYPES							
	Coffee (berry)	Paddy (Rice)	Banana	Arecanut	Coconut	Orange[74]	Jackfruit[75]	Mango
January	✓	✓	✓	✓	✓	✓		
February	✓		✓	✓	✓			
March	✓[76]		✓	✓	✓			
April			✓	✓	✓			
May			✓	✓	✓		✓	✓
June			✓	✓	✓		✓	✓
July			✓	✓	✓	✓	✓	✓
August			✓	✓	✓	✓	✓	✓
September			✓	✓	✓	✓	✓	
October			✓	✓	✓			
November		✓	✓	✓	✓			
December	✓	✓	✓	✓	✓	✓		

6.3.2 Overall patterns of elephant sightings

Elephants were reported and sighted in the estates in all months, but there was a peak in numbers reported during the peak coffee season months (See Chapter 5, Figure 5.1). Using both the number of sightings and the number of elephants reported for each sighting event, I explored the relations between elephant numbers (log transformed for normalization) on each estate and the independent variables. Univariate analysis of variance was conducted to analyse the relationships on elephant group size visitation depending on various factors across months.

[74] Orange was were classed in terms of months of availability not 'seasons.
[75] Jackfruit was called as 'present' or 'absent' by month; however each sighting event also had an abundance category.
[76] Only in 2011.

Overall, there were significant main effects of coffee season, jackfruit abundance (high / low), paddy, and mango presence (See Table 6.2) on elephant numbers. The model explained over 30% of the variance in elephant numbers, suggesting that elephants were using these estates for their resources, as well as refuges during the coffee season. For the overall analysis, the categories for jackfruit were categorized into either low or high. There were significant interactions between coffee season and the presence of a refuge area as well as coffee season and jackfruit abundance. These main effects and interactions are explored in detail below.

Table 6.2: Univariate ANOVA of Log total number of elephants (elephant group size * number of sighting events for that size; N=386) reported and the main factors influencing elephant use of coffee estates[77].

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	23.094[a]	30	.770	5.862	.000	.368
Intercept	10.958	1	10.958	83.450	.000	.216
Coffee Season	.614	1	.614	4.673	.031	.015
Jackfruit Abundance	1.901	1	1.901	14.479	.000	.046
Paddy Season	.836	1	.836	6.367	.012	.021
Orange Presence	.292	1	.292	2.226	.137	.007
Mango Season	.746	1	.746	5.683	.018	.018
Refuge Area	.208	2	.104	.792	.454	.005
Coffee Season * Jackfruit Abundance	1.479	1	1.479	11.266	.001	.036
Coffee Season * Refuge Area	1.695	2	.848	6.455	.002	.041
Error	39.956	302	.131			
Total	139.310	333				
Corrected Total	62.750	332				

a. R Squared = .324 (Adjusted R Squared = .307)

[77] Coffee Season (Present/Absent), Jackfruit Abundance (High/Low), Paddy Season (Present/Absent)), Orange presence by month (Yes/No), Mango Season (Present/Absent) and Refuge areas (At, Close and Distant).

The results of this analysis indicate these fruiting seasons may influence elephants' use of coffee estates in Kodagu. Orange presence and proximity to refuge areas in coffee estates did not determine elephant use of coffee estates as the main effects were not statistically significant. However, the interaction was statistically significant for coffee season with jackfruit abundance and with proximity to refuge areas. Overall effect size for the main effects and the two interaction effects were small (See Table 6.2 Partial Eta Squared).

6.3.3 What are the effects of refuge areas on the presence of elephants during the coffee season?

A further analysis of variance used data on the number of reports of elephants to explore the effect of independent factors on elephant presence in coffee estates. The predictors for "presence" versus the predictors for "numbers when present" (Table 6.2.) might be expected to be different. Log transformation was carried out to normalize the data.

While there was no main effect of refuge area in the overall analysis of total numbers of elephants (See Table 6.2), there was an interaction with proximity to refuge areas (three categories: At, Close and Distant) and coffee season on the number of reports of elephants (ANOVA: $F_{2,1217} = 44.290$, $p < 0.001$) with a medium effect size (partial eta squared = 0.068). Elephants appear to be sighted distant from refuge areas more during coffee season than during non-coffee season (See Figure 6.2 (a) and (b); See Chapter 5, Section 4.4). However, as the main effect of coffee season was found to be significant in the overall analysis of total numbers (See Table 6.2), and because coffee ripening is seasonal, a relative difference of reports of elephant presence appears during coffee and non-coffee seasons (See Figure 6.3).

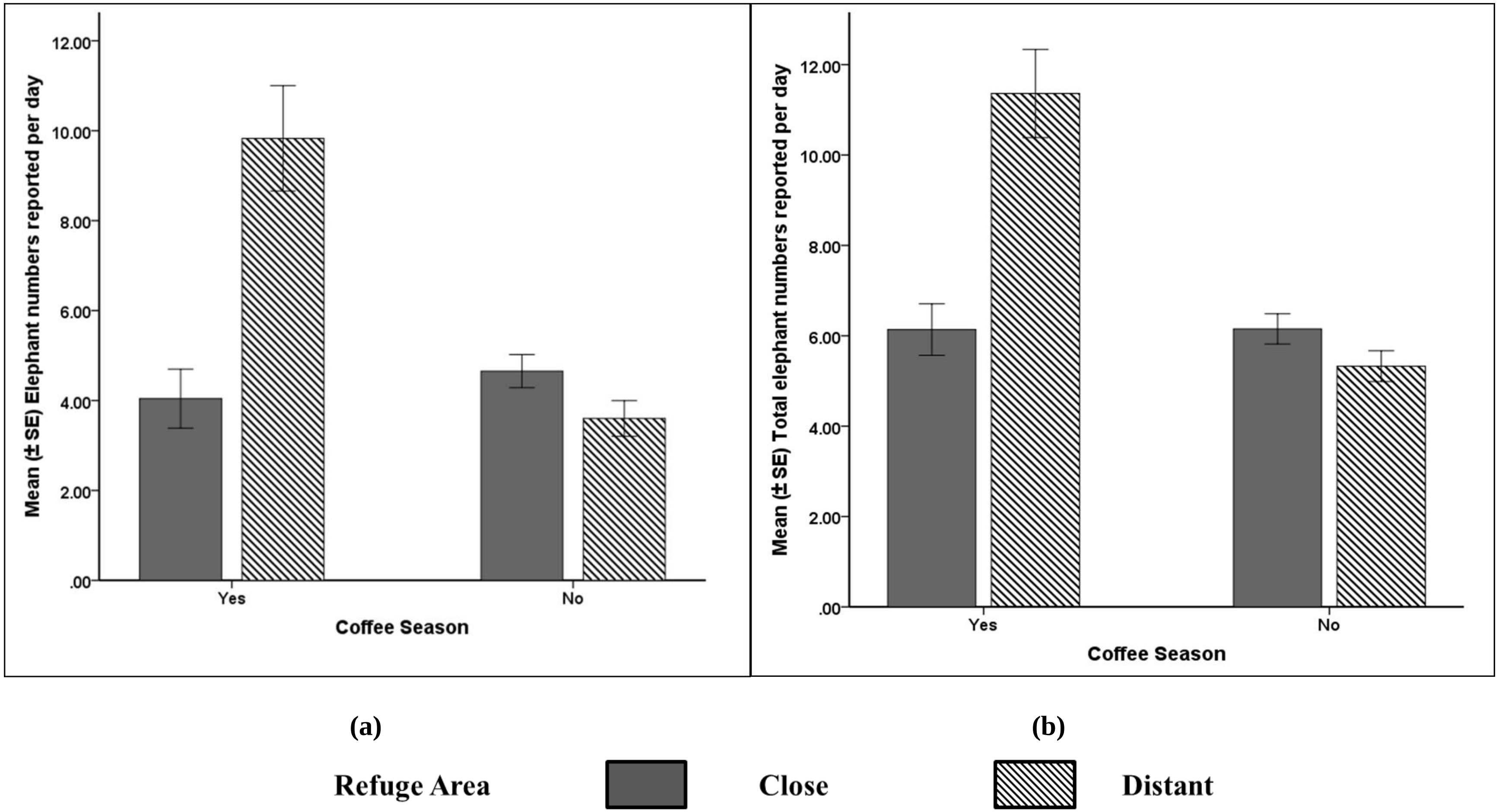


Figure 6.2 Presence of elephants in close proximity to identified refuge areas during coffee season (a) Mean number of elephant sightings REPORTED (b) Mean total number of elephants (group size * N reported per day) (N=386).

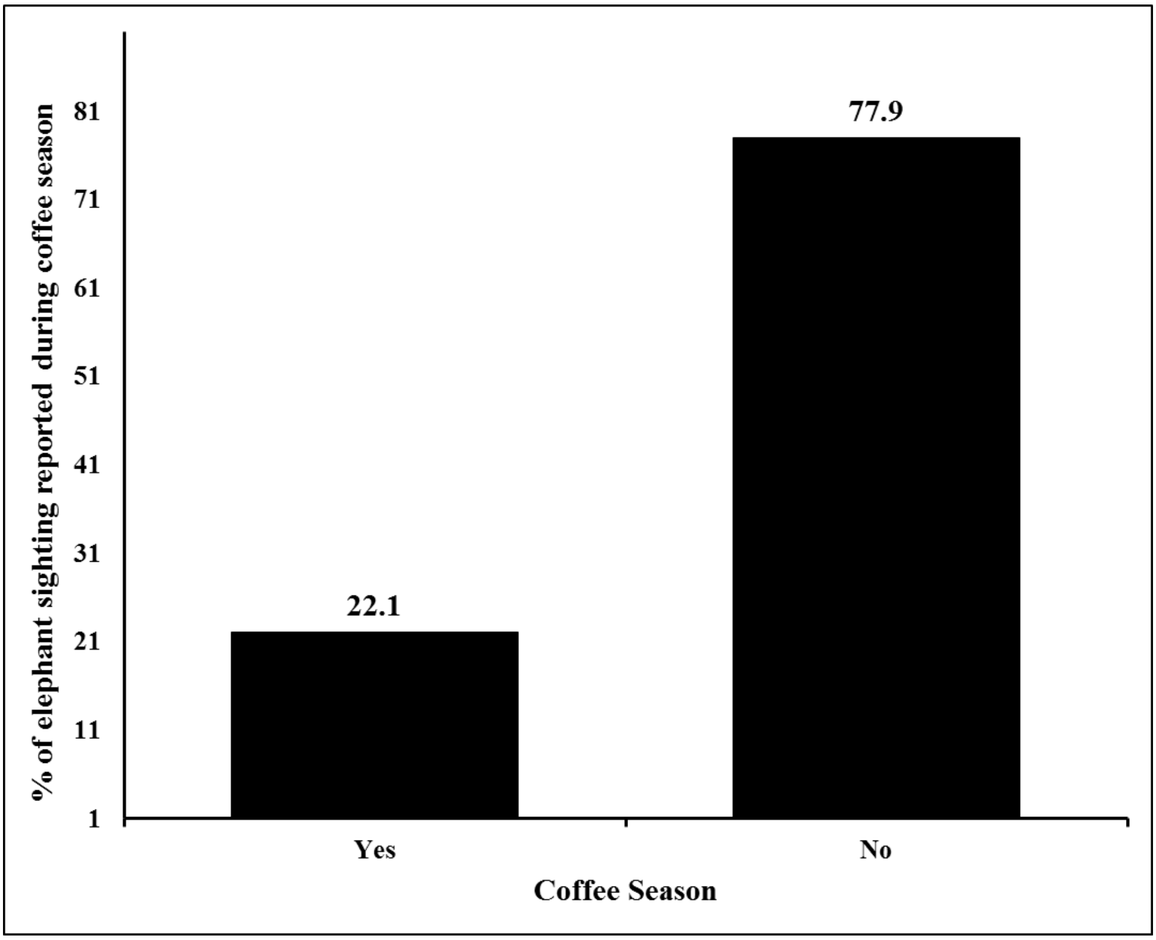


Figure 6.3 Relative percentage of elephants during coffee season and the non-coffee season reported to be using the study estates (N=1532).

<u>6.3.4 Does proximity to the forested areas during coffee season have an effect on elephant presence?</u>

A second analysis was carried out controlling for elephant presence in relation to coffee season where a Type I (hierarchical) model was run. The interaction between the distance to forest areas and elephant presence within the coffee estates was found to be significant (ANOVA: $F_{1,\ 1578} = 101.45$, $p < 0.001$) between the coffee and non-coffee seasons with medium effect size of 0.060 (partial eta squared). Raw data on sighting events indicate that elephants were visiting coffee estates further from the forest areas (See Figure 6.4). Comparisons of the mean number of elephants in coffee estates during coffee season indicated that elephants appear to frequent those estates which were at close proximity to the forest areas (See Figure 6.5).

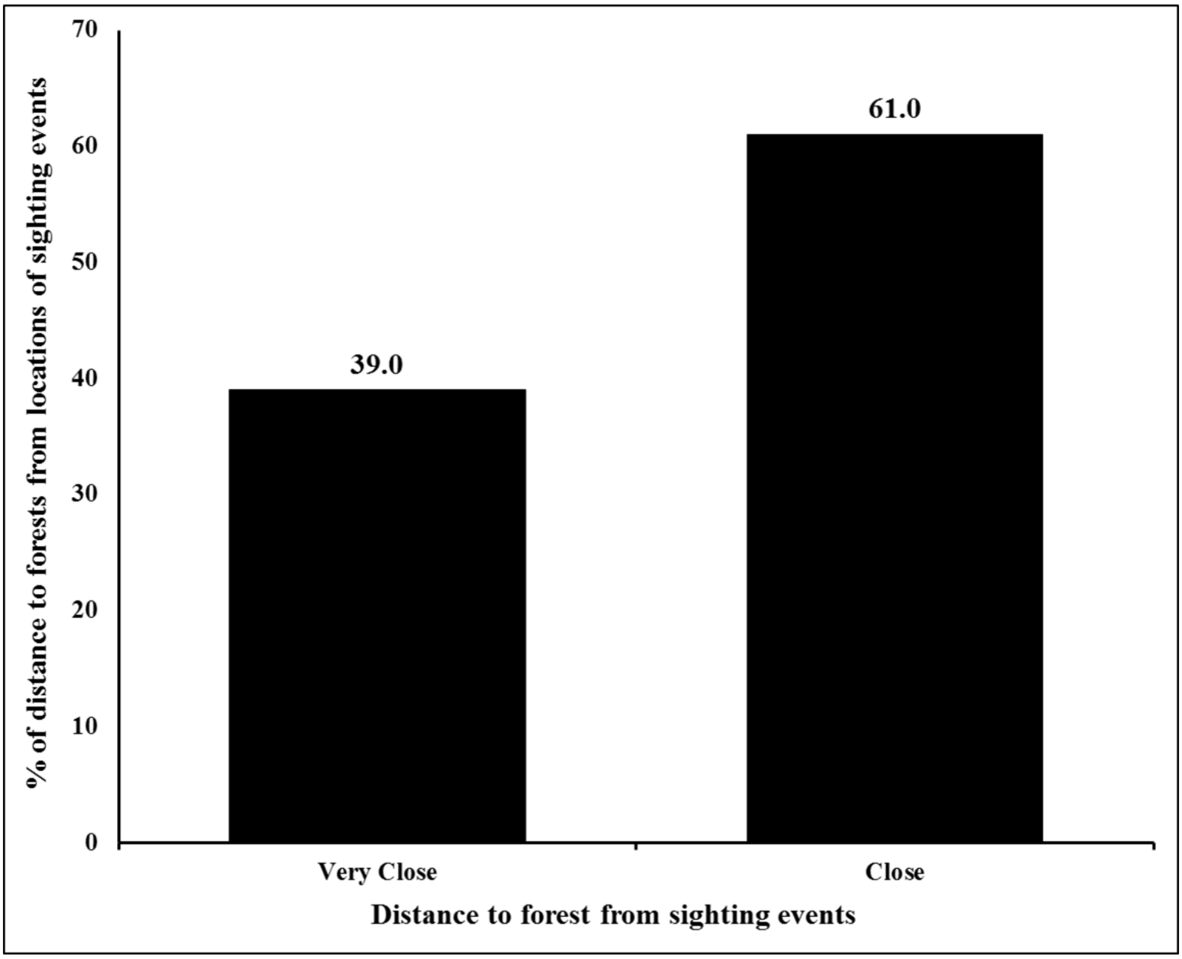
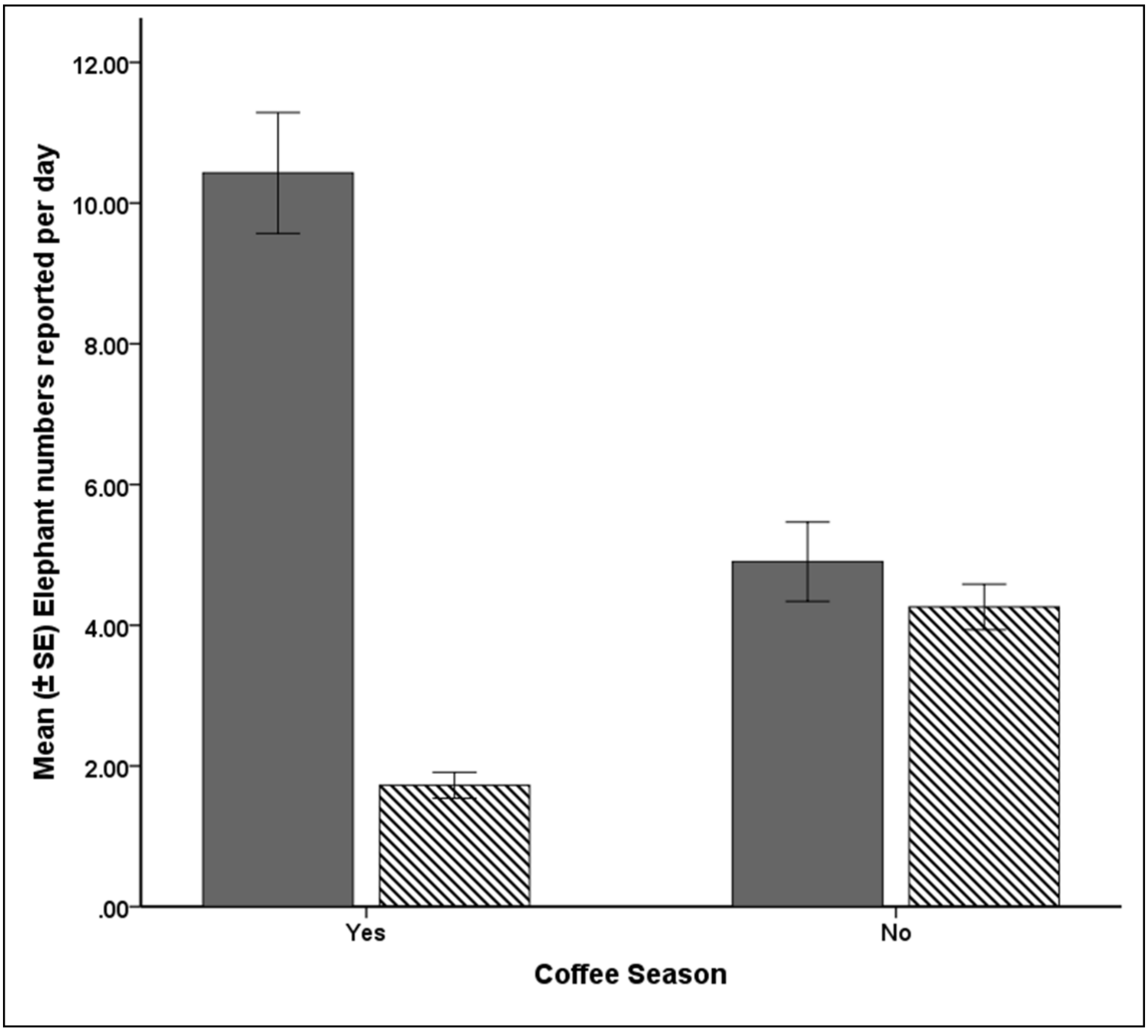


Figure 6.4 Relative percent of sighting of elephants that were close or very close to the forest areas (N= 1582).



Forest Distance **Very Close** **Close**

Figure 6.5: Mean (± SE) total number of elephants reported per sighting of an elephant group per day during coffee season close or very close to forest areas (N=386).

6.3.5 Effect of jackfruit abundance on total elephant number during coffee season

Elephant numbers were significantly greater in both coffee season (ANOVA: $F_{1,1579}$ = 19.322, $p < 0.002$; See Table 6.3) and jackfruit season (ANOVA: $F_{1,1579}$ = 29.012, $p < 0.002$) which suggests that although there was an individual effect on the presence of the two fruiting season, there was no synergistic effect of the presence of each of these resources on total elephant numbers, since the two seasons do not coincide. However, analysis of the quantity of jackfruits (presence: high or low) in coffee estates indicated that the presence of elephants in certain specific locations may be affected by the availability of jackfruits within these locations (ANOVA: $F_{3,1324} = 56.247$, $p < 0.001$) with a small effect size of 0.041 (partial eta squared). The main effects of coffee season (ANOVA: $F_{3,1324} = 7.992$, $p = 0.005$, partial eta squared = 0.006) and availability of jackfruits (ANOVA: $F_{3,1324} = 91.051$, $p < 0.001$, partial eta squared = 0.064) were statistically significant, indicating that the presence of each influenced both total elephant numbers and their presence on coffee estates.

Table 6.3: Association between number of elephant sighting events during coffee and jackfruit abundance ($X^2 = 22.07$, df = 2, p< 0.001).

Jackfruit Presence	Coffee season		Total
	Yes	No	
High	85	197	282
Low	48	34	82
Total	133	231	364

6.3.6 The effect of other food resource availability during coffee season on elephant visitation of coffee estates

The availability of paddy rice during coffee and non-coffee season had an effect on the presence of elephant on coffee estates (ANOVA: $F_{1,1578} = 89.945$, $p < 0.001$) with an effect size of 0.054 (partial eta squared). The main effects of coffee season ($F_{3,1578}$ =

20.152, $p < 0.001$, partial eta squared = 0.013) and paddy rice season ($F_{3,1578}$ = 20.152, p = 0.003, partial eta squared = 0.006) were found to be significant. However, it appeared that elephant presence in coffee season did not co-vary with paddy rice season (See Figure 6.6 a and b). Similar results were also found for the orange fruiting season (ANOVA: $F_{1,1578}$= 10.320, p =0.001, partial eta squared = .006; See Figure 6.7). Elephant presence in coffee estates was significantly greater in both coffee season ($F_{3,1578}$ = 20.636, $p < 0.001$, partial eta squared = 0.013) and orange season ($F_{3,1578}$ = 129.047, $p < 0.001$, partial eta squared = 0.076) independently.

During mango season, elephant numbers were significantly greater in both coffee season (ANOVA: $F_{1,1579}$ = 19.141, $p < 0.001$, partial eta squared = 0.012) and mango season (ANOVA: $F_{1,1579}$ = 13.944, $p < 0.001$, partial eta squared = 0.009) suggesting that although there was an individual effect of the two fruiting season, there was no synergistic effect of these resources on elephant numbers, since the two seasons do not coincide.

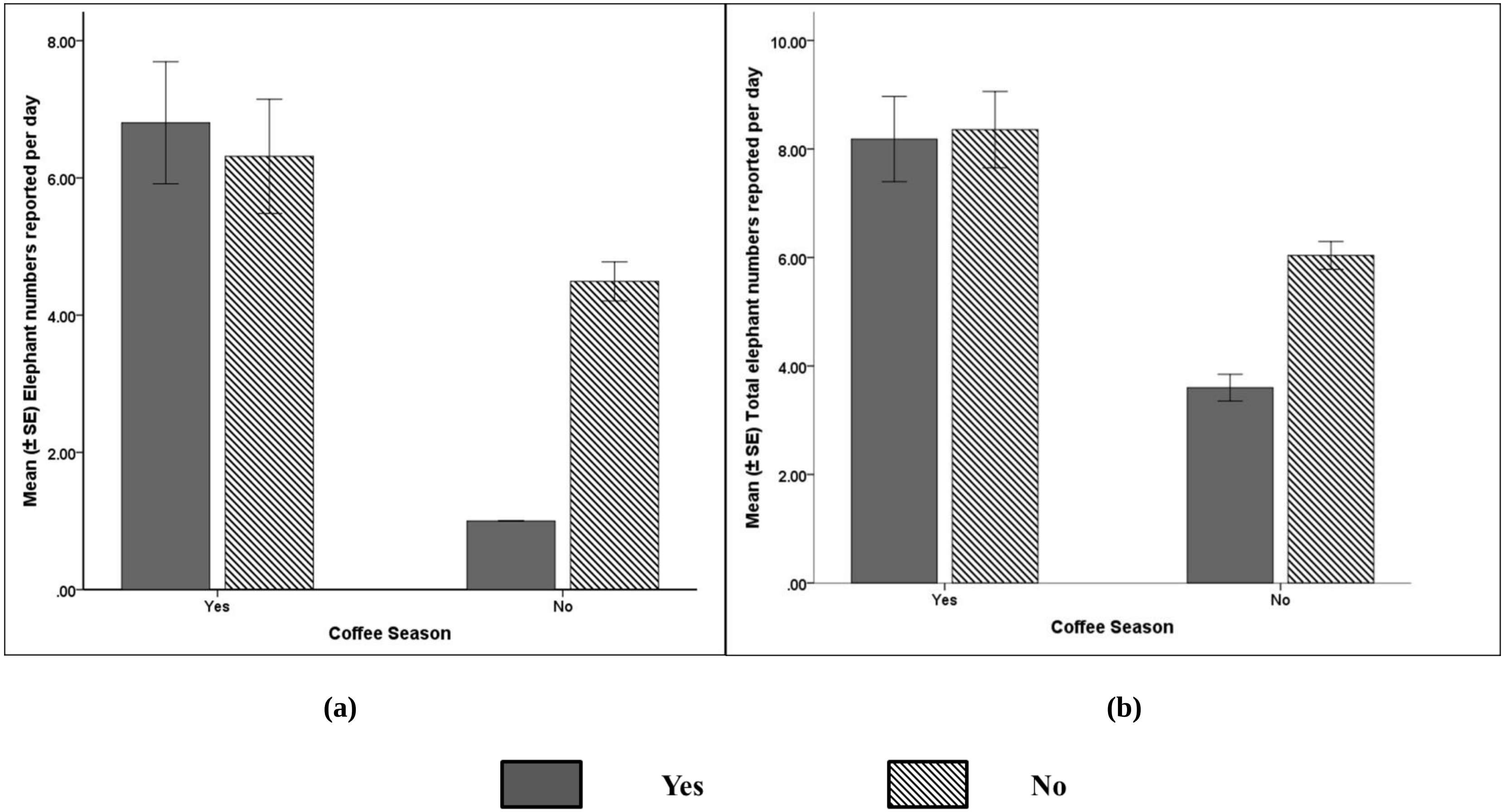


Figure 6.6 Number of elephant sightings (Mean ± SE) reported per day during paddy season in relation to coffee season (a) Number of elephant sighting events reported per day (b) Mean total of number of elephant sighting events reported per day (N=386).

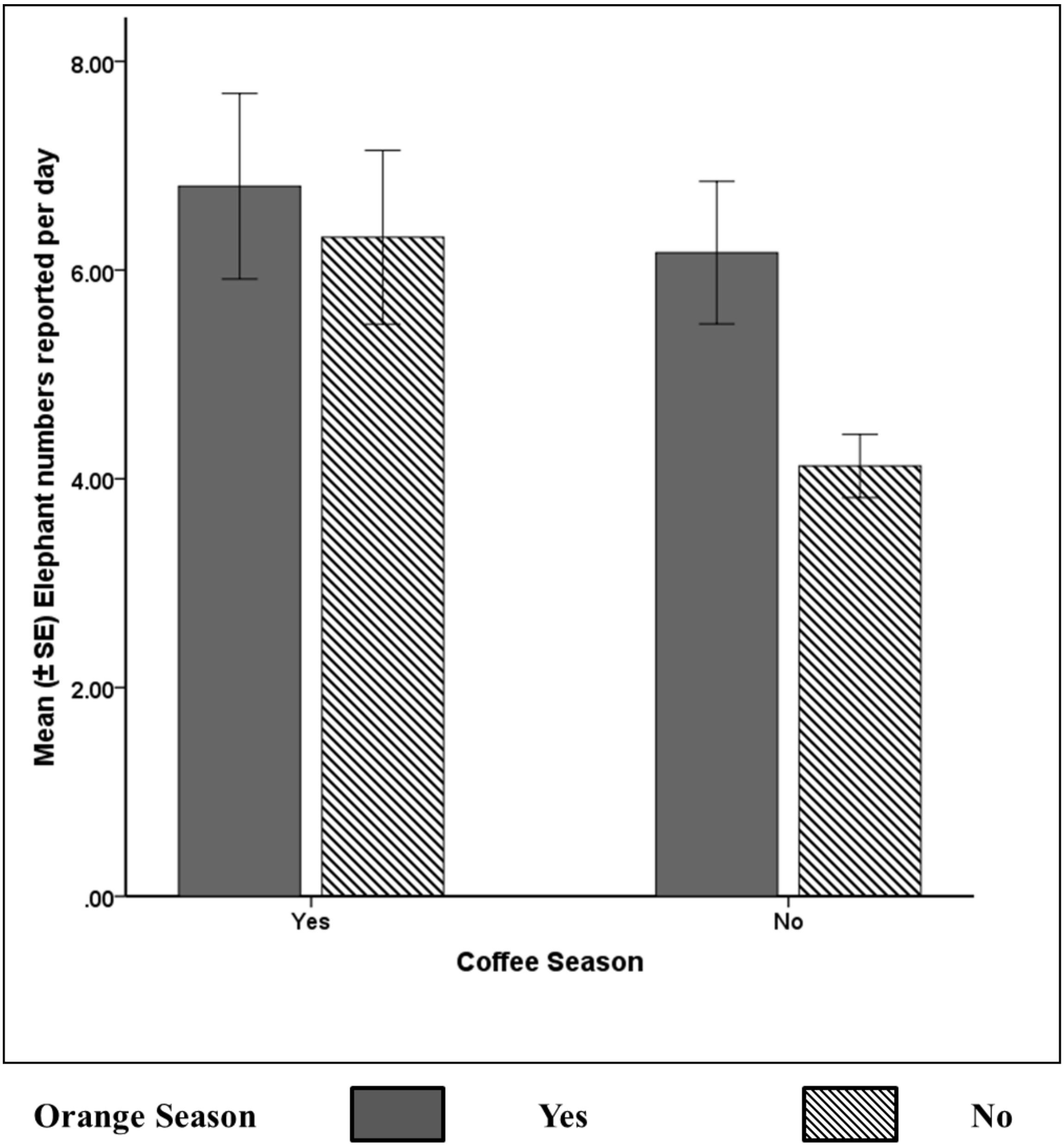


Figure 6.7: Mean (±SE) number of elephant sightings reported per day during coffee and orange season (non-coffee season) (N=386).

6.3.7 What is the effect of group size and type of elephants during coffee season?

6.3.7.1 Group type

Chi-square analysis on the group type (coded as Family, Male Solitary, Male group, Unknown; See Chapter 5, Section 3.5.1) suggested that there was a significant difference in the presence of group types during the coffee season by comparison to the non-coffee season ($X^2 = 35.32$, df = 1, $p < 0.001$). Overall results indicated that family groups were present more often during the coffee season than were other group types; however, the refuge areas were used comparatively less during the non-coffee season (See Figure 6.8).Due to poor visibility, there were occasions where elephant group composition were not categorized and thus marked as Unknown group type composition.

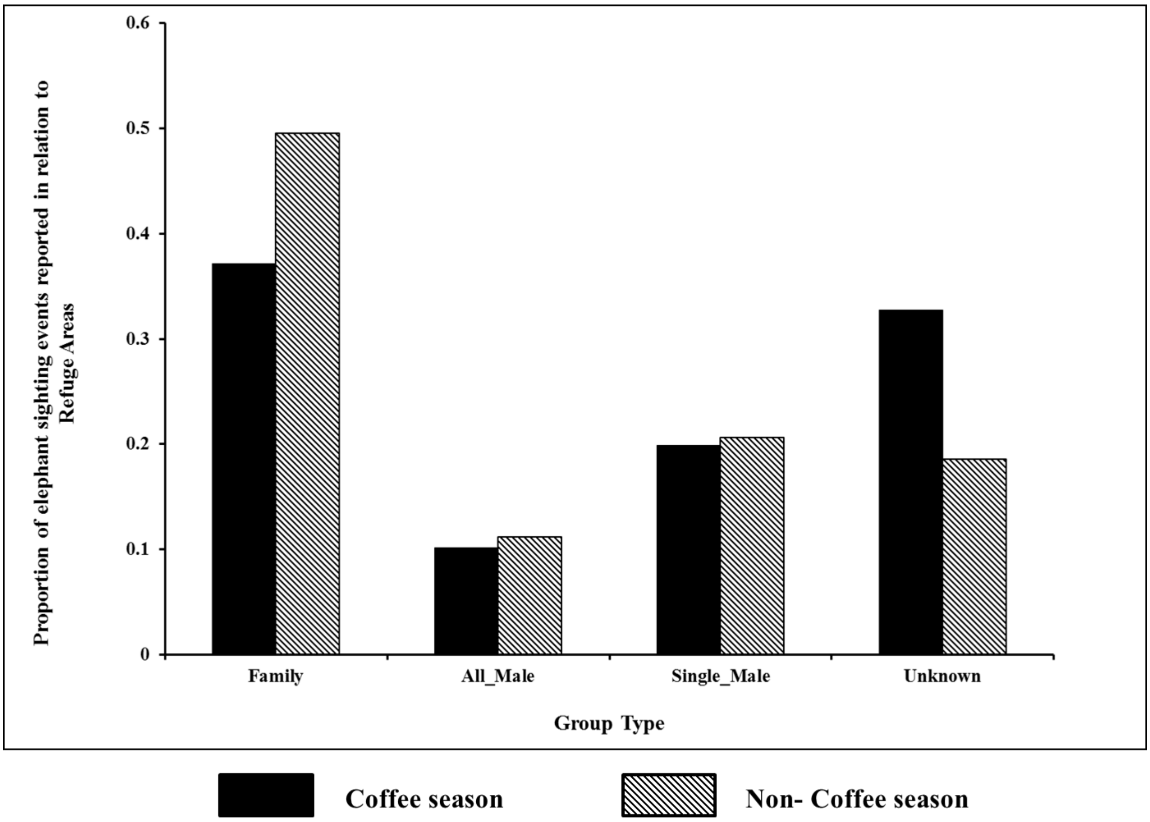


Figure 6.8 Proportion of group types of elephant sightings reported during coffee and non-coffee season and their relative use of refuge areas within the study coffee estates (N=1271).

When of the proximity of each sighting event to refuge areas was grouped by close or far within plantations, there was less close proximity usage of refuge areas during the coffee season by comparison to the non-coffee season for family groups (See Figure 6.9). The proportion of sightings of male groups did not vary between coffee seasons.

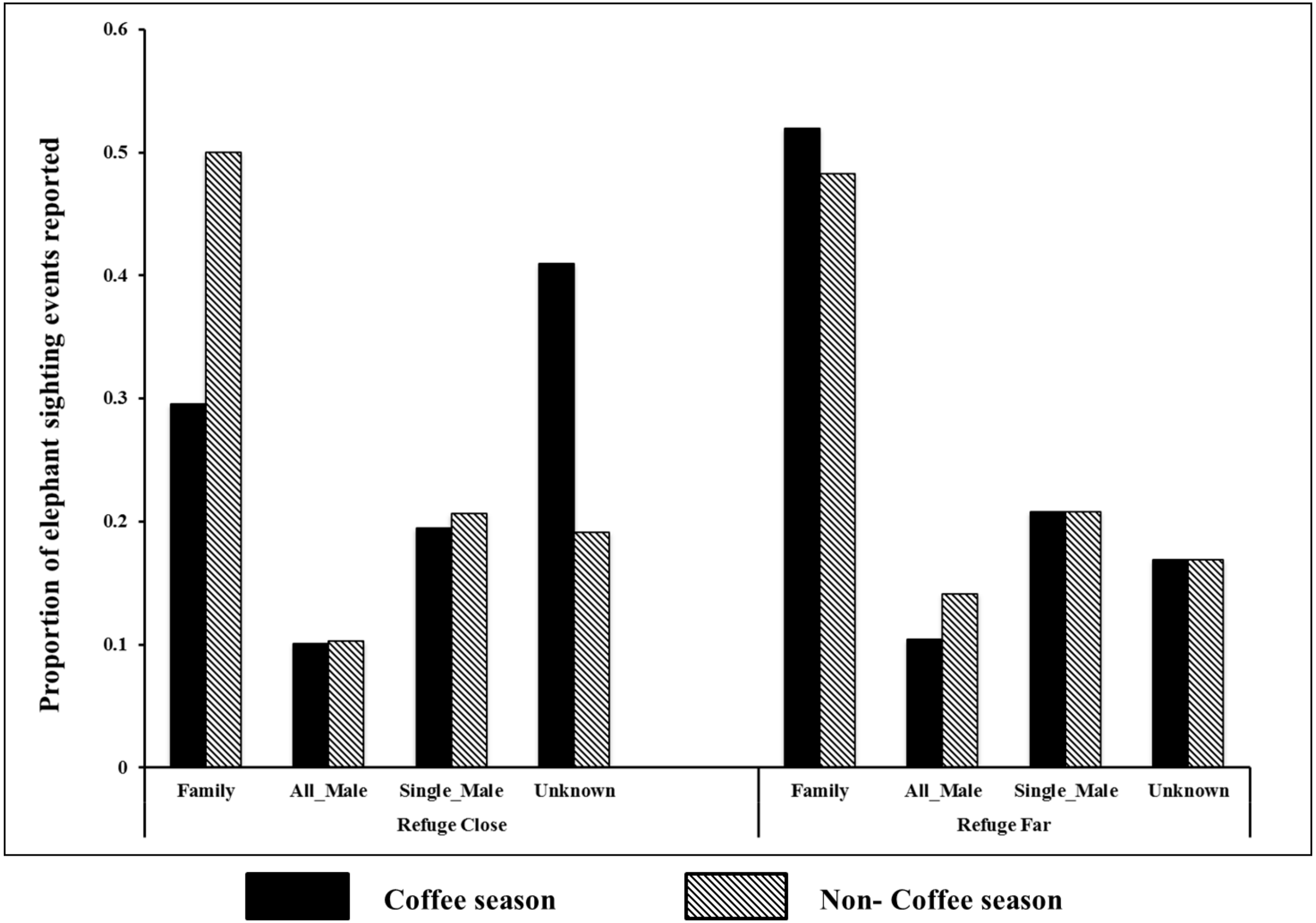


Figure 6.9 Proportion of group type of elephants reported during coffee season and their usage of Refuge areas (N=1271).

6.3.7.2 Group Size

The overall proportion of elephant group sizes in relation to group type is represented in Figure 6.10. Fewer groups of elephants were seen in the coffee season than the non-coffee season (See Figure 6.11 a and b). However, the number of individuals within the groups appeared to be larger during the coffee season. Thus, elephants seemed to be moving within the coffee estates as fewer but larger groups than they were during any other time of the year.

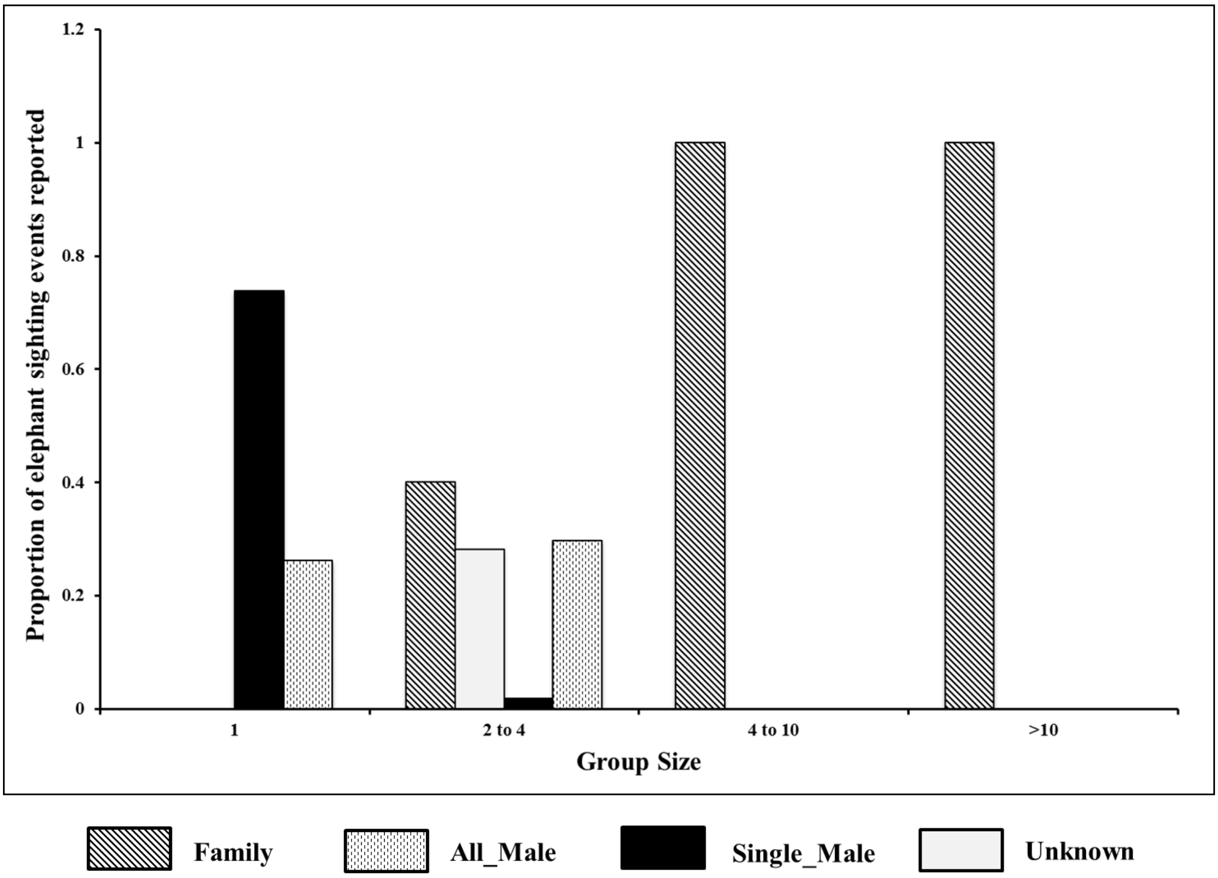
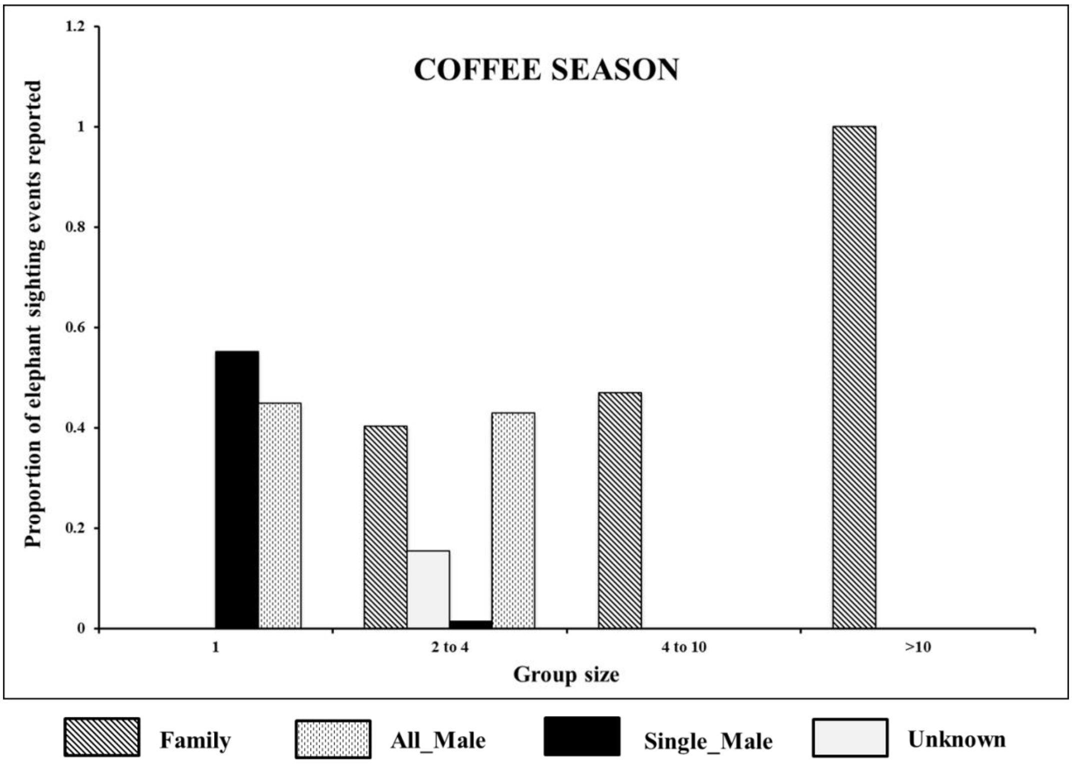
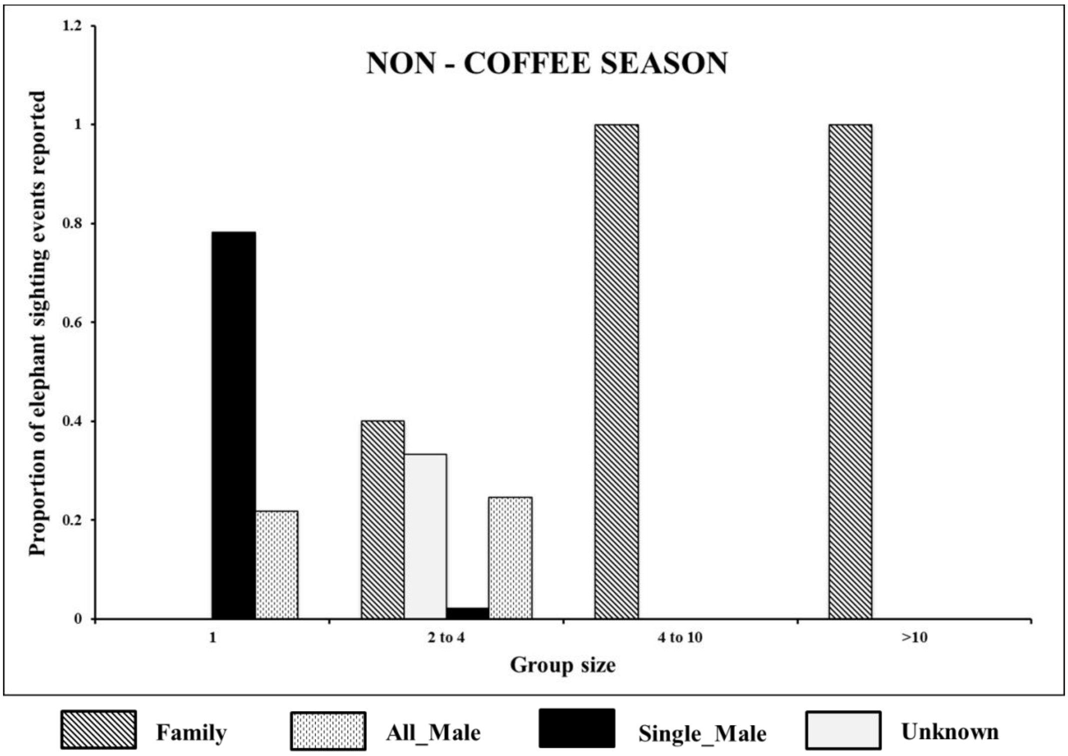


Figure 6.10 Total proportion of group sizes of elephant sighting events reported by group type (N=1571).



(a)



(b)

Figure 6.11 Proportion of group sizes of elephants reported during (a) coffee (N=388) and (b) non-coffee season (N=1183) in relation to group type.

6.4 Discussion

Specific causes for elephants' using coffee estate have not been determined by any previous studies. High resource availability and shade cover have been proposed as the main reasons for elephants using these coffee estates, which were easily accessible from the protected forest boundaries (Nath & Sukumar, 1998; Kulkarni *et al*., 2007; Bal *et al*., 2008). The possibility of the estates lying on a migration route was also suggested to be a further reason for the use of coffee estates; a possible migration route was suggested by the reports of raiding events, which traversed the north eastern region to the west in Virajpet Division (See Chapter 4).

6.4.1 Elephant presence in relation to coffee as a resource

Use of refuge areas in the coffee estates was found to vary seasonally depending on coffee or non-coffee season. Coffee ripening season starts in December and continues until February or March. Seasonality of fruiting trees or plants in the post-monsoon period provides access to high levels of food resources. During the coffee season, refuge areas were used less, elephant sightings were observed further from the refuge areas and the elephants were often moving. 13 months of data on elephants presence represented on the map (See Appendix 13) indicates that there was a constant movement of elephants within the coffee estates. However, this map is only a representation of locations where elephants were sighted in specific study sites. Long-term monitoring of elephant movements within coffee estates across Kodagu is necessary to demonstrate if there are elephant movement paths and to determine their frequency of use on coffee estates. The constant movement of elephants during coffee season as reflected from the maps of sequential sightings could be explained in terms of higher human density within the estate. During coffee picking season, migrant workers are employed to increase the work force along with the permanent workers employed by these private and company-owned large estates. One of the reasons for employing migrant workers is because there is a labour shortage (Deepika & Jyotishi, 2013). These migrant workers have little or no experience with elephants leading to disturbance of both workers and elephants (See Chapter 9). The increase in human density and a requirement to pick coffee berries at particular time periods determined by managers means that workers will access and work at many different locations within the estates, again potentially increasing their interaction interface with elephants.

During non-coffee season, such human activities are less intense. Thus, elephants have access to isolated refuge areas within the estates during the non-coffee season, but have no such advantage during coffee season. When the elephants are present in the areas where the work is scheduled, they are either chased by the estate guards or by the workers away from their current location. They may be chased into forest areas, or to a different location within the estate, or even to the neighboring estates. These movements can continue until elephants have been able to find a zone where there are no human activities on that day. This could be one explanation for why elephant were sighted at locations further from the identified refuge areas during the coffee season as they were constantly moving between areas to avoid human contact. Elephants, and especially females, are known to avoid areas within 10 km of human settlement and roads (Barnes *et al*., 1991; Newmark *et al*., 1996; Galanti *et al*., 2006; Harris *et al*., 2008) but to use the areas within 10 km of water resources (Thouless, 1995; Stoke & du Toit, 2002; Harris *et al*., 2008). Elephants in coffee estates in Kodagu occurred in close proximity to human settlements (human settlements is defined here in terms of small clusters of estate workers' housing colonies occurring at various locations across the estate); however, elephants seem to avoid towns like Siddapur, Pollibetta, Madikeri, etc.

Elephants, thus avoided people not in terms of proximity to the human settlement, but by choosing to hide in refuge areas at certain locations (see also Graham *et al*., 2009), especially during periods of high human activities occurring on the estate.

Bal *et al*. (2008; 2011) suggested that elephants may have been using the entire area of large estates as refuge areas. With only a very few large coffee estates, it is important to understand to what extent these estates have become refuge areas for the elephants. The elephants might be exploiting these estates as 'forest patches' and venturing out to affect other, smaller coffee estates (<10 ha). With higher human density in smaller estates, it may not be possible for elephants to use any areas as refuges or hideouts, unlike the large coffee estates which usually have isolated places at any given time. There are as yet no data on the extent to which elephants taking refuge in larger estates then damage crop production in smaller estates. Is the damage caused by elephants deliberate or occurring while travelling through the estates? What are the roles of other small forest areas like private forests within the coffee estate and sacred groves (See Chapter 2) in elephant movements? These indigenous forested areas are slowly being converted into agricultural lands; if they are acting as refuge areas than there will be loss of vital habitats causing more frequent hostile human-elephant interactions.

There are also no data on where the elephant population in Kodagu come from or move towards. But, as discussed above observations of elephants moving between neighboring estates suggests that either the elephants may be moving as a result of being chased by some estates or alternatively, that certain estates fall within the possible migration route which elephants may be using frequently. These are assumptions deriving from the observations made during one year for this particular study.

Determining which of these possibilities may be occurring requires long-term monitoring studies to determine and evaluate the use of coffee-agroforestry landscape.

6.4.2 Proximity to Forest Areas

Many Kodagu coffee estates are found at borders of both Reserve Forests and protected areas. Also, coffee estates mirror the forest areas with their abundance of natural water and food resources. It has been proposed that a critical threshold of 30-40% of forest cover is required, below which elephants are forced to use more human-dominated landscapes increasing the interaction interface between people and elephants, resulting in crop depredations, injuries and/or death of both parties (Chartier *et al*., 2011).

There is also a possibility that a few elephant individuals within the population could be using the proximity of coffee estates to the forest areas to their advantage to venture out and raid crops and coffee estate during the night or at times of low human activity and then returning to the forest areas. A few elephants, if there is a 'migration' route as suggested in some earlier studies (Nath & Sukumar, 1998; Kulkarni *et al*., 2007; Bal *et al*., 2008), may venture further away from the forest boundaries and frequent coffee estates on these routes. Coffee estates were located at varying distances from the Reserve Forests and the protected areas like national parks within Kodagu. My study area was close to the Reserve Forests of Devamachi and Maukal. The study estates were thus only categorized into 'bordering /very close' (≤ 50 meters) and 'close' (> 50 meters)to the forest areas. However, the general patchwork of forests in this region resulted in no significant independent effect of distance to forest on elephant sightings, total numbers or group sizes within the estate.

Sightings and reports of elephants in close proximity to the forest areas appeared to be higher during coffee season. This may be due to the number of elephants that have started to move out of the protected forest areas. Again, this could reflect an onset of elephant movements' longer distnace from one place to another.

In north eastern side of the district, there were many records of crop compensation events (See Chapter 4). However, these events were not equally distributed across the district. For instance, a few villages neighbouring those with frequent crop-raiding events have either low or no record of events (Bal *et al*., 2008; See Chapter 4) indicating there were other external factors influencing elephant use of areas besides proximity to the forests. Presence of deciduous forests and large corporate estates may also be influencing the use of coffee estates by elephants, as discussed above (see also Chapter 5).

The study estates, which are large company-owned estates, recognize the importance of the location of their coffee estates within potential elephant migratory routes and acknowledge this by promoting conservation of biodiversity. They have placed warning signs of the presence of elephants and of their usual sighting locations within the estates. Thus, the distance to Reserve Forests may not influence the elephant's visitation to the coffee estates when they are using the movement corridors. Data on the elephant movement paths have not yet been clearly established. This will require monitoring elephant movements through GPS collared elephants that are recognized and identified as frequent users of the coffee estates in the site-specific locations. Logistical problems did not allow me to conduct such expensive research, but I attempted to identify few elephant individuals and/or groups through video and photo documentation and recording GPS locations whenever possible.

At a landscape level, previous work also showed that increasing distance of estates from Reserve Forests did not appear to decrease the frequency of elephant visits to the coffee estates (Bal *et al*., 2008). In this study,, the distance of the Reserve Forests to the *preferred trees*[78] within the estates did not have a significant effect on elephant visits. Thus, the factors affecting reports of elephant visits to the coffee estates are not simplysuggest that these visits are for foraging or as the consequence of proximity to the forest areas.

6.4.3 Influence of fruit trees on elephant reports

Density of trees producing fruits that were eaten by elephants was found to be positively correlated with the density of elephant trails in Nouabalé-Ndoki National Park (Congo) (Blake & Inkamba-Nkulu, 2004). The authors found that the elephants used permanent trails and moved in a straight line between large fruiting trees. Campos-Arceiz & Blake (2011) suggested that elephant trails could represent a form of societal spatial memory where elephants may be using a trail or network of trails to access resources, for example, fruiting trees (e.g. Gautier-Hion *et al*., 1985).

High fruit resource availability in coffee estates may be one reason why elephants are entering these estates. Since coffee is cultivated under the shade of mostly native tree species, we find high tree density in most coffee estates consisting of jackfruits, arecanut, coconut, orange, wild mango, banana, chickoo, etc. and green foliage like Dadup (*Erythrina subumbrans*), and *Ficus* spp. All of these were elephant foods (See also Chapter 7).

[78] As categorised by Bal *et al*. (2008), preferred trees were those *'trees that were damaged by elephants and were recorded in the compensation cases by the Forest Department and reported by the interviewees'*. The preferred trees were jackfruits, banana, orange, wild mango, arecanut, coconut, erythrina, silver oak and other lesser damaged species.

My results suggested that the presence of jackfruits did influence elephant sighting events, specially outside of the coffee season. However, tree density and the presence of *preferred trees* (as defined by Bal *et al*., 2008) did not show any significant relationship with elephant sighting, suggesting that elephant visits were not solely determined by the presence of *preferred trees* (Bal *et al*., 2008; 2011). Local coffee planters and people believe that one of the main reasons for elephant visitation to coffee estates is due to their attraction to jackfruits (Nath & Sukumar, 1998; Kulkarni *et al*., 2007; Bal *et al*., 2008; Narayana, 2009). As noted above, there was a strong main effect of jackfruit availability on both sightings and total numbers of elephants, which interacted (negatively) with coffee as jackfruits were available outside of the coffee season. Some coffee estate owners have taken the action of cutting down all the jackfruits before they ripen so that they do not attract the elephants. Such a management strategy for controlling elephants' visitation has not been proven and requires more data on effect of jackfruits on elephant's use of coffee estates. However, in this study it was clear that jackfruits were not the only reason elephants were using or visiting coffee estates.

Oranges appeared to have an additional influence on the presence of elephants within the estate but more during the coffee season than non-coffee season. This result could also be due to the presence of larger foraging groups of elephants by comparison to non-coffee season. Similar results were also found for paddy rice availability where elephants were present more during the coffee season in conjunction with paddy rice than during the non-coffee season. Damage to oranges and also other fruits such as mango are limited because of the unequal distribution of these fruits within the estate and they have low or no economic value as a whole. Although Coorg oranges were known to have been cultivated to a large extent because of their quality and sweetness, the increasing demand for coffee has resulted in with farmers converting their agricultural lands mostly into coffee estates.

Elephants have an ability to find and remember food, especially during extreme droughts (Foley, 2002). Regular use of the identified refuge areas within the coffee estates may also be explained in similar terms. The strategic location of these refuge areas needs to be better understood; however, with the available data from this study, it was clear that elephants were using certain areas in relation to water and food resources (e.g. jackfruits). Chimpanzees (*Pan troglodytes*) are known to use Euclidean cognitive maps to remember a resource location within the forests and navigate directly to the location without any landmark (Normand & Boesch, 2009).

Water availability has been considered to be a predictor variable for elephants visiting certain areas (Bal *et al*., 2008). Spatial comparison of Reserve Forests and the coffee estates suggested that places with high water availability had frequent elephant visitations. This was also true when the number of water bodies were statistically compared in a previous study (Bal *et al*., 2008). In my study, water presence was not included in analysis of sighting events as every estate had at least one water tank. In large estates, refuge areas were located at water tanks within the estate. These water bodies were constructed within the estates for irrigation, especially after coffee flowering. The setting of flowers is important for better yield of coffee berries and this requires some rainfall. If this does not occur, the estates start sprinkling waters from these water bodies for the blossoms. And also, water is required for other irrigation processes for the rest of the year. Thus, these water bodies are located in such a way that the sprinklers can be set-up to draw water for the processes mentioned above. As such, my analyses suggested that proximity and access to these water bodies determined refuge areas.

Family groups appeared to use refuge areas within estates more than any other group type did, both during coffee and non-coffee seasons. With calves and juveniles in the herd, elephants might seek to avoid human encounters especially in human-dominated landscapes. Reduced use of refuge areas during coffee season might indicate that these families are constantly moving between areas because the estate workers chase them. Restricted opportunities to observe elephants without causing any harm or disruption of work to the estate workers meant that most of the sightings were during feeding and this could have led to a discrepancy in the representative nature of the results[79].

6.4.4 Individual use of coffee estates

Most of the data gathered for this research consisted of GPS location, estate name, time and month of the year, and numbers and sex of elephants. Although these data are not adequate to explain seasonal patterns and ranging patterns of the elephants in the study area, the pattern of recorded events over a year suggested that at least few identified individuals and/groups were using specific routes to access one certain estate areas.

For example, the male elephant (Oldie) was observed most of the year in Yemmegoondi coffee estate, which was not very close to the forest fragments. His observations and GPS positions indicated that he was using a similar route to that of the large groups (SWING) travelling within the coffee estates. Before the onset of coffee ripening

[79] With thick Robusta coffee bushes (Video 2, 3, 4), behavioural observations were not possible, thus I would have had to make observations at specific time. During the field work, when I was informed about the presence of elephants at certain estates in a specific location, with familiarity of the elephants' adaptability of using the coffee estates, I would take a guess of a specific time they would come out of the hiding in most of the occasions for observations.

season, Oldie was last spotted in October at Margolly coffee estate closer to the Maldare Reserve Forests in musth (reproductive state). He was a well-known elephant in the region, and his presence would be reported immediately and this information spread across different coffee estates. After October, there was no report of his presence anywhere. People started to believe that poachers or other wild tuskers might have killed him, since local people believed that he never left coffee estates to go into forest areas. But in December, he was spotted again in Gattadhulla Division of Margolly coffee estates, which was very close to the Maldare Reserve Forest. Report of sightings indicated that Oldie was seen walking out of the Maldare Reserve Forests onto the main road and then entering the Gattadhulla coffee estate that had boundaries next to the main road. Also, my observations one particular large group (22 individuals recognized) mostly occurred From January 2012 to March 2012 (post-monsoon) suggesting consistent use of Gattadhulla division of Margolly estate, Siddapura and Yemmegoondi Division, BBTC estates of the study coffee estates (and also use of other private-owned coffee estates that were located between these estates) estates for 3 months (Appendix 10 Video 6); prior to that period most of the sightings were of lone male elephants or group of 3-4 male elephants and small family herds of 6 to 8 elephants. Number of male groups (See Appendix 12, Video 6) did not differ significantly between the coffee and non-coffee season although in relation to the group size there were larger male groups during the non-coffee season.

There is as yet only one individually-based study conducted by WWF and Kerala Forest Department on two male elephants. These two elephants were collared with remote sensing-GPS in Kerala by a WWF team and have been monitored since 2011; they are known to use Kodagu during migration. Estate managers and workers who are aware of the researcher, Mr. D. Boominathan[80] from WWF, have been reporting on the collared elephants prior to and during my study period. One of the elephant's collars was reported to have dropped off and thus visual monitoring of the movements of only one elephant was being carried out during the period of my study. Information from these collared elephants' movements showed that elephants entered Kodagu district from Thithimathi Forest Reserves (Personal communication with Kodagu Forest Department officials) and they then entered coffee estates like Pollibetta, and Yemmegoondi (which were part of my study estates).

6.5 Conclusions

Although this study does not provide robust data on individual movements, it represents the first baseline study on elephant populations using the region. The data suggested that specific individual elephants and family groups were frequent users of the study sites throughout the year and that they seemed to follow specific travel routes. A long-term study on the movement of these elephant individuals and groups would provide more precise information. This information would further our understanding of whether these regions are a part of home range of resident elephant populations or transitional regions used during movements from one protected area to another.

Fruiting trees within the coffee estates are present abundantly across Kodagu and thus their availability may not be a factor influencing elephants' choice of refuge areas within these coffee estates. During the course of the field work and also from observations by local people, it was evident that the elephants were using specific parts of estates as 'safe' resting and sleeping areas during the day. For future studies, it is

[80] No communication was possible during the field work.

important to consider the shade cover, proximity to the other sources like water, and the movement paths of elephants to understand elephants' adaptations and behavioural flexibility within the human dominated agroforestry systems.

For successful conservation planning it is critical to balance interests of the wildlife with those of local inhabitants; understanding a species' use of landscape and their range is essential (Douglas-Hamilton & Douglas-Hamilton, 2005). Complexity and the multi-dimensional nature of the problems caused by hostile human-elephant interactions in Kodagu urgently require a systematic long-term study to encourage co-existence between people and elephants.

Chapter 7

CONSUMPTION OF COFFEE BERRIES BY ELEPHANTS

CHAPTER 7: COFFEE CONSUMING BEHAVIOUR OF ELEPHANTS

7.1 Introduction

Asian elephants inhabit various ecosystems from the dry, thorny forests of southern India and Sri Lanka to the tropical most forests of Southeast Asia (Sukumar, 2006). Elephants are generalists feeders and considered as 'megagardeners' of the forest (Campos-Arceiz & Blake, 2011; Beaune *et al*., 2013). They consume more than 100 plant species (McKay, 1973; Sukumar, 1990; 2003; Chen *et al*., 2006; Campos-Arceiz, 2008b) and fruits also constitute the main components of diet for elephants ranging in forested habitats (Short, 1981; White *et al*., 1993; White, 1994; Blake, 2002; Morgan, 2009; Campos-Arceiz *et al*., 2008b). For those fruits that are part of their diet, elephants ingest and defecate large numbers of viable seeds (Sivaganesa & Johnsingh, 1995; Kitamura *et al*., 2007; Campos-Arceiz *et al*., 2008a; Samansiri & Weerakoon, 2008; Baskaran & Desai, 2013; Jothish, 2013). The size of fruits and seeds do not inhibit feeding on fruits as Asian elephants have large mouth and gape (Campos-Arceiz & Blake, 2011) and effective tooth areas for easy consumption. They are known to consume fruits which are between 2.6 - 8.1 cm in length with most of them being brown and red colour (Kitamura *et al*., 2002; 2007).

It is well established that wide ranging mammals like elephants cannot be restricted within the boundaries of protected areas and their home range often incorporate areas well beyond established protected areas (Naughton-Treves & Treves, 2005). Using human-dominated agricultural lands, elephants have the opportunity to access resources like water, cultivated crops and fruits such as paddy rice, maize, banana, arecanut, coconut, and jackfruit (See Chapter 6) that have considerable economic and social value for people. This overlap in use creates competition for space and resources between people and elephants which may lead to negative interactions between people and elephants.

Crop-raiding is one of the main consequences of the interface between elephants and people, resulting in increased intolerance towards elephants (Barnes, 1996; Tchamba, 1996; Williams *et al*., 2001) and consequently hostility for conservation efforts (See also Chapter 8). Paddy rice is considered to be one of the most raided agricultural crops by Asian elephants as it has high nutritional values compared to grass found in the forested areas (Sukumar, 1990; 2003; Webber *et al*., 2011). Madhusudan (2003) reported that in Bhadra Wildlife sanctuary, Karnataka, the average losses of crop by elephants is equal to 11% of the monetary value of the grain production of the affected households.

Increases in the numbers or frequency of elephants using the coffee-agroforestry lands have been attributed to the coffee consuming behavior of elephants, especially during coffee season. Bal *et al*. (2008) attempted to document the coffee consuming behaviors of elephants, which have to date only been reported in Kodagu in India. They suggested that the elephants were intentionally consuming coffee berries but that this tendency may be restricted to few individuals within the population; adults may have more opportunities to forage on coffee berries than do juveniles due to the height of the berries. The increasing expansion of coffee agro-forestry is one reason for the loss of natural forests in the region of Kodagu, but few studies have evaluated the long-term effect of agricultural practices such as coffee production. When berries are consumed by dispersing species such as elephants, these seeds have the potential to become an invasive species through dispersal (Joshi *et al*., 2009; Muthuramkumar *et al*., 2006).

Coffee has been grown alongside elephants in this region for over a century; it is however only recently that there is evidence of coffee seed dispersal in natural forests, and whether this is dispersal is due to elephants, birds or other species (primates, pigs) is unknown. As coffee foraging has been considered to be the exploitation of a novel resource (Bal *et al*., 2008) which is not yet widespread in the estate-using elephants, coffee berry consumption by adult elephants indicates adaptation to a new foraging domain that requires experience on the part of the elephant to assess whether coffee berries are edible or not.

Although this may be a behavior adopted by only a few individuals within the elephant population, over time, it is possible that this behavior will spread among the remaining individuals of the elephant population through social learning (e.g. Donaldson *et al*., 2012). This spread could eliminate the earlier observed age-difference of coffee berries ingested within the population. The possibility of coffee becoming potential novel food resource for the elephants and thus a demonstration of new adaptations of foraging behaviours for elephants within Kodagu region needs to be examined further in future studies. The aims of this chapter were to re-assess whether elephants were consuming coffee berries in relation to consumption of other fruits and to determine whether coffee consumption had become general to elephants in the estate-using population. Why were elephants visiting these estates? Were they coming as a function of food availability (as evidenced from seeds in dung), or for safety in travelling between risky areas, as suggested in part from the data on group size and frequency (See Chapter 6)? The exploration of food remains present in dung should provide some perspective on these questions.

7.2 Methods

Elephant dung has been suggested to be an important biological tool in sustaining plant biodiversity in disturbed soils (Paugy *et al*., 2004). The mild mouth and gut treatment of seeds by Asian elephants results in a high proportion of the ingested seeds that are defecated intact and in good conditions for germination (Campos-Arceiz *et al*., 2008a). As it is difficult to detect intake of and damage to seeds from direct observations of plants, the diversity of seeds dispersed is generally quantified by using dung content methods both in African and Asian elephants (e.g. Kitamura *et al*., 2007; Morgan & Lee, 2007; Varma *et al*., 2008; Blake *et al*., 2009; Campos-Arceiz, 2009). When elephants consume fruits, some seeds are defecated intact and some are chewed in the mouth, while the others are partly digested in the guts. In Thailand, Kitamura *et al*. (2007) examined dung piles of Asian elephants to determine the presence or absence of seeds or fruit matter and also the net seed/and or fruit contents. Dung samples were collected using road transects survey and *ad-libitum* site samples and were hand shredded and dissected to find seeds or fruit matter. Morgan & Lee (2007) examined elephant dung samples *in situ* for gross contents and fine contents were assessed through sieving and washing. In Vietnam, similar methods of dung sampling were carried out to examine plant and seed content (Varma *et al*., 2008) where the dried coarser remains were examined under microscope for identification of plant species and parts. These studies have illustrated the importance of dung sampling as indicators of diet when elephants cannot easily be observed foraging.

Two experimental studies have studied fruit seed passage in elephants, where one was on African elephants (Dudley, 1999) and one on Asian elephants (Campos- Arceiz *et al*., 2008a). And in Kodagu, only one study has looked at the extent of coffee consumption by elephants through counting coffee seeds in dung samples (Bal *et al*., 2008). Coffee seeds are mostly intact when they pass through the gut of the elephants (personal observations, See below), although a few of them may be digested during the gut passage – these quantities remain unknown. On a coffee branch, a cluster of seeds usually consists of 20-30 coffee berries (Bal *et al*., 2011). When elephants consume these berries, the two cotyledons of the coffee seeds either break into separate cotyledons or do not break when passed through the gut. When sampling fresh dung, we noted that some of the berries passed through the gut without being digested or damaged at all.

The number of coffee seeds found within the dung sample was counted in this study using the same method as by Bal *et al*. (2008) to be able cross-correlate the results (see Figure 7.1; also See Chapter 3, Section 6). Coffee seeds for each dung samples were counted and weighed. Each individual cotyledon was considered as one seed. Effort was made to take measurements of intact dung boli[81]. However most of the dung piles were damaged due to impact on ground or trampling by elephants, and if they were found on estate roads by being run over by vehicles. Since the sample size was small (N=202), data on the age of elephants as determined by dung sample was not included as only very few measurements of boli diameter were possible in the sample (e.g. Morrison *et al*., 2005). Thus, the age-structure of elephants consuming coffee berries is not analysed and cannot be directly compared with the earlier study (Bal *et al*., 2008). Most of the dung samples were collected between May 2010 and March 2011, for a period 11 months, which resulted in the lack of data for the month of April.

I collected dung samples using two methods: in the first session I conducted line-transect methods (5 months) and in the second session I collected only Category A

[81] Boli – An elephant dung-pile consists of 2 to 4 boli, each of which are in cylindrical shape and an average diameters vary from 6 – 18 cm, depending on the age of the elephant.

(fresh) dung encountered (6 months) (See Chapter 3, Section 3.3). Dung samples were removed from the sample transects once the sampling was complete to prevent double counts. All the dung samples were weighed before examining for the contents. All intact or semi-intact boli (N = 202) were sieved for seed presence. Analysis was conducted only on those contents which were easily detectable with the naked eye.

Figure 7.1 Presence of coffee in dung samples.

All the dung samples were collected for confirmation of the presence of coffee seeds (See above), the presence of two major fruits known to be highly selected by elephants in this regions jackfruit and rain tree seeds, and the presence of minor fruits (mango and oranges). These fruits play a significant role in the frequency of visits and group size (See Chapter 6), and were thus chosen for analysis here. Each boli of a dung pile was checked for contents. All other fruit and food content types were also recorded and weighed together. Then each content type was separated, and if feasible counted and weighed. Jackfruit seeds, remains of outer shell of jackfruit and other identifiable remains were weighed together. Then, only jackfruit seeds were separated, counted and weighed. Mango seeds were also counted and weighed separately and also together with any other remains like mango skin. Dung sample with orange seeds or peel and *Ficus spp*., and other citrus fruits were found; these fruits were recorded as present but not analysed for abundance. Oranges usually passed the gut without proper digestion and thus most of the orange seeds consumed were intact and easily identifiable. If there were only seeds, then the seeds were compared to already identified sample seeds of other citric fruits. If it was difficult to establish the name of the citric fruit, it was recorded in the general citric fruit category. Dung samples were also examined to check for the presence of fibrous matter (leaf, grasses) and were grouped into four different categories for analysis. These were 1) fibre absent, 2) low fibre (only a small proportion of the bolus contained visible structural fibre), 3) medium fibre (obvious fibre within the bolus) and 4) high fibre (majority of the dung was fibre). The bolus diameter (N = 33) was estimated by calculating the average of the diameters along the longest and shortest axes of minimum three cylindrical boli of each pile (Morrison *et al*., 2005). Because of impact or damage, most of the dung boli were inappropriate for measuring boli size. Category A (fresh) samples were difficult to encounter because of the fast decomposition of boli due to dung beetles and other insects found within coffee estates or damage due to vehicles. The visual inspection technique was used here to categorise the relative proportion of non-coffee contents in the dung, comparable with other studies (eg, Bal *et al*., 2008; Kitamura *et al*., 2007; Morgan and Lee, 2007; Verma *et al*., 2008), rather than sieving, drying and weighing of all contents. Drying was not logistically possible in these humid field conditions. However, as described in Chapter 3, coffee seeds in each dung pile were counted and weighed using a portable 5 kilogram (± 10 gram) weighing scale.

7.3 Analysis and Results

7.3.1 Overview

Results are based on the 202 dung samples (separate boli within a single defecation) within the study coffee estates. Dung samples collected within 24 to 48 hours of defecation (Category A – Barnes & Jensen 1987; Appendix 5) were a total of 89. There was a significant difference in the number of boli detected and counted across months (two-way $X^2 = 127.44$, df = 66, $p < 0.001$, N = 202, Cramer's V = .324; See Figure 7.2). These monthly differences were not due to sampling intensity which was constant between months, and may reflect the distribution of elephant sighting events by month on the estates for 2011, the year of dung sampling (See Chapter 5, Figure 5.1). Alternatively, the distribution might reflect the greater ease of finding intact boli during the non-rainy months.

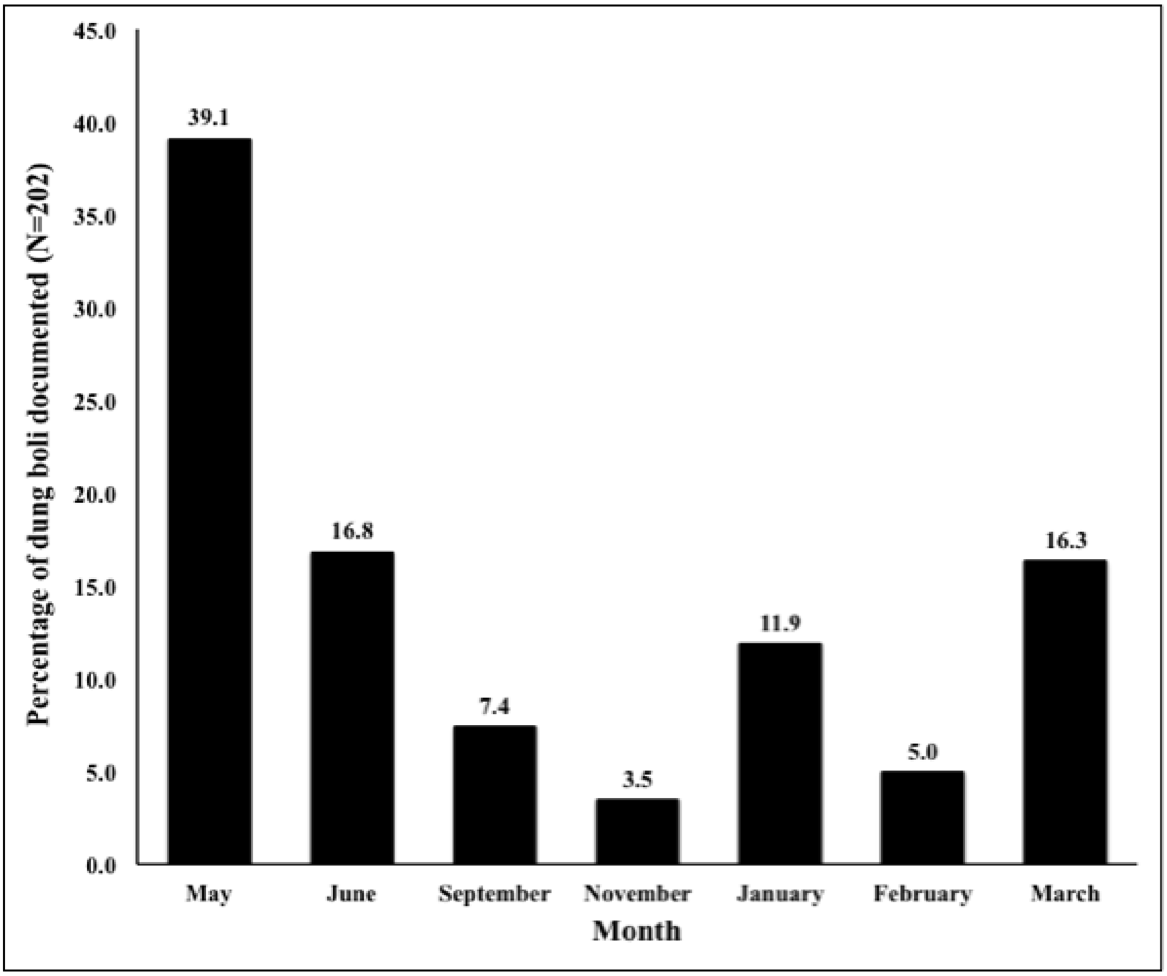


Figure 7.2: Percentage of dung boli surveyed by month (N= 202).

Associations between the number of seeds in relation to the presence of fibre and fruits (seeds or any remains of fruits for example orange peel) in the dung were analysed using univariate ANOVA within each month of the study period. To determine whether there were interactions between the presence of fruit in relation to the abundance of coffee seeds (log transformed for normality). A hierarchical (sequential) model was used to test for interactions between presence of fruits and coffee seeds controlling for monthly variation. To evaluate associations within variables (for example: three categories of seeds), one-way and two-way chi-square analyses were carried out.

Table 7.1 Associations between the number of coffee seeds (log) and the presence or absence of all other fruits[82] in dung using univariate GLM (hierarchical model controlling for month). Only first order interactions are shown.

Source	Type I Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	120.263[a]	31	3.879	4.955	<.0001	.475
Intercept	106.882	1	106.882	136.525	<.0001	.445
Month	**91.184**	**6**	**15.197**	**19.412**	**<.0001**	**.407**
Albizia saman	.309	1	.309	.395	.531	.002
Orange	1.887	1	1.887	2.410	.122	.014
Mango	**6.963**	**1**	**6.963**	**8.894**	**.003**	**.050**
Jackfruit presence	.077	1	.077	.098	.755	.001
Month * *Albizia saman*	.140	3	.047	.060	.981	.001
Month * Orange	.997	3	.332	.425	.736	.007
Month * Mango	.158	2	.079	.101	.904	.001
Month* Jackfruit presence	**13.565**	**5**	**2.713**	**3.465**	**.005**	**.092**
Error	133.088	170	.783			
Total	360.233	202				
Corrected Total	253.351	201				

a. R Squared = .475 (Adjusted R Square = .379)

[82] Parameters here are the presence of seeds or remains of fruits.

7.3.2 Presence of Coffee

Of the total 202 dung samples surveyed, 60.9% (N=123) of the dung samples contained no coffee seeds while 39.1% (N=79) contained coffee seeds. All the dung samples were then classed into three categories[83] (following Bal *et al*., 2008) of none (N = 79), less than 50 (N = 34) and greater than 50 (N = 45) coffee seeds present within the dung samples. Of the total sample, 16.8 % or 43 % of the sample with coffee seeds had fewer than 50 coffee seeds while 22.3 % or 57% of those with seeds had more than 50 coffee seeds. The possibility of finding coffee seeds in each dung pile was assumed to be equally distributed among the three categories. Differences between categories of the quantity of coffee seeds were significant (one-way classification chi-square: X^2 = 69.931, df = 2, $p < 0.001$, N = 202; Cramer's V = 0.489; See Figure 7.3). While most elephants did not appear to consume coffee, when they did ingest it, they tended to do so in some quantities suggesting intentional foraging.

[83] The three categories were as categorised by Bal *et al.,* (2008) to be able to compare the results between the two studies which took place 5 years apart.

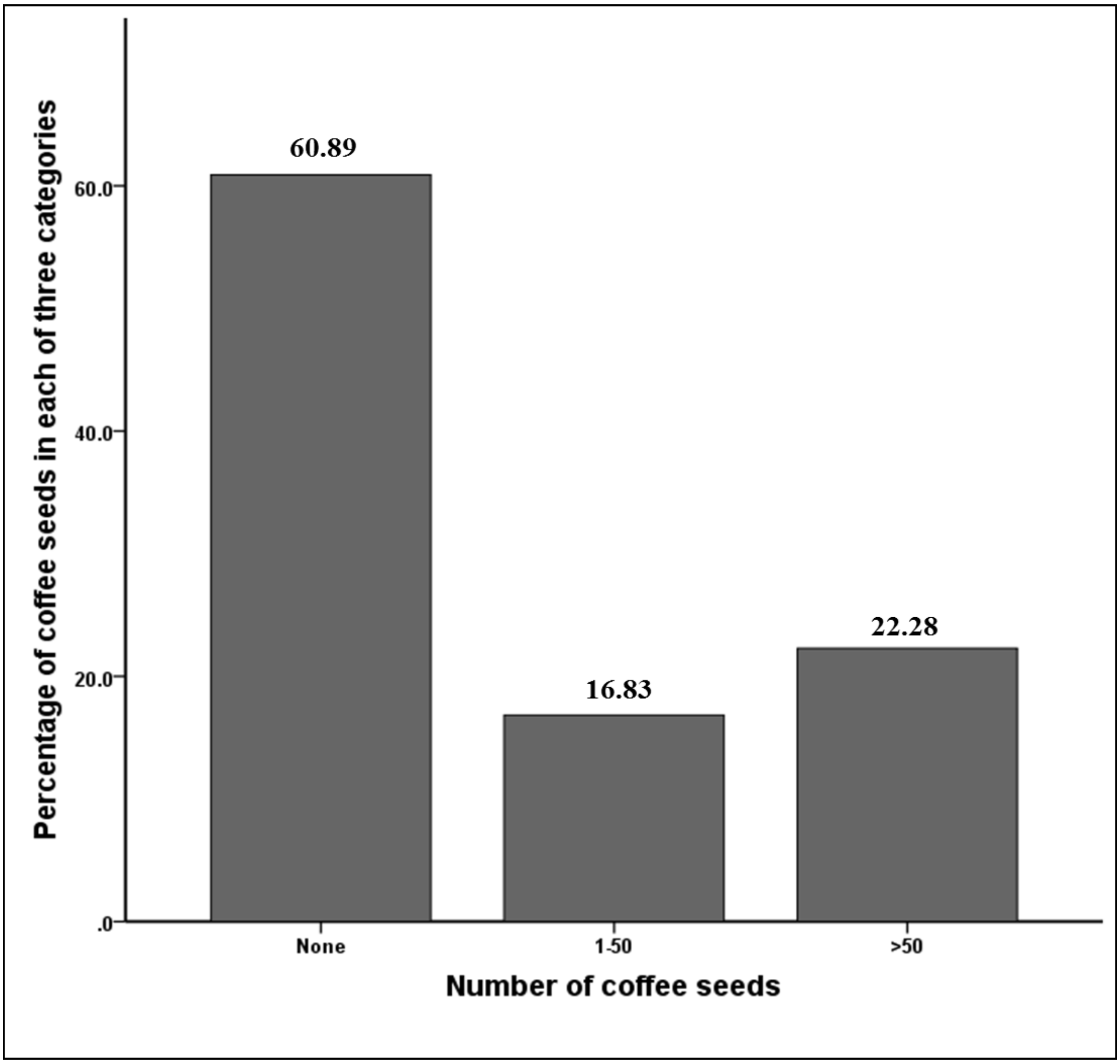


Figure 7.3 Percentage of coffee seeds (frequency distribution) in each of three categories (frequency cluster) present in dung samples (None = no seeds present, 1-50 seeds present and > 50seeds present; (N=202).

7.3.3 Presence of coffee in relation to jackfruit (*Artocarpus heterophyllus*)

The results above suggest that when coffee seeds were available (during the coffee season of January to March), elephants were indeed foraging on coffee berries as indicated by the earlier study (Bal *et al*., 2008). Coffee seeds in dung peaked in January and February (the main picking season), with smaller numbers of seeds observed from March to June (See Figure 7.4). The question addressed here is whether the consumption of coffee was inadvertent – due to the attraction for and consumption of other fruits, which were also available at the same time? Jackfruit was a key fruit consumed by the elephants and influenced elephant numbers (See Chapter 6). The presence of jackfruit seeds within the dung samples was found to be higher during the month of June (See Figure 7.3) and jackfruit seed counts in the dung were not associated with the consumption of coffee, as indicated by seed counts (ANOVA: $F_{1,194} = 2.267$; $p = 0.134$, NS, partial eta squared = 0.012).

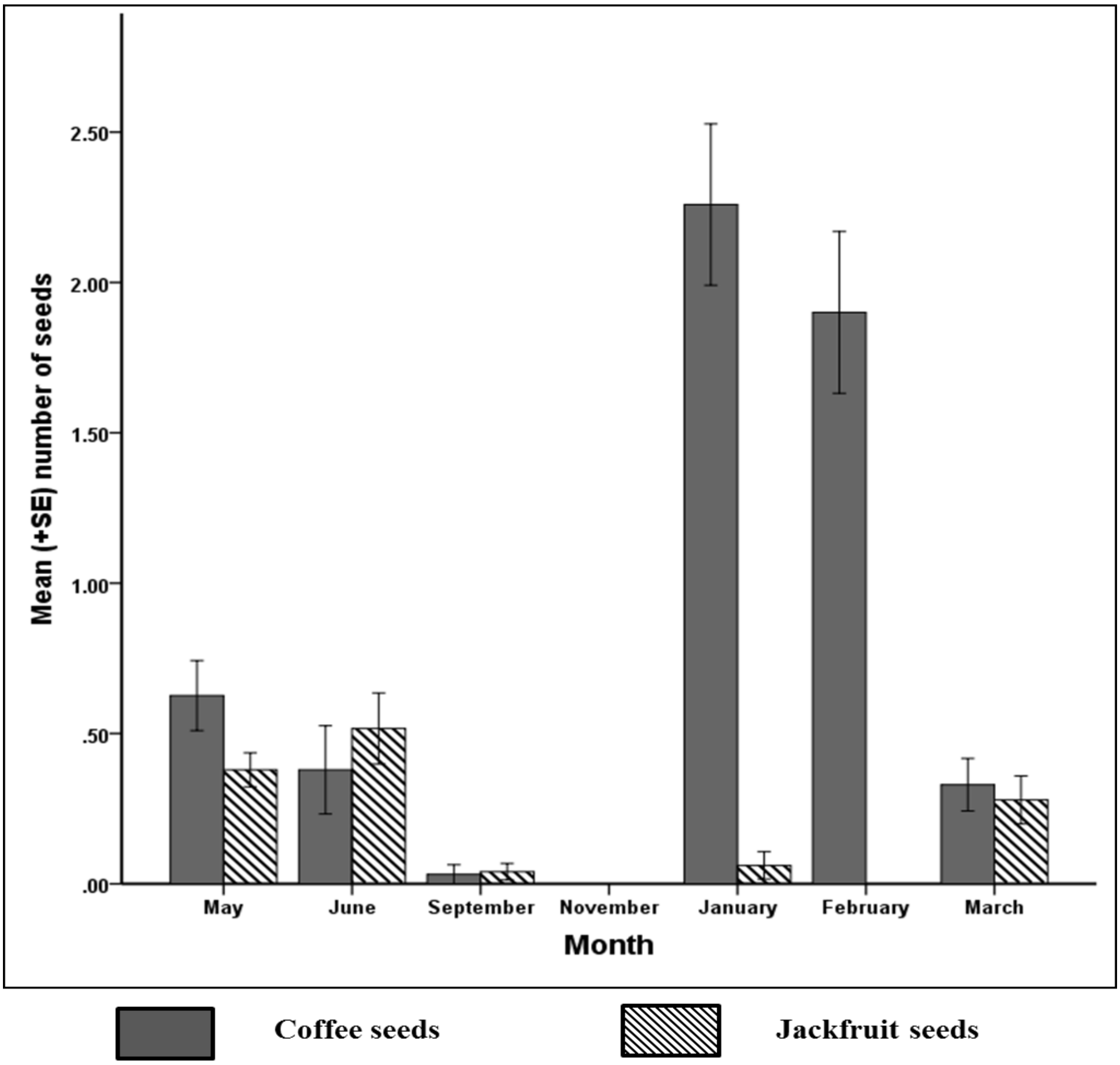


Figure 7.4 Mean (±SE) number of Coffee seeds (log) in relation to the number of jackfruit seeds – by sample Month (N = 202). Months missing were not sampled due to loss of dung within 24 hrs after defecation.

Were elephants attracted to the coffee plantations in order to eat jackfruit? Bivariate correlations indicated that in months when more jackfruit was available, less coffee was found in the dung (Pearson Correlation, $r = -0.154$, $N = 202$, $p < 0.05$, two-tailed). Similar results were found for the fresh dung sample where jackfruits available had no relationship with whether coffee was present in dung (See Figure 7.5). Exploring the relationship between counts of jackfruit seeds and counts of coffee seeds in fresh dung, found no significant association ($r = -0.61$, $N = 89$, $p < 0.05$, two-tailed). This lack of association suggested that the consumption of each species was independent and a function of the seasonal availability of each fruit type. However, the attraction of jackfruit (over coffee) as a food resource remains to be determined. There was no significant difference in the presence or absence of jackfruit by coffee seed category ($X^2 = 0.909$, $df = 2$, $p = 0.60$, NS, $N = 202$).

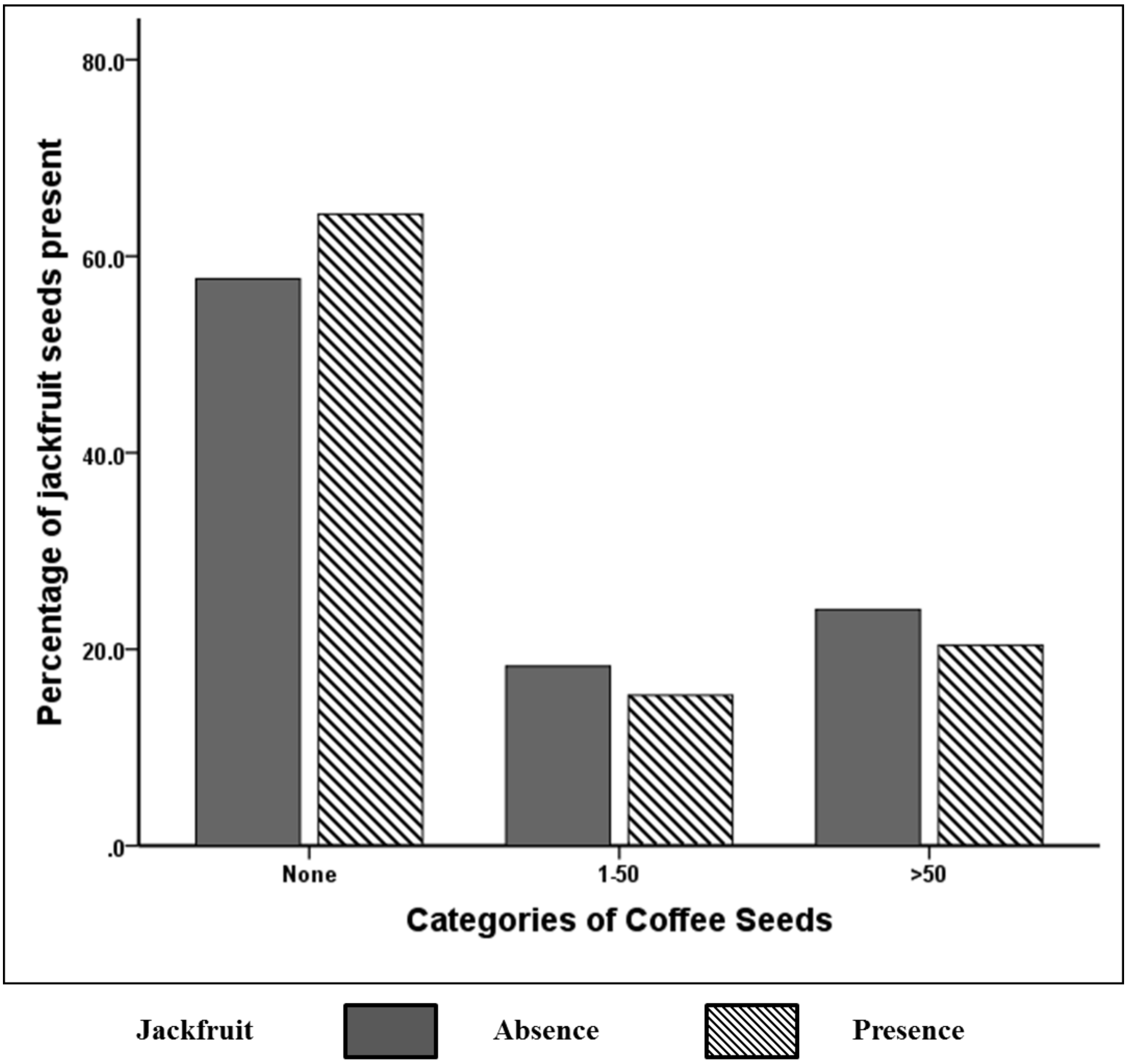


Figure 7.5: Percentage of dung samples with jackfruit present or absent by category of coffee seeds[84] (N=202).

<u>7.3.4 Presence of *Albizia saman* (rain tree)</u>

Albizia saman (rain tree) seeds in the dung samples were found to be significantly more likely to be present during the months of March and May (See Figure 7.6). The flowering and fruiting of the rain tree coincides with the months indicated in the Figure 7.4, suggesting that the elephants have a marked preference for these fruits. The peaks

[84] Total dung samples N = 202 in relation to the jackfruit presence (N = 98) or absence (N=104. None coffee seeds (Jackfruit: Absence = 60, Presence= 63), 1- 50 coffee seeds (Absence = 19, Presence = 15) and > 50 coffee seeds (Absence = 25, Presence = 20).

in consumption were, like jackfruit, unrelated to the monthly peaks in coffee consumption (ANOVA: $F_{1,194} = 0.370$, $p = 0.544$, NS, partial eta squared = 0.002).

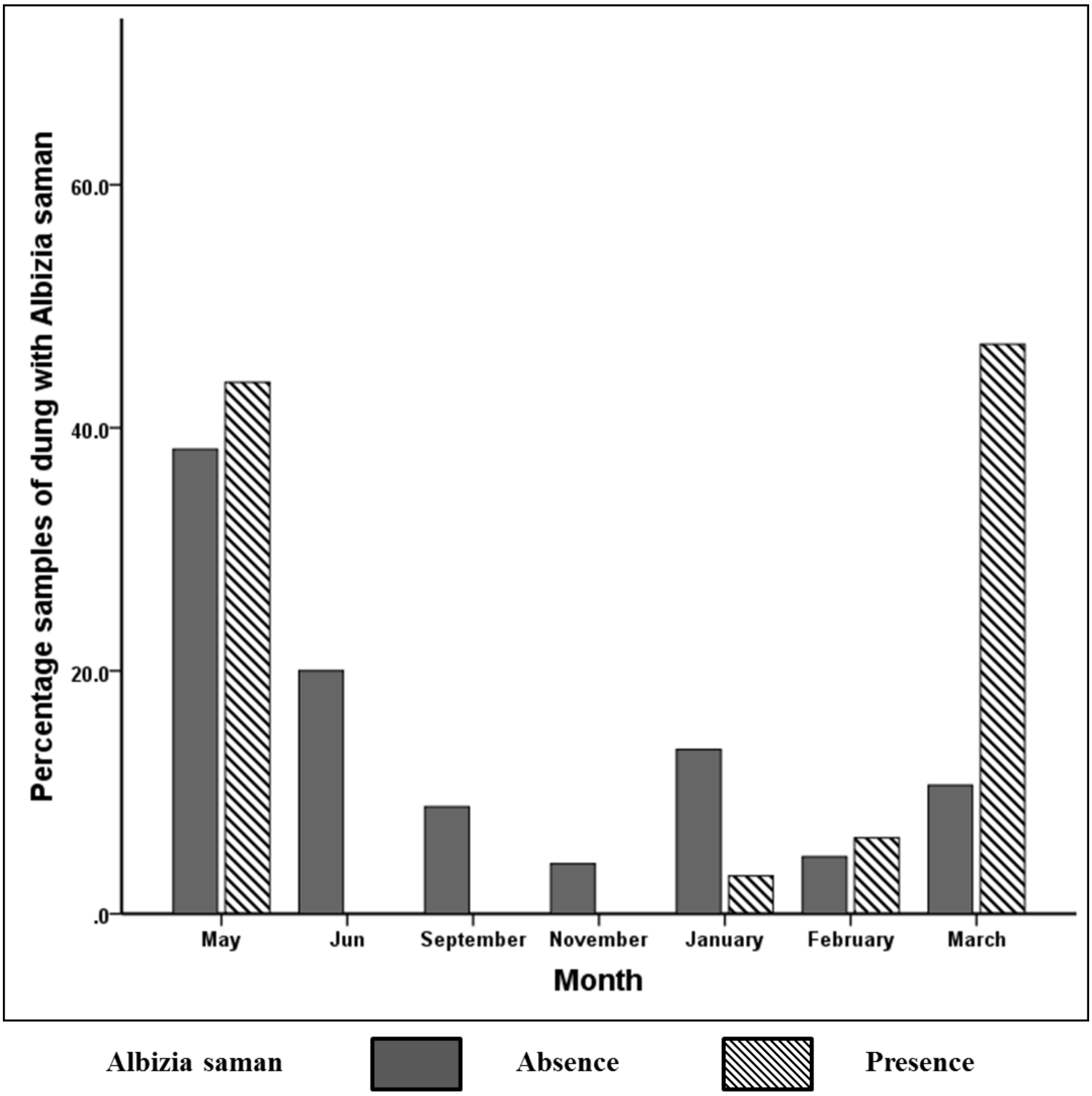
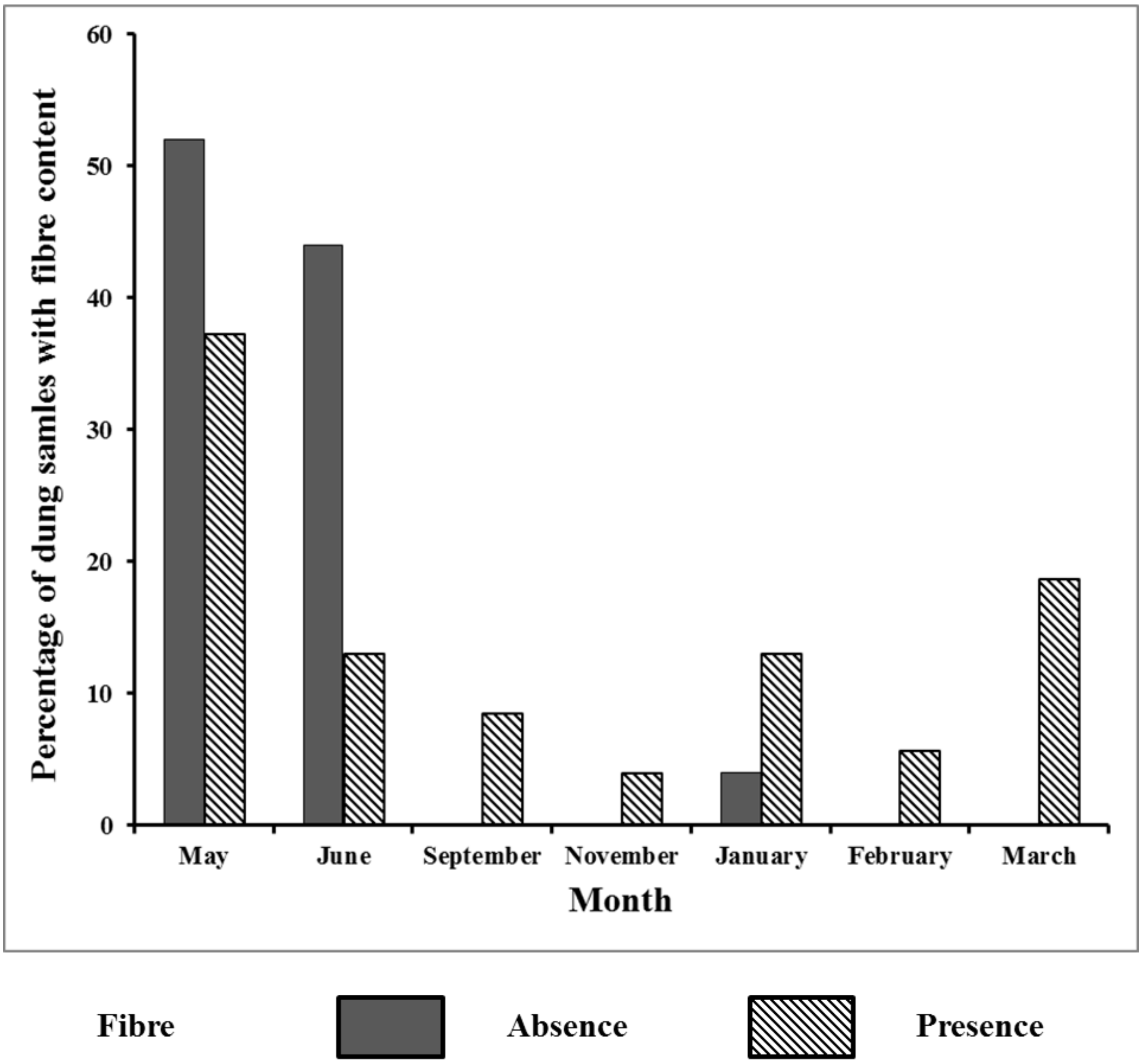


Figure 7.6 Presence (N = 32) or absence (N = 170) of *Albizia saman* in the dung samples (N=202) by month.

<u>7.3.5 Presence of Fibre</u>

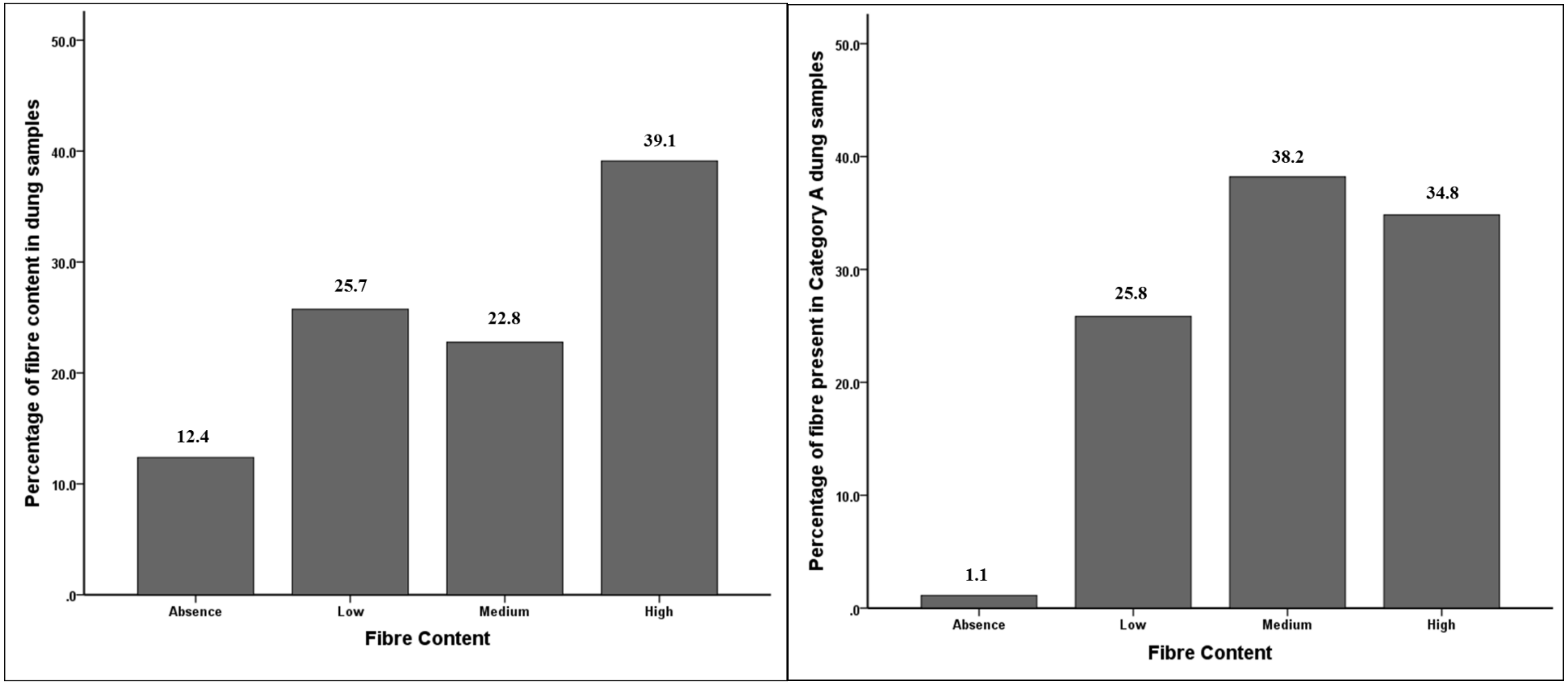
About 39.1 % (N=79) of dung samples contained high presence of fibre and only about 12.4% (N=25) had an absence of fibre (in the months of May and June) (See Figure 7.7a). The rest of the sample contained 22.8% (N=46) medium and 25.7% (N=52) low

presence of fibre (See Figure 7.7b). Of the fresh dung samples collected during the second phase of the field work (September 2010 to March 2011) almost all contained fibres (98.9%) although there were fewer categorised as high fibre overall (See Figure 7.7c).



(a)

Figure 7.7 (a) Percentage of dung samples with fibre (N = 202) documented during the study period by month.



(b) (c)

Figure 7.7 Percentage of presence of fibre in (b) all the dung samples (N=202) (c) Category A Dung (Fresh Dung) sample (N=89).

Fibre was slightly related to the presence of fruits in dung (using a summed presence across all fibre categories) (two-way chi-square: $X^2 = 21.02$, df = 12, p = 0.05, Cramer's V = 0.186). When fibre was absent, the summed presence of fruit was highest, while when fruit was absent, fibre was high (See Figure 7.8). Presence of fibre in the dung was not directly associated with the consumption of coffee, as indicated by seed abundance (ANOVA: $F_{1,194} = 2.709$; p = 0.101, NS, partial eta squared = 0.014).

7.3.6 Other fruit presence in the dung

I was able to detect mango (large) and orange (small) seeds in the dung as well as coffee, jackfruit and rain tree. The relationship between coffee seed numbers in dung and the presence or absence of these two other fruits was also explored. Mango seeds were significantly likely to be found with larger numbers of coffee seeds, once month had been controlled for ($F_{1,170} = 8.894$; p = 0.005, partial eta squared = 0.050; See Table 7.1). This association was due to the fact that both mango and coffee peaked in availability in January (See Figure 7.9). There were no significant associations with the presence of orange seeds.

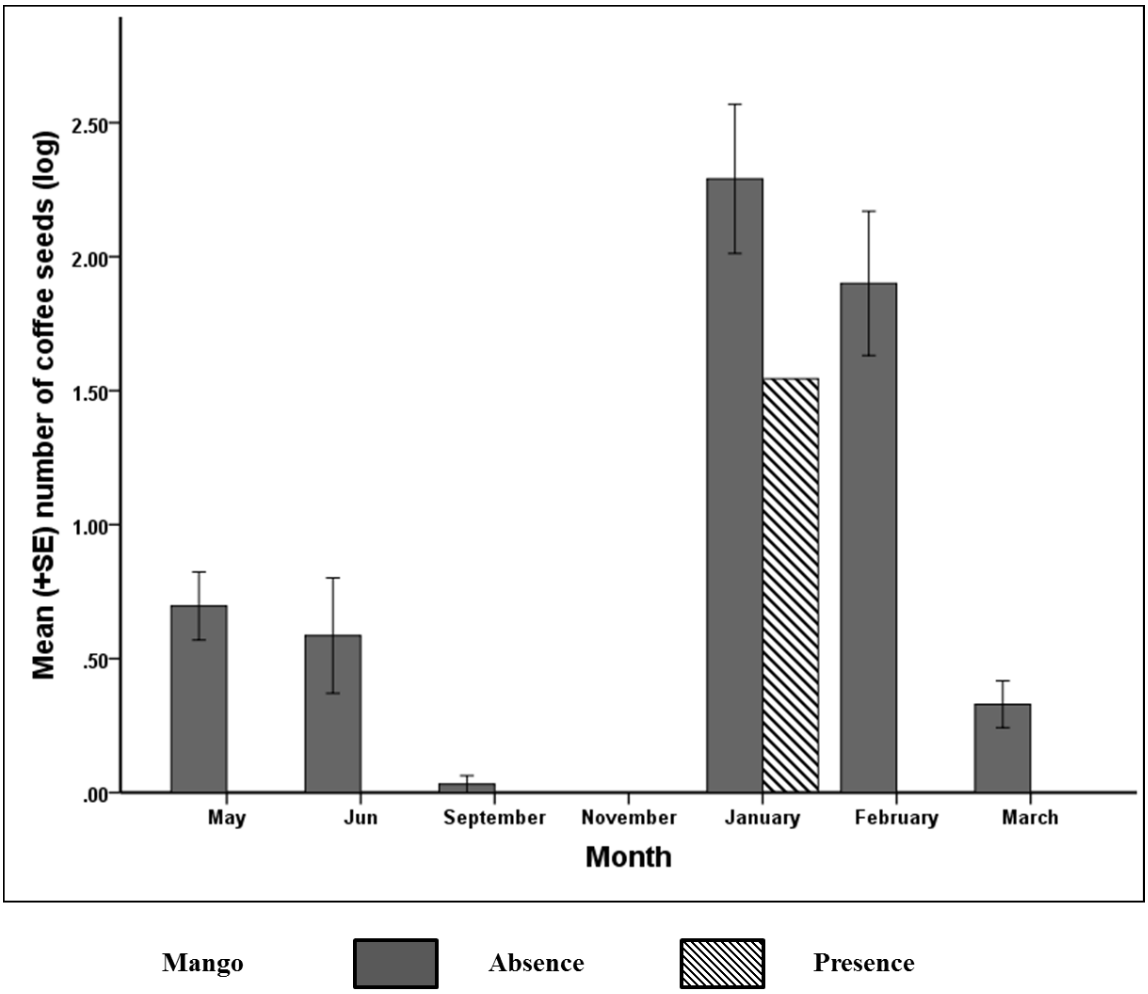


Figure 7.9 Mango presence or absence in dung with coffee seed abundance (log) by month (N = 202).

7.3.7 Relationship between fibre and fruit content in the dung sampling period

Results from the dung sample suggested that there was some interaction between the intake of grass or green foliage and fruits (See Figure 7.8). When the presence of fibre was low or only present to a limited extent, t the elephants were feeding on fruits. However, the dung samples alone cannot reflect availability – merely selection. A larger sample size is required to determine whether elephants were choosing their food resources within the coffee estates or from other cultivated lands in relation to fruit availability**.**

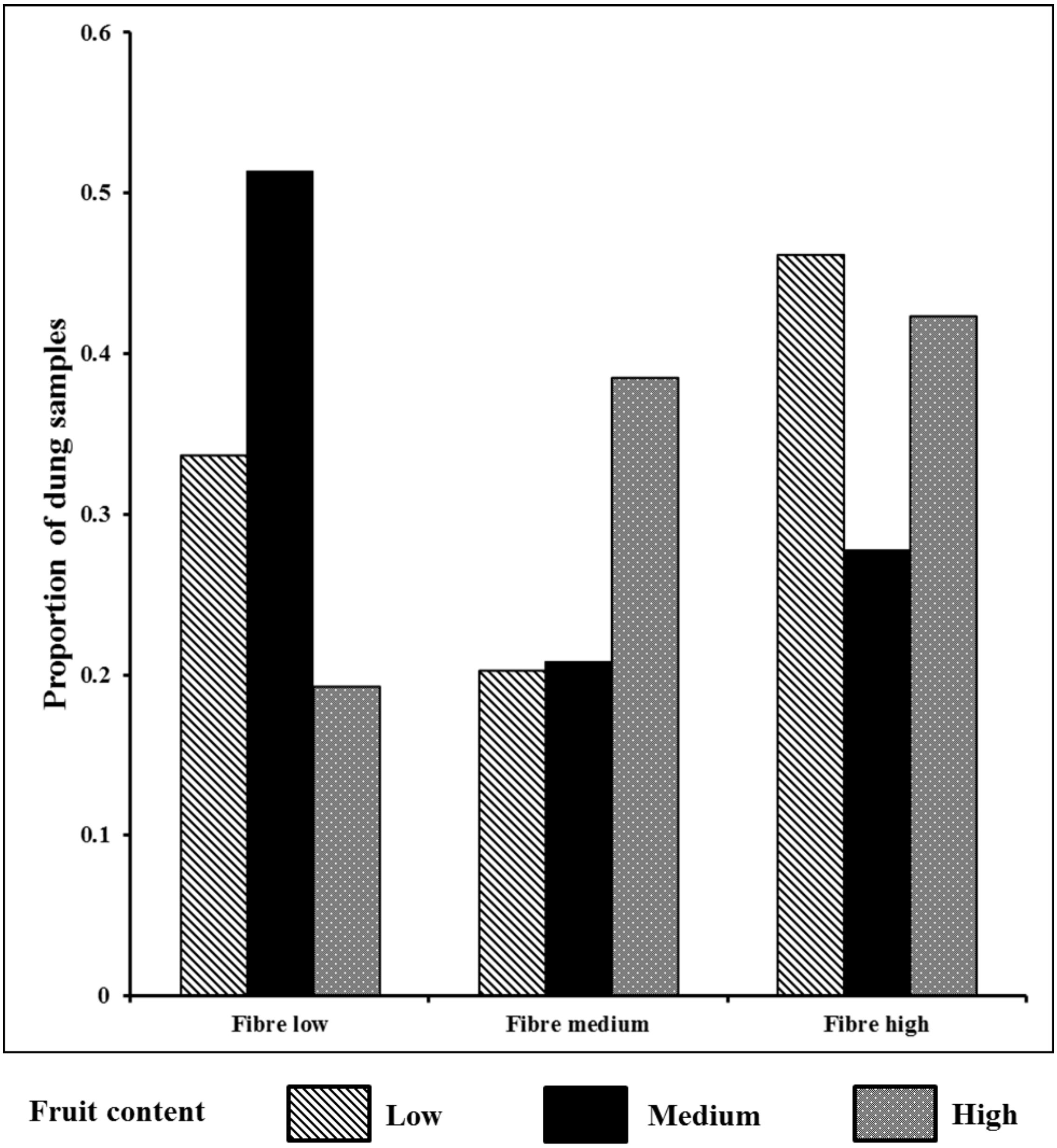


Figure 7.8 Relationship between the presence of fibre (low/none, mid, high) and the presence of fruit (low/none, mid, high) in dung over the entire sampling period (N=202).

7.4 Discussion

This dung study was also conducted to determine whether elephants consuming coffee berries during their visit to coffee estates. Results suggest that there was a trend for foraging on coffee berries among the elephant populations visiting the study sites. Consumption of coffee peaked during the coffee picking season and was generally unrelated to the consumption of any other fruits, other than some co-association with seasonal presence of the other fruits such as mango. However, with the available data I was not able to determine if coffee consumption was the cause of high densities of elephants during the coffee season (See Chapter 5). Bal *et al*. (2008) suggested that their analyses did not show any relationship between canopy cover and the frequency of elephant visitation, in contrast to previous studies which suggested that a more intact high canopy cover increases elephant presence in a forested area (Barnes *et al*., 1991; Vanleeuwe & Gautier Hion, 1998; Theuerkauf *et al*., 2000; 2001).

Were the elephants intentionally choosing coffee as a food? Bal *et al*. (2008) tested the chance feeding of coffee berries by elephants and proposed that fewer than 5% of the dung piles should have at one or more coffee seeds if they ingested coffee seeds while feeding on other vegetation like leaf, grass, bark, etc. Almost 40% of the dung samples in this study contained at one or more coffee seeds suggesting the possibility that elephants were deliberately consuming coffee seeds.

Bal *et al*. (2008) also suggested that about 50% of the dung samples should test positive for presence of coffee seeds to establish that elephants have a 'strong preference' for coffee seeds. A strong preference would indicate whether elephants were consuming coffee berries by chance or not. Bal *et al*. (2008) found that although coffee was seasonally present, damage patterns were similar to those for perennial crops and occurred during all periods, with an additional rise in crop-raiding in the month of February, the peak coffee ripening season. It would appear that elephants in my population were still below the threshold to indicate habitual coffee consumption but well on their way to preferentially selecting coffee in those months when it was highly available. To validate this suggestion and uncover the mechanisms for social transmission of a new feeding tradition, long-term monitoring of elephants' consumption of coffee is required. In order to determine and establish coffee berries as 'strong attractant' for elephant visitation during the coffee season, better observational data based on individual identities are required (See Chapter 5). Further studies should identify the individual elephants frequenting the coffee estates and a long-term examination of their movement pattern and actual time spent within the coffee estates so as to evaluate coffee berries as the novel foraging resource for elephants.

Coffee consumption was previously suggested to be an unusual behaviour of only few individuals or a section of the population, rather than behaviour common to the entire population using Kodagu (Bal *et al*., 2008). Elephants entering into these coffee estates appear to be locally resident elephant population with very few migrant or transitory elephants (See Chapter 5) observed during fieldwork. Coffee-foraging behaviour can be attributed to this local, resident elephant population, but this is not yet clearly evident whether coffee consumption is an unusual behaviour of only few individuals of that population or of much of the population using the plantations. One problem with dung samples is that, in a resident population, the same individual is likely to be sampled on a number of occasions. Thus determining the generality of coffee consumption requires sampling of forest-living elephants as well as those on estates.

Human-elephant interactions are sometimes caused by only few individuals of a population (Hoare, 1999a; 2000; Nelson *et al*., 2003), so the possibility of learning and acquiring a certain novel behaviour could be limited to few individuals. But elephants are considered to be highly intelligent and social animals; thus there is a high possibility of learning through socio-culture exchange between and within the elephant populations. Spatial segregation of the dung piles surveyed for coffee seeds also suggests that there was no localization of coffee consumption within the coffee estates and thus the consumption of coffee berries could be a behaviour involving a number of elephants from different social groups on estates and thus might represent a general trend in the local population (Bal *et al*., 2008).

Bal *et al*. (2008) suggested that elephants appeared to be spending half of their feeding time consuming coffee berries within the randomly selected coffee estates in six villages of Chennangi and Chennayanakote. They sampled dung samples (N = 209) into adults and juveniles based on the boli size and their results indicated that adults showed more preference for coffee than did juveniles. However, the observed dung piles for juveniles with coffee seeds for the population in their study were relatively few (N = 15). Because of a limited sample with intact boli, I was not able to analyse for any consistent age effects. If foraging on coffee seeds is a novel behaviour, it appears that the juveniles and the younger elephants are also slowly acquiring the habit of feeding on coffee seeds (personal observation). Further research should focus on examining the number of adult elephants that are consuming the coffee berries in relation to the other age categories within the population. It is also important to determine if there is a difference in coffee consumption between family groups and male (solitary or group) individuals. This could be examined by evaluating the damage of coffee berries after an event has occurred and by recording the total loss and coffee on the ground (fallen berries due to elephant disturbance). It is important to establish a protocol for such studies as the peak coffee season is only three months of the year but there is constant coffee picking work throughout the estates. Robusta (*Coffea canephora*), in contrast to Arabica (*Coffea arabica*), coffee is cultivated extensively across Kodagu district and the elephant preference for Robusta coffee areas as refuge areas (See Chapter 7) suggests that the coffee berries that are consumed by the elephants are Robusta. Thus, information on elephant preferences between the two different species of coffee berries would help to better understand the causes of acquired coffee foraging behaviour in relation to elephant usage of a coffee landscape.

A novel reliance on coffee may further increase the negative attitudes towards elephants and also change the nature of the problems existing between people and elephants. If most of the elephant populations using coffee agro-forestry begin consuming coffee berries as food resource, strategies to manage and reduce hostility at the human-elephant interface become extremely difficult to devise and implement. With coffee as the main agricultural cash crop along with paddy rice, the costs of compensating crop damage would escalate and retaliatory killings may increase. Currently, loss of coffee in Kodagu is thought to be mostly accidental damage to the coffee plants and coffee berries during the elephant movements within the coffee estates, although I provide evidence here that a number of elephants are intentionally consuming coffee. In addition, the other major concern is the safety of the estate workers within the coffee estates, which could be increasingly at risk if the elephants are attracted to plantations and start intentionally eating more and more coffee.

Kitamura *et al*. (2007) found only 21% of the Asian elephant dung piles sampled contained fruit seeds in comparison to 65% of dung piles with seeds for African forest elephants. The proportion of savannah elephant dung with seeds is intermediate (~40%; Gonthier, 2009) but the seeds tend to be small and from leguminous trees or shrubs. Thus, to calculate actual coffee berry loss, it important to assess the fruit removal rate by elephants in each specific population. However, it is difficult to measure such losses as the elephants' visitation to a feeding area depends on their movement patterns and thus they may only visit a specific feeding area occasionally. Even one visit by elephants can have a significant impact on fruit removal (Campos-Arceiz & Blake, 2011); for example, consuming coffee berries at one location or a single paddy rice field depredation. Even if we consider one dung pile as one feeding instance as suggested by Bal *et al*. (2008), it is difficult to estimate the extent of the loss of coffee berries during feeding. Some of the coffee berries are dropped while feeding and during accidental damage to the coffee plants by elephants who may not be feeding on the coffee berries but playing or using the branches as a tool for scratching or to drive away the flies (personal observation). It is also important to consider the rate at which seeds can be consumed relative to their accumulation in the gut and then defecation. Greater knowledge of these processes is required in order to assess the offtake rates for coffee.

According to optimal foraging strategy theory, Sukumar (1990) explains that high palatability, high nutritive value and the fact that crops are easily accessible and abundantly available act as attractants for elephants and thus increasing crop damage. Future studies should also focus on coffee's nutritive value as a food resource for elephants. If coffee berries are preferred by elephants for some nutrients, regardless of whether the behavior was opportunistic, this preference could potentially contribute to exacerbating new foraging and ranging patterns within certain elephant populations. For example, while coffee berries contain only trace amounts of most minerals and vitamins, and few macronutrients such as fat or protein, they do contain some antioxidants including chlorogenic acid as well as the stimulant caffeine (USDA Nutrient Database).

Elephants are known for their sensitivity to smell and they use their olfactory ability to find fruits in the forested habitat (Campios-Arceiz & Blake, 2011). Similar situations could be occurring within the 'managed forests' of coffee agro-forestry where elephants may be attracted to the strong odours of fruiting trees like jackfruits, mangoes, oranges and probably coffee berries. But such assumptions require examination in order to determine whether olfactory cues of ripe fruiting trees in coffee estates are resulting in high influxes of elephants into the coffee estates.

7.4.1 Does other fruiting tree presence affect the consumption of coffee berries?

In Chapter 6, the analyses suggested that tree cycles influenced elephant usage of the estates. Analyses in this chapter indicated that the presence of jackfruits during coffee season had no direct effect on foraging on coffee berries. Forest Department compensation records indicated that elephant visitations were not directly associated with the presence of jackfruit trees during jackfruit season (Bal *et al.*, 2008). But the presence of jackfruit trees at high numbers, especially in large estates, suggests that jackfruits could be one of the attractants, although not the only attractant, for elephants to visit the estates. Jackfruits are grown non-commercially and consumption by elephants does not have any impact on the farmers' livelihood income. However, with the possibility of jackfruit being a significant attractant for elephants, incidental damage to other crops may affect the farmers of the region. Coffee planters have even taken steps to cut down jackfruits in an attempt to discourage elephants from entering the estates (See Chapter 6). Observations during data collection indicated that elephants were aware of the presence and location of jackfruits within the estate, suggesting that elephants may have been picking up olfactory cues from jackfruits to determine their location, as suggested above.

Fruits trees like jackfruits, rain tree, mango, and oranges are abundant in the estate forests and are damaged during their specific fruiting periods. As shown above, mango seeds coincided with coffee seeds in dung. But as with all these fruiting trees, the natural phenological cycles of flowering and fruiting with the monsoon leads to high levels of co-occurrence in fruiting seasons. There are also incidental damages to other cultivated crops like cardamom and ginger which are mostly the result of elephants trampling these crops on their way towards coffee estates, paddy rice and maize regions. Elephant visitation to coffee plantations was also found to be significantly higher during the paddy rice harvest season (Bal *et al*., 2008).

Spatio-temporal memory may also be a reason why African elephants are able to selectively exploit fruiting trees. In Lopé Reserve and Petit Loango, Gabon, elephant densities are known to increase during the fruiting season of *Sacoglottis gabonensis* (White, 1994; Morgan, 2009). It was assumed that the elephants were moving outside their normal home ranges into high fruiting areas (White, 1994). Elephants are known to be intelligent animals which can process complex cognitive spatio-temporal information (Hart *et al*., 2008). Elephants may be able to assess changes in environmental conditions and thus anticipate the onset of rains in locations up to 200 km away (Vilioen, 1989), keep track and predict fruiting cycles in their ranges and surrounding areas, and also keep track of the locations of members of their family group (McComb *et al*., 2001; Bates *et al*., 2008). However, there have been no studies to date that have confirmed that elephants time their movements into plantations with the onset of coffee berry ripening season. More studies need to be conducted to understand the movement patterns of elephants both into and within the coffee estates. Are they responding to the coffee season or is the coffee season merely an opportunistic food resource that as generalists, elephants have exploited as a novel food resource. The results of this study only reconfirms coffee as a possible novel food resource (See Bal *et al*., 2008), while the presence of elephant aggregations into larger groups (See Chapter 6) suggests that during the post-monsoon and coffee ripening period, coffee agro-forestry resources may be acting as an attractant on elephants' spatio-temporal movements.

7.4.2 Other available plant species or fruits for elephants foraging in coffee estates

7.4.2.1 Foraging on Albizia saman (the rain tree)

The Fabaceae and Poaceae are two plant families dispersed by elephants that overlap between African and Asian elephants (Sukumar, 2003; Campos-Arceiz *et al*., 2008a). I examined dung samples for the presence of other contents like the rain tree seeds. These tree are introduced Neotropical members of the Fabaceae and elephants are known to consume the fruits in the form of pods (Samansiri & Weerakoon, 2007; Campos-Arceiz *et al*., 2008a). The presence of rain trees in coffee estates was not uncommon. The largest aggregations that I observed during the coffee season preferred to use areas with rain trees and the elephants were observed to be feeding on the fallen fruit pods of the rain tree (Block 23, Yemmigoondi Division).

7.4.2.2 Foraging on green foliage (Fibrous content)

Asian elephants show strong seasonal changes in diet composition, with less nutritious diets that are high in indigestible fibre during the dry season (McKay, 1973; Sivaganesan & Johnsingh, 1995).

The green foliage that is most available is the flowering plant, *Erythrina subumbrans.* Management of these 'managed forests' of coffee estates are highly labour intensive and requires regular maintenance. Shortage of labour and increasing wages have led to conversion of native tree species into monoculture plantations dominated by silver oak (*Grevillea robusta*) which aim for easy management of the coffee estates without compromising shade cover. Apart from silver oak, *Erythrina* is also cultivated in the coffee estates for shade and fertiliser usage, and it also acts as food resource for elephants (Bal *et al*., 2008; personal observation). Similar to jackfruits, feeding on such green foliage was unrelated to consumption of coffee berries during coffee season. Feeding on *Erythrina* was observed during field work in most of the estates. In Gattadhulla division of Margolly coffee estate, the majority of the sighting events of elephants were during their feeding on *Eyrthrina* and *Ficus* spp. These observation were made mostly in the Arabica coffee plots which had better visibility than did those of Robusta coffee.

Coffee estates have an extensive undergrowth of fresh grass throughout the estates and especially in swamp areas near the water bodies/tanks in the estates. During the field work, I observed that the elephants spend most of their feeding time in the areas with higher grass availability. These swamp and water bodies were open areas and elephants were observed to venture into these areas mostly in the late afternoon to early morning when there was little or no human activities within the coffee estates. Being generalist feeders, elephants are known to feed on what is available, but are known consume only specific parts of a plant at a certain time (Osborn, 2004). For elephants to feed on crops, Osborn (2004) suggests that there should be a decline in the quality of wild grasses and thus there is a link between the quality of the grass and the onset of crop-raiding towards the end of the wet-season. Unlike grass, crop are known to retain high nutrient value when they mature and thus have lower fibre content and with if any, few chemical and physical defences and thus being consumed by elephants at higher rates.

About 19.8% of Kodagu's land area is under paddy rice cultivation (Deepika &Jyotishi, 2013), which is mainly concentrated in the low-lying area of Kodagu district (See Figure 2.2 in Chapter 2, Section 2.1; Bhagwat, 2002). Of which, about 8% of is considered to be treeless that is mainly used to cultivate paddy rice and these paddy fields are located in between coffee estates. As indicated in chapter 4, paddy rice season was indicated to be one of main seasonality of crop-raiding along with the seasonality of fruiting trees (Bal *et* al., 2008). Elephants may be using their olfactory signals to coincide their raiding pattern to paddy ripening seasons (Santiapillai & Read, 2010). In Rajaji National Park, few group and single adult bulls were observed to have regularly using certain human-dominated landscapes in the night and then entering the parks in the dawn (Joshi & Singh, 2007). Adult bulls are considered to engage in 'risky' activities of crop-raiding to fulfill their nutritional gap from browse to grass feeding transition during different seasons (Sukumar, 1989; Osborn, 2004). Also, it was observed that the elephants were venturing out of the forest areas to human settlements close to the park boundary to feed on paddy (*Oryza sativa*) and sugarcane (*Saccharum officinarum)* and also on home gardens near human settlement areas (Joshi & Singh, 2007).

In Kodagu, due to extensive crop-raiding, paddy rice cultivation have now been abandoned by many farmers which are now being used as grazing land for the livestock while few farmers have started converting them into coffee plantations. Similar situation was found in villages around Kibale National Park, where the lands were either abandoned or left as fallow land (Naughton-Treves &Treves, 2005). However, such drastic measures were taken only on land sizes lesser than <1.8 ha and large farmers seem to cope with the damages signifying the different land-use practices and greater flexibility in field management.

African and Asian elephants are commonly known to disperse *Ficus* genera (15 species). Although data were not collected for the extent of feeding on *Ficus* spp. by elephants (and detection of the tiny seeds in dung was very difficult), it was evident during sighting events that the diet composition of these elephants also consisted of *Ficus* spp. as documented by earlier studies. *Ficus* spp. are maintained within the coffee estates under the native tree species canopy cover. Coffee estates thus appear to have high enough resource availability for elephants to sustain their visits throughout the year. However, as there are no previous studies of how these coffee estate landscapes function for elephants, it is still not clear whether elephants are frequenting these areas for their high resource availability or whether they are merely using them as part of their traditional movements and foraging cycles. I have suggested above that the elephants using the coffee estates may be residents rather than migratory, and residential knowledge may explain the high proportion of coffee consumption. More individually based studies are needed.

7.4.2.3 Importance of coffee consumption by elephants and their role as seed dispersers

Many tree species in the tropics and sub-tropics depend on animal-dispersal (Howe and Smallwood, 1982; Fleming *et al*., 1987). The roles of elephants as seed dispersers and their impacts on the structure of the plant communities have been extensively examined (Campos-Arceiz & Blake, 2011). The animal's body size, diet composition, ranging patterns, and overall ecological niche affect the distribution and survival of seeds of many plant species (Campos-Arceiz & Blake, 2011).

It is thus important to study and understand the elephant's potential for dispersal of seeds for plant communities, especially for larger seeds, and also in terms of their effects on the spread of invasive species (Campos-Arceiz *et al*., 2008a). Elephant consumption and defecation of seeds poses a risk that cultivated crops like coffee plants will become an invasive species in tropical forests, especially with increasing disturbance to the remaining forest patches (Joshi *et al*., 2009). Elephant coffee feeding behaviour may increase the risk of coffee being dispersed far into rainforests if the elephants are moving between the estates and intact primary forests. Such risks are greater for the coffee estates adjoining the forests.

Elephants play an especially important role in the long-distance dispersing of seeds (Corlett, 1998). We have as yet only a minimal understanding of the consequences of coffee consumption on native tree species in the forest areas. Even if coffee ingestion is a recently acquired novel food tradition and only for a few individuals in a local population, the longer term availability of coffee berries within forest fragments may facilitate the spread or adaptation of these food consumption patterns within the entire elephant population in future.

Asian elephant disperse seeds over 1-6 kilometres but possibly not over as long a distance as the African forest elephants; this finding may however be due to most of the studies in Asian elephants being focused on their movements within highly fragmented landscape (Campos-Arceiz *et al*., 2008a). Irrespective of the distance of dispersal, Asian elephants are able to disperse large amounts of seeds (Campos-Arceiz *et al*., 2008a; 2008b) across different habitats. Coffee estates adjoin areas of the reserve forests and national parks in Kodagu. In Valparai, Joshi *et al*. (2009) showed that the presence of coffee growing inside the forest fragments are those same species cultivated in the adjoining coffee estates and Robusta was able to spread within both disturbed and undisturbed areas. They also proposed that there was an influence of propagule pressure from adjoining plantations, with edge effects and seed dispersal by animals affecting coffee invasiveness. Seed deposition through elephant dispersers are at larger scale and which potentially can be subjected to secondary dispersal (Magliocca *et al*., 2003).

DNA analysis on dung samples can aid in determining and identifying which individuals within the population or populations of elephants are consuming coffee (Bal *et al*., 2008; Chiyo *et al*., 2012). Furthermore, such analyses would provide a baseline understanding of home range of the individuals of the local elephant population using the coffee-agroforestry. If combined with additional opportunistic photo or video documentation, understanding demography and behavioural dynamics of the local population would be possible. This requires a long-term monitoring within the coffee estates of Kodagu, but with visual observation of elephants difficult within the estates, non-invasive genetic sampling may facilitate determination of the population demography and also provide us with necessary data to understand the nature of elephants' utilization of coffee estates.

7.5 Conclusions

The small sample size of the study stresses the need for larger sample sizes of dung piles across seasons, for DNA-analysis of dung samples to identify individuals consuming coffee berries and for a long-term monitoring system to understand and determine the damage to coffee seeds. Understanding the hostility of people towards elephants requires quantifying the actual damage to coffee production or determining whether the problems of elephant-human interactions derive from local people's attitudes and perceptions and which then affect conservation actions in general. Future research on elephant consumption of coffee berries should consider examining the benefits or disadvantages of coffee feeding on elephants' health and also on their behaviour. This may help in understanding the escalating human-elephant interaction dynamics within the study area and in developing a protocol to manage negative human-elephant interactions.

Chapter 8

PERCEPTIONS AND ATTITUDES

CHAPTER 8: PERCEPTIONS OF ELEPHANTS ON COFFEE ESTATES

8.1 Introduction

Persistent interactions between people and wildlife have resulted in varied perceptions and attitudes towards wildlife and its conservation. This interaction of people and wildlife on a daily basis is an important factor to consider if we aim to develop successful conservation management and to gain acceptance from local people (Narayana, 2009). Attitudes of local people towards wildlife vary within the community depending on the gender, ethnicity, socio-economic variables (Naughton-Treves, 1997) and prior experience with wildlife. The 'nuisance value' of wildlife on people mind is pronounced when there are crop losses or livestock depredation or threat to people's lives in subsistence agricultural societies (Lee & Priston, 2005).

In Asian countries, elephants are regarded as a valuable economic and cultural asset by some people, whereas farmers perceive them as agricultural pests (Bandara & Tisdell, 2002). Such opposing views are common in most Asian countries; Bandara & Tisdell (2002) suggest that the attributed nature of any given wild animal as a pest or as a resource depends on individual perspective, on economic opportunities, and on the regulatory environment in which the species exist. Since the wildlife species interests compete with human interests, they are defined as "pests" (Lee, 2010)

The status of wildlife as pests is also dependent on the degree of visibility and geographical concentration or dispersion of crop damage caused by animals. The classification of wildlife as pests or assets also differs between the conservationists and farmers with the former considering elephants as valuable assets and the latter as "pests". Hill (1998) suggested that the assessment of people's attitudes, especially towards large, potentially dangerous animals, is an important element in formulating appropriate policies for the conservation of wildlife. Attitudes may vary as each group in the community might differ in relation to traditions to wildlife, in levels of tolerance and avoidance, hierarchal power structures and gendered exclusions (Lee, in press). There has been very little work carried out in relation to the socio-economics of 'agricultural pests' and the significance of the loss of both subsistence and cash crops in relation to the economic losses or the changing perceptions or attitudes of people (Lee & Priston, 2005).

People's willingness to tolerate wildlife is influenced by cultural factors as well as recent experiences with them (Riley, 2006; Kuriyan, 2002; Kalternborn *et al.*, 2006). As discussed in Chapter 1, cultural associations between Asian elephants and people have been known to exist from historic times. The presence of elephants, both wild and captive, is mentioned in ancient scripts and the art and sculptures in temples represent pictorial evidence of this long association. Sociocultural and religious traditions in Sri Lanka placed elephants at the highest level of respect and reverence (Seneviratne & Rossel, 2008). Conservation of elephants in India has thus been mostly based on this cultural ethos to encourage people to co-exist with elephants.

A crucial point in the conservation of Asian elephants is the strong tradition of elephant worship among the people of Asian countries. While this was true in earlier days, increased levels of negative or hostile human-elephant interaction has posed a severe problem in the conservation of elephants in many Asian countries. Attitudes and perceptions of wildlife saw changes with the advent of colonialism, especially in people-wildlife interactions or inter-dependence (Lee & Priston, 2005; Seneviratne & Rossel, 2008). In India, with people's lives still involved in religious and cultural beliefs we can hope to revive the values of animals as an aid for conservation. Elephants in India and most of its Asian range countries are still a strong and an important part of the cultural identity and heritage. In India, elephants recently were given the status of the 'national heritage' of the country. A study in Kenya (Kuriyan, 2002) on the Samburu pastoralists suggested integration of culture along with economic incentives as effective in promoting positive attitudes towards wildlife. Apart from religious perception, studies have suggested that local resistance and protests over resource constraints imposed by protectionist conservation strategies, regional land-tenure systems and their administrative representatives has amplified hostility due to crop-loss from large mammals (Gillingham, 1998; Gillingham & Lee, 2003).

The resolution of hostile human-elephant encounters is an economic and social issue with ethical dimensions (Sukumar, 2003). One of the important factors in shaping the social dimension is the difference between the perceived and the actual loss of crops to wildlife depredation and individual experiences of these losses (e.g. Priston, 2005; Inskip & Zimmermann, 2009). Perceptions and behaviour of people towards wildlife are affected by the available economic incentives. Socio-economic factors influencing a farmer's attitudes depend on land availability, success of the growing season, economic dependence on rural activities and so forth. Lee and Priston (2005) suggested that even a little crop-damage, can have a significant impact on people' perception when considering the market economy. The economic loss or per capita damage is higher when tree crops like arecanut and coconut are destroyed as loss is not just for that year but for following years until the tree is replaced (Sukumar, 1989). In India, assessments of monetary loss and the effectiveness of compensation schemes have been very few (Madhusudan, 2003).

Non-users' assessment of wildlife value depends on socio-economic characteristics of the respondents (Bandara & Tisdell, 2002). Rural people have more influence on the survival of wildlife (Hoare, 2001). Bandara and Tisdell (2002) found a marked difference where the urban dwellers were positive towards elephant conservation. Rural respondents showed a mixture of positive and negative attitudes towards the conservation of elephants though their responses about conservation of wildlife in general were positive. Such responses may be due to the close proximity of the farmers to nature with all its unpredictability and their direct contact with wildlife "pests". Negative attitudes to elephant conservation were attributed mostly due to land scarcity and inadequate compensation money but this did not imply that they were completely opposed to elephant conservation. It is important to understand that the future of any wildlife depends on all stakeholders; those at the interaction interface, those promoting species conservation, and the elephants themselves who are partners in the ecosystem.

Some of the other major negative social impacts of interaction with threatened species such as elephants are missed school or work, additional labour costs, loss of sleep, fear, restriction of travel or loss of pets (Hoare, 1999a). These are important as elements of daily life for people and if restricted from normal activities it is obvious that people will develop negative attitudes towards the source of that restriction; in this case elephants. One recent study found that elephants were "blamed" as the source of poor school results when parents were unable to find funds to pay school fees (Sitati *et al.*, 2012). While crop damage, property damages, livestock, injuries and fatalities are considered as visible impacts of human-wildlife interactions, there are few studies that suggests hidden impacts of human-wildlife interactions on people's mental-health and well-being (Chowdhury & Jadhav, S., 2012; Jadhav & Barua, 2012; Barua *et al*., 2013). The hidden impacts are considered to be 'secondary' or 'indirect' consequences of human-wildlife interactions that are uncompensated, temporally delayed, psychological or social in nature (Ogra, 2008; Barua *et al*., 2013)

Hoare & Du Toit (1998) propose a hypothesis for the interface of elephant and human interactions stating that "the elephant distribution is inverse to the human distribution and that elephant abundance is dependent upon human abundance, based on relative densities at a national or sub continental scale". They proposed that a crucial point in developing conservation planning in unprotected areas is the identification of the human density level that represents the threshold of human-elephant coexistence. However, it is not just the densities of people and elephants that negative or hostile interaction is based on, it also depends on the spatial (the distribution of elephants and people) and temporal (seasonal) factors (Barnes *et al*., 1995; Hoare, 1999b; Hoare and Du Toit, 1999; Smith & Kasiki, 1999). When wildlife causes serious damage to people's livelihoods and their lives, sometimes people resort to killing them, termed as lethal control (Woodroffe *et al*., 2005). Once wildlife is perceived as 'problem animals', they may be killed legally or illegally through various methods by private individuals, organized communities, bounty hunters and local, state and national governments. This killing when taken into local hands poses problems of a different sort-leading to confrontations with enforcement agencies, with conservation organizations and potential "demonization" of locals.

For the survey on attitudes and perception of people in Kodagu, the people are classified as wealthy (>30 acres), medium (5-30 acres) or small/subsistence farmers (<5 acres) depending on the total area of land they possess (See Chapter 3, Section 3.7). For instance, a farmer with more than 30 acres potentially would be less affected by crop raiding than would the farmer with 5-7 acres. The amount of crop loss both total and relative to the remaining area needs to be taken into consideration rather just the frequency of crop raids. For instance, if there is a successful raid by elephants in a paddy field, the crop yield for the year is lost for the farmer. The impact would be greater if the farmer is from low-economic background. In addition, the farmer and the family invest in guarding and patrolling the crops from elephants and other agricultural pests, sometimes with the possible risk to their lives. The unique and complex land tenure system of Kodagu thus has a major feedback on the socio-economic factors. It is necessary to understand how these land tenure systems divide farmers into different categories and what rules and regulations this imposes on them. With all these laws and regulations, the political issue of crop damage is integrated into the socio-economic factors.

As mentioned earlier (See Chapter 7, Section 4.2.1) paddy cultivation has been abandoned by many farmers, especially land sizes with less than 1.8 ha. Large farmers seem to be able to cope with crop losses, and possibly elephant presence was less threatening in a larger area, signifying different land-use practices and greater flexibility in field management. Large farmers suggest financially strong and powerful people able to influence socio-political issues. So, it would expect that large farmers would resent elephants more and demand more compensation from government.

Intensity of interaction also has a major impact in shaping the attitudes of people. Human-elephant hostile interaction is spread throughout the region, but hotspots with high intensities (by frequency and extent of crop loss) have been identified (Nath &

Sukumar, 1998; Kulkarni *et al.*, 2007). There are also regions where there is almost low or no interaction. So does the presence or absence of such interactions have any impact on the attitudes of people? The answer to this question is important as it shows the extent of social influences on the attitudes of the people. In Kodagu, the responses to Human-elephant hostile interaction vary widely (Kulkarni *et al.*, 2007). There seems to be a certain level of discontent among all classes over such interactions. However, this discontent is not necessarily expressed unless people are asked to discuss their perceptions of elephants (Nayarana, 2009). There are also local newspapers which provide information on the location of elephants and their activities and alert the farmer to be vigilant. Media plays a significant role in influencing people's opinions, perceptions and attitudes towards the issues portrayed, and this also holds true for human-wildlife "conflict" detailing the risks posed by the presence of wildlife around people (Gore *et al.*, 2005; Gore & Knuth, 2009; McQuail, 2010). Public dissemination of wildlife related issues is mostly carried out by the mass media (Bhatia *et al.*, 2013). People's perceptions of risks are considerably influenced by media reports and can lead to overestimation of danger, social amplification of risk and possible development of stigma (McComas, 2006). For instance, negative headlines crop-raiding or human injury by elephants might lead to development of negative perceptions by people.

Nath and Sukumar (1998) showed that the link between religious perceptions and protecting elephants in India was relatively low (16%). It is interesting to question the extent of cultural effects on people's attitudes. Has there been a change in people's values and attitudes towards life? If so, why? Has the economics begun to overshadow the cultural symbolism in this age of markets? How and when can these cultural beliefs be used in conservation to integrate with other lifestyle and educational factors to foster positive attitudes towards wildlife?

8.1.1 Factors affecting attitudes among farmers in Kodagu

Imposing certain regulations on people's lives may increase the resentment towards elephants. Coffee estates are deserted after the working hours from about 6 pm in the evening until the next morning 7.00 am. During my fieldwork, I noticed that elephants would take shelter at areas within the coffee estates where there are no or very few people and stay there until about 3 or 4 pm in the evening. The people working in the large estates can only engage in personal activities during the early morning before work or in the late evening after work. This includes collecting firewood, visiting town for grocery shopping, going to meet people and for men and also few women to consume alcohol. Transportation facilities are limited during the evening hours and this requires people to walk to town and few use their private motorcycles. But the presence of elephants effectively imposes a 'curfew' on people with regards to travelling or even to stroll around their houses or colonies. Even during daytime, children find it difficult to travel to and from to school if they miss the available transportation. Transportation facilities in terms of private jeeps are available where people pay between 5 to 10 Rupees as cost.

Every estate has "colonies" of houses scattered across the individual estate area. Larger estates require large number of workers to help in various activities from pruning to picking coffee, thus large number of colonies to accommodate the workers. Presence of elephants within coffee estates is unavoidable given current patterns of elephant habitat use. It is important to make people living within these estates to understand that for better co-existence and to avoid injuries and death of both elephants and people, certain restrictions have to be in place and have to be followed. Such impositions are not welcomed by the people as they feel that their freedom to live their life has been infringed upon especially by elephants. The fear of elephants causing disruption in daily livelihood and threat to lives has resulted in great animosity and resentment towards wildlife, especially towards charismatic species like elephants.

8.2 Methods

8.2.1 Pilot Study

In this chapter, I qualitatively explore the attitudes towards elephants and conservation that were expressed to me during interviews in 2009 with a mixed set of land-owners (n = 135). The attitudes here reflect responses to a variety of questions (See Chapter 3 and Appendix 11), and may not represent underlying realities for these people, but rather their specific responses to me while I was asking those questions. Interviews were conducted in all three *taluks* of Kodagu, i.e. Madikeri, Virajpet and Somwarpet. Each *taluk* was divided into three zones of high, medium and low events of elephant crop damages reported to Forest Department, based on the criterion for categorising data used in previous studies (Nath & Sukumar, 1998; Kulkarni *et al*., 2007; Bal *et al*., 2008; See Chapter 4). The main assumption was that farmers with more substantial land holdings are economically more stable and better able to withstand crop-raiding damage, so famers were categorised as large landholding farmers (> 30 acres); medium landholding farmers (5 to 30 acres) and subsistence/small landholding farmers (5 acres). The sample size for each group was 15 respondents in each zone making a total of 45 interviews for each zone and a total of 135 interviews (See Chapter 3). Thus, there was an equal distribution across farm sizes but biased towards male farmers due to lack of willingness on the part of women to respond (See Chapter 3). Questionnaires were evenly distributed across levels of interaction intensity and by farm size (15 in each category of high, medium and low intensity; See Chapter 3, Section 3.7). Thus sample sizes are small and the results presented here are intended to be qualitative and descriptive.

As I used snowballing sampling method to choose respondents across the shortlisted villages, permission for an interview and oral consent was taken only after approaching the respondents. I also asked for their permission to record the interview through the record player and they can refuse if they do not want it be on record. I informed them that they can refuse to answer any questions and have the right to stop the interview at any given point.

Interviews were conducted using questionnaires, in English and Kannada[85] and in Kodava with the help of a translator wherever[86] required. Interviews lasted from 15 minutes[87] to two hours, depending on their eagerness to share and discuss information. A few interviews were followed up with an estate visit along with the respondent farmer who showed recent damage caused by elephants and frequent paths of entry and/or exit into their estates by elephants. Questionnaires and interview methods were approved by the Psychology Ethics Committee, University of Stirling.

8.2.2. Semi-structured interviews

In addition to pilot study, I carried out semi-structured interviews with estate managers, estate workers, guards, and other local people in the community. These were recorded only as notes since people were more reluctant to speak out when they knew that they were being recorded (personal observations pilot study and current study). These

---

[85] Language spoken predominantly in the Karnataka state.

[86] Translator: Local acquaintance from the study area; only during the preliminary study between May and June 2009.

[87] Interviews lasting 15 to 20 minutes were those respondents who were not interested in further discussion of the issue, either because they had not been affected by elephant damage or those for whom co-existing with the elephants was part of their daily routine, especially those in close proximity to the forest areas.

informal discussions were carried out whenever there was an opportunity to establish a conversation with the local people. I have included these notes in the discussions to further establish the results from the pilot study.

Data were aggregated by response type into frequencies for comparison. Chisquare tests were used to compare categorical responses. ANOVA tests were used for multiple comparisons.

8.3 Analysis and Results

8.3.1 Perceptions of risk and elephants

Interaction intensity was coded as high, medium and low for the area based on reported crop-raising events (See Chapter 4). Each farm was coded for intensity within its specific area. Most respondents expressed some "fear" of elephants (72.6%); their fear was both in relation to threats to their lives and to crop losses (responding "both" threats, 60% of the total responses for fearing elephants). This overall high level of perceived threat was related to intensity of interaction (X^2 = 1.061, df = 2, $p < 0.05$, N=135, Cramer's V = 0.06), with farmers of all sized farms who had low intensity of interactions having fewer responses of "fear" (Figure 8.1).

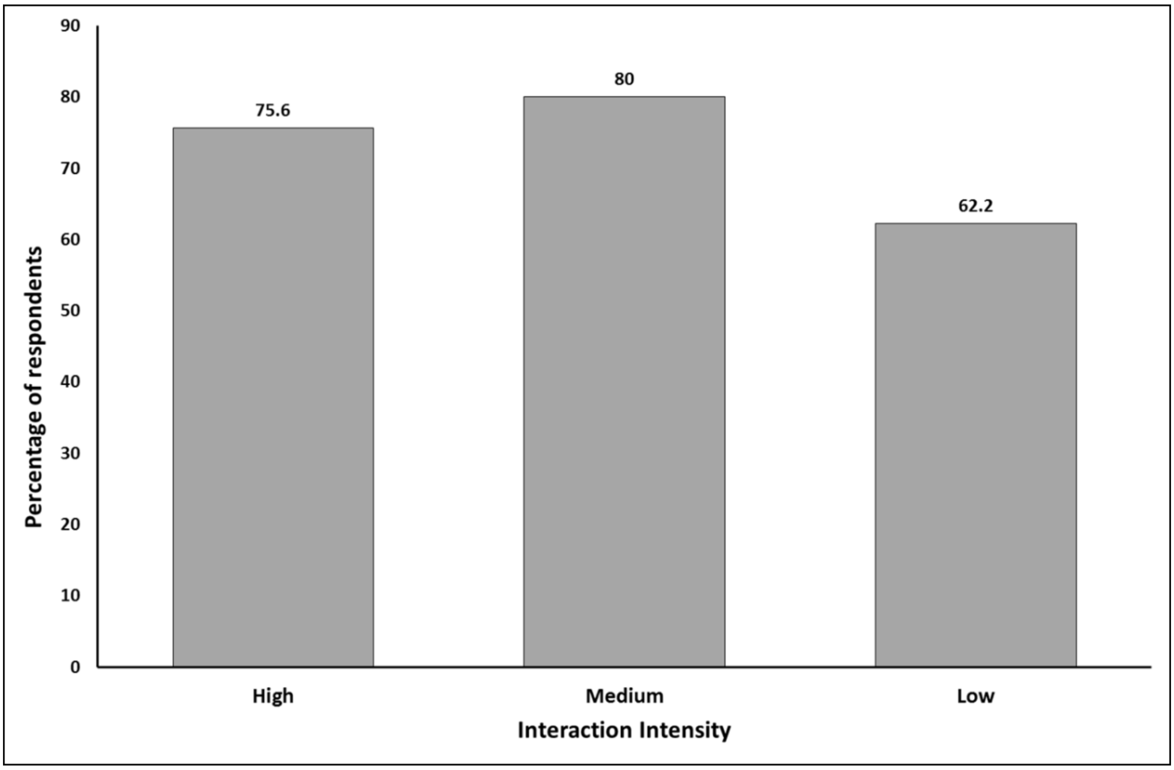
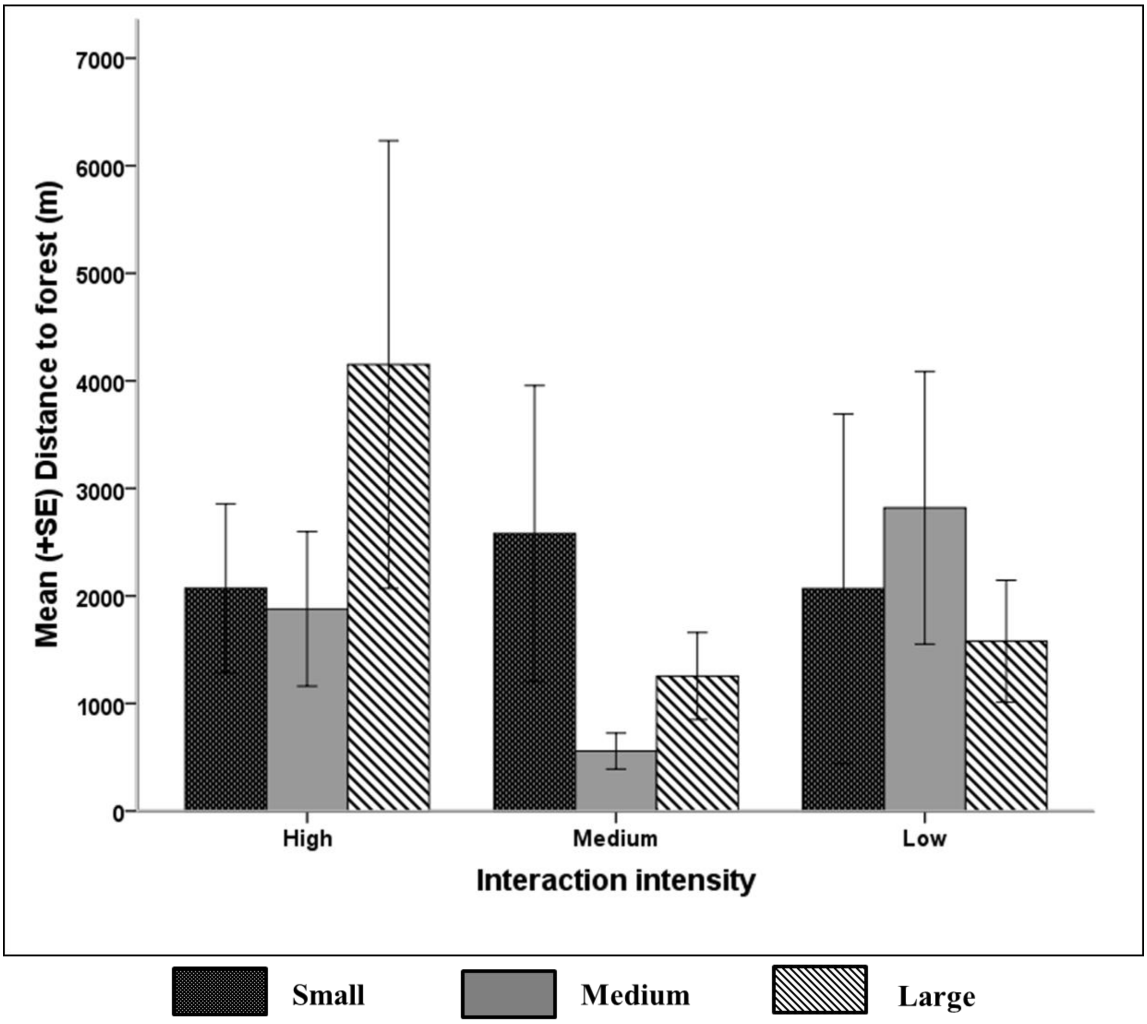


Figure 8.1 Percentage of respondents expressing high fear of elephants (loss of life and crop loss) by intensity of interactions (N=45, for each intensity of interactions).

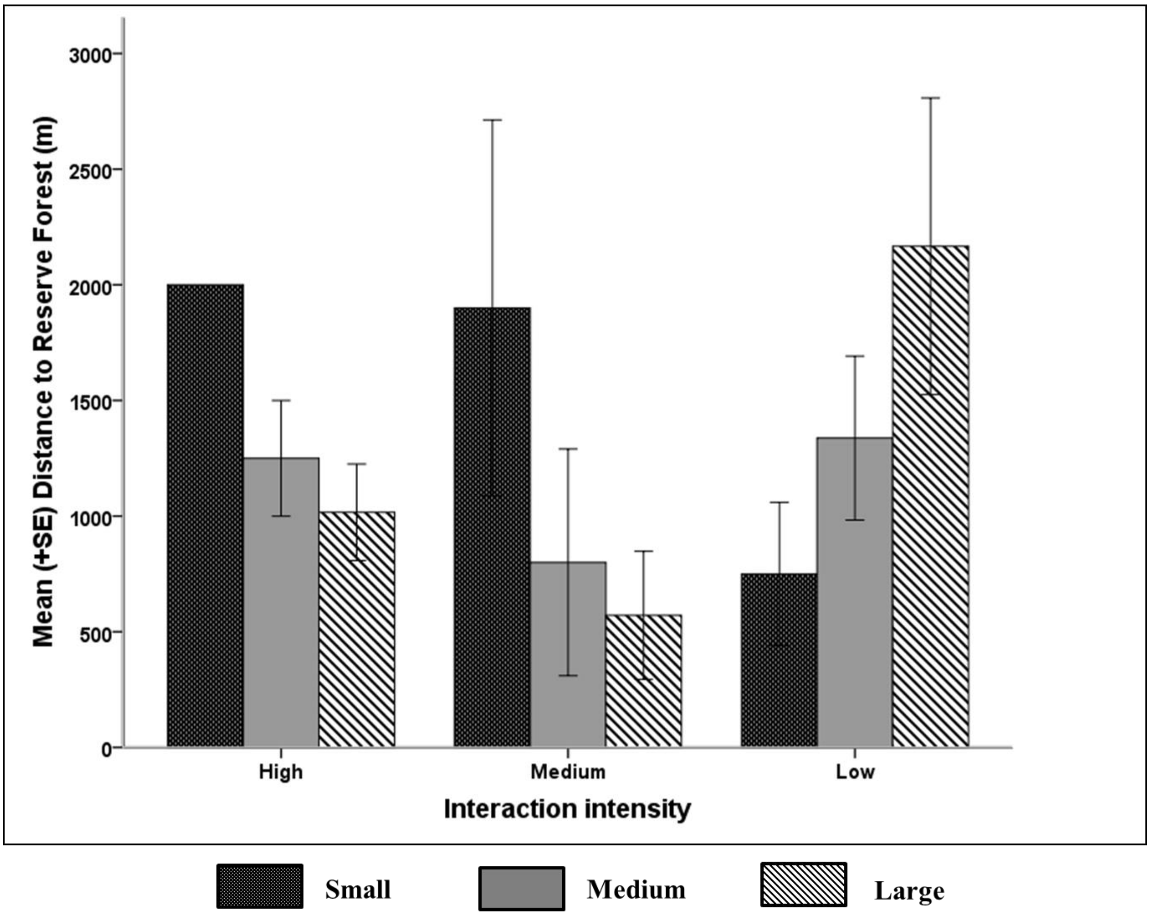
In the responses to questionnaires, however, there was no significant association between interaction intensity, farm size, and responses that "elephants had a right to life" ($X^2 = 0.5$, df = 4, NS). Most respondents (69.6%, N= 135) stated that elephants did have a right to life. Overall, there was a highly significant proportion of respondents who also thought that elephants should be protected (86.6%, $X^2 = 28.9$, df = 4, N= 135, $p < 0.01$, Cramer's V = 0.33). These patterns were the same irrespective of interaction intensity and farm size. Only three respondents actually replied that elephants should not be protected, while the other 15 respondents were undecided. Only seven respondents mentioned religious reasons for protection of elephants.

8.3.2 Factors associated with intensity of interactions

In this study, distance to forest did not influence the intensity of interaction; closer proximity to the forest was not associated with higher intensity of interaction (F_2 = 0.81, 108, NS; Figure 8.2a). However, the close proximity of a Reserve Forest and farm size interacted with interaction intensity ($F_{4,46}$ = 2.67, p = 0.047; Figure 8.2b).



(a)



(b)

Figure 8.2 Mean ±SE distance to Forest (a) and Reserve Forest (b) by interaction intensity and farm size (N=45, for each intensity of interactions).

However, there were no differences between large and small farmers in their willingness to “let elephants live” (X^2 = 11.43, df = 8, N=135, NS), while farmers of all sizes and interaction intensity expressed the perception that their tolerance of elephants had decreased over the last 10 years (82.6%). Large farmers did appear to be slightly more tolerant at high interaction intensity than did the small and medium sized farmers with high interaction intensities (Figure 8.3).

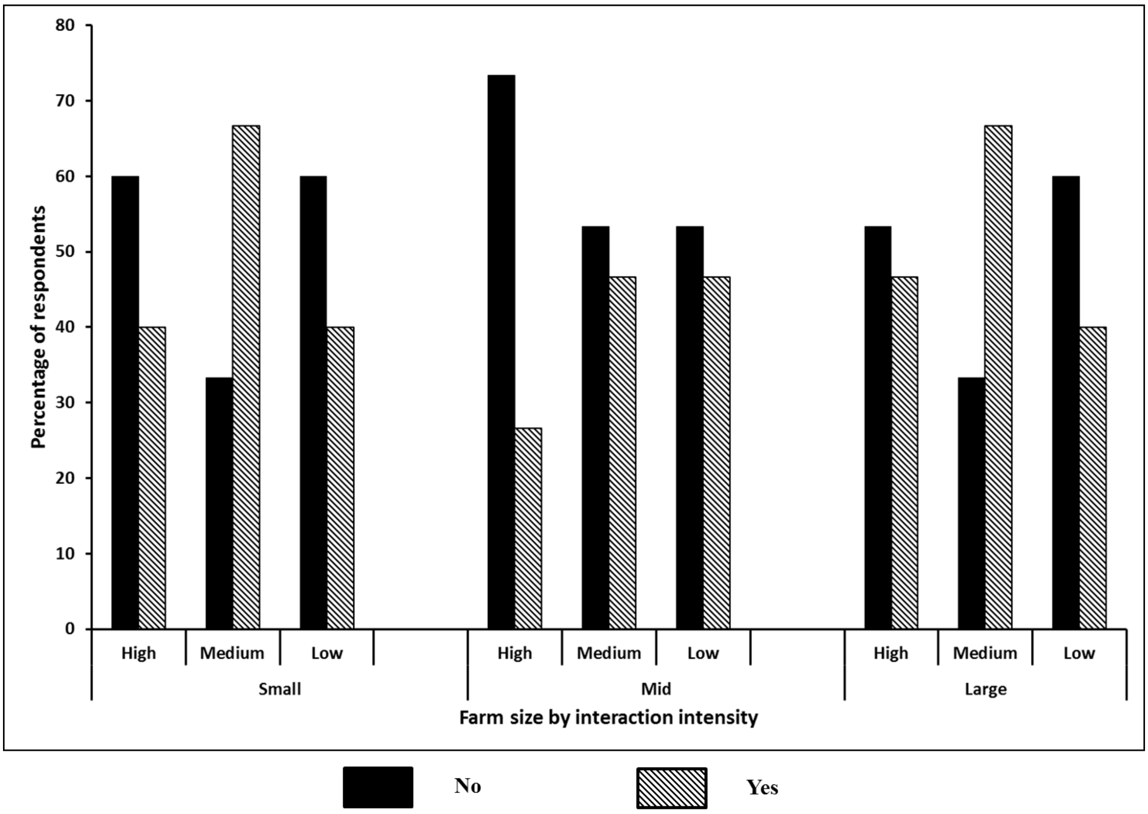


Figure 8.3 Responses to the question "Are there too many elephants" by interaction intensity and farm size (N=45, for each intensity of interactions).

Damage by elephants could be perceived to be "catastrophic" even when raids were rare and highly localized. Also, it is typical that the frequency and the extent of damage as expressed during interviews varies significantly within and between villages, between crop species and between years. Elephants were ranked as the top species for crop damage by 54.4% of 125 respondents to the question. Wild pigs (31.2%), monkeys (12.8%) and deer (1.6%) were all ranked among the "top" pest. Pigs were the most consistent second ranked pest (65 out of 99 total responses), while monkeys were the most consistent third ranked pest (19 out of 55 total responses). Given that pigs tend to cause greater loss than monkeys or deer (Priston, 2005; Webber, 2006; Gillingham & Lee, 2003), the level of actual as opposed to perceived damage caused by elephants remains unknown. When the respondents were asked 'are there too many elephants' with regards to increase in elephant population in Kodagu, farmers in high and low intensity interaction areas felt that the elephant population has not increased (62.2% and 57.8% respectively), whereas farmers with medium level of intensity of interaction felt that there seemed to be increase in elephant population in the area (See Chapter 8, Section 4.2). Farmers' knowledge on elephant activity patterns suggested that the elephants moved mostly during the night (89.6%) in the estates when the human activity is relatively low. Frequency of elephants visits to these estates was considered to be high (58.5%), with the concern that these high visits began only recently. Respondents expressed the view that there seem to be no pattern of visits and both solitary and family herds (65.2%) frequent theses estates regularly.

8.3.3 Opinions on current mitigation management strategies

The actions and activities of the Forest Department in relation to measures to manage elephant movements into farms (solar fences, trenching, driving elephants away) was in general viewed as ineffectual by these respondents (68%) with only a small proportion replying that the actions were effective (5.9%). Respondents (80%) stated that for effective implementation using trenches and/or fences, regular maintenance of these set-ups have to be undertaken. Most of the farmers stated that the first action that they do when they sight elephants is to chase them out of their estates into either neighbouring (63% approximately) estates or nearby forests. Of the 88 respondents who expressed an opinion about the level of compensation for crop damage, 84 were dissatisfied with the level, regardless of the level of intensity of interaction and the economic status of farmers (X^2 = 14.248, df = 2, $p < 0.01$, N=135, Cramer's V = 0.402).Of the total 135 respondents, 68 respondents had claimed compensation for elephant damage.

No respondents suggested culling and most respondents were unsure of whether translocation would be effective (N=102); only 32 were willing to agree with this suggestion as a strategy to manage elephants. And only eight respondents were aware of the conservation and research based activities that were occurring across the landscapes suggesting that dissemination and communication between conservation scientists and local people need to be addressed for successful implementation of mitigation management strategies. Most respondents (84.4%) showed interest in working with the forest department and local community centres to maintain the fences, suggesting that if appropriate designing, distribution, co-operation between stake holders was established, negative human-elephant interactions could be reduced and encourage community spirit in wildlife conservation.

8.4 Discussion

The human dimension is the key for successful human-wildlife co-existence across the globe. People's well-being, especially those who share their lives in close proximity with the wildlife, encourages building a positive conservation attitude towards wildlife. People constantly feel threatened by wildlife in terms of both crop damage and personal safety (See example, Hill, 1998, 1999; Hoare, 2000; Lee & Priston, 2005).

8.4.1 'Fear' - affecting attitudes and perceptions

Fear of losing their crops and life have greater influence than the actual damage. Losing their annual income in terms of crop loss may result in further hardships socio-economically, especially for small subsistence farmers whose livelihoods are dependent on that one crop yield. In my pilot study interviewing the farmers for my Master's thesis in 2009, expressed similar attitudes. Farmers expressed their concerns over the fear of loss of life as their main concern; however loss of crop contributed equally to fostering negative attitudes or perceptions of elephants. Some of them expressed their understanding of why elephants feed on agricultural crops which most of subsistence farmers and their family depend on for their survival. In large corporate estates where my study sites were based, more than the actual damage to crops (i.e. coffee berries), managers raised concerns of the safety of the workers, their families and themselves. Even though, large corporate estates are under constant pressure to perform better every year, the economic effect of loss of crops is minimal by comparison to that experienced by the independent small subsistence farmers.

Coffee estates in Kodagu are owned by farmers from different socio-economic backgrounds. Some of the smaller estates are located between two or more large coffee estates. Large coffee estates, as discussed earlier (See Chapter 6), seem to be used by elephants as refuge areas and smaller coffee estates only for movement. When elephants use these landscapes, the coffee plants or berry damage have different consequences for different farmers. However, people's safety is a common concern for everyone. For the effective designing and implementation of management strategies, it is important to make people feel more secure and also to provide compensation for crop damage as economic incentives for positive co-existence with elephants and wildlife in general.

In Kodagu, houses are scattered sparsely across the landscape except in the centre of each town. Accessibility to basic requirements like shops, town, hospitals, schools, etc., are limited and thus most people travel by foot, especially during night. Local people tend to take short routes through coffee estate roads. This places them at risk of encounters with elephants especially in isolated areas. Most of the government schools are located between coffee estates where public transport does not reach. Students have to take the coffee estate roads to travel to and fro from school during the risky hours of morning and evening when the elephants are known to move more during these hours. This constant fear due to living amidst the elephants promotes negative perceptions. Local communities, estate owners, forest department and government could work together to provide better facilities like for transportation ensuring people's safety, and thus improve perceptions and attitudes.

Although most of the respondents felt that the elephants need to be protected, they also stated that elephants don't have the right to live. Such opinions indicate that retaliatory killing of elephants can become a threat to local elephant population if there is of continued increase in negative people and elephant interactions. Some of the respondents, during both study periods, suggested that the license to shoot wild animals destroying crops be reinstated. Although, they do not support hunting (See Chapter 8, Section 4.), a need for lethal weapons was gaining popularity.

A few estate managers stated that in order to restore people's confidence, they offered prayers to local deities (personal communication) to keep elephants away from their respective estates and prevent any fatalities. Such ceremonies clearly are for psychological support for the workers and are undertaken by management to display their support and understanding of the workers' conditions in the field and in the hope that workers would not migrate to new places in search of better safety and jobs. During interactions and discussions with the estate workers and guards on everyday basis, I was made more aware of their concerns for personal safety and that of their families. People have expressed their frustrations of dealing with the dangers in working on estates and their thoughts about moving into cities with their family for better security and lifestyle.

8.4.2 Hunting and other control measures

Kodagu is an excellent example for a multi-use zone landscape. This small district is surrounded with forests on all three sides and there are also many small fragmented and pocketed forests within the district itself. The cultivated agricultural lands break the continuity of the forests. Although there has been extensive use of agricultural lands, the tree cover has remained much the same. But, this does not mean that the human activity is less in those areas with canopy cover. The high interaction interface between the people and elephants may result in either provoked or unprovoked attacks. Previously, problem animals were controlled through lethal control as a form of compensation. The traditional Kodavas were known to be hunters and warriors (See Chapter 2). Because of the type of landscape and the spaces between each household, people used weapons as protection from unforeseen interactions with both people and animals. They had the rights to hunt. Although hunting rights have been taken abolished, even today each household is allowed to have a licensed gun and machete for safety. There are currently petitions filed to reinstate the hunting rights, so that people would be able to protect their crops and in case of threat to human life, the right to kill the wild animals like elephants, primates, wild pigs, etc.

Conover (2002) suggests that hunting may increase tolerance towards wildlife and thus reducing retribution killing or other lethal methods of dealing with problem animal. The same attitude was voiced by many residents of Kodagu during my fieldwork; they wanted to have the license to “shoot and kill” animals especially to prevent any life threatening encounters and to “scare” them from their private land. They expressed the opinion that in earlier days when hunting was allowed, wild animals venturing estates was much less frequent as people felt that these animals were scared of them.

However in this sample of farmers responding to my questionnaire, only four individuals thought that the hunting of elephants should be allowed. A total of 44 were unwilling to express an opinion, but the majority was opposed to hunting of elephants. Gunshots in air are still used in coffee estates as a noise deterrent to drive elephants out of the estate, especially by Forest Department officials and estate guards (See Section 4.3; also Chapter 3 Section 3.7) and farmers who own guns (with license). This is only short-term effective deterrent as elephants usually come back to the original location when there is very little or no activities of people (personal observation and communication with local people). During this study, discussions with estate workers suggested that they feel safer with the presence of estate guards with a gun when elephants are around. They felt that they do not have to be on high alert all the time, as there is someone who is looking out for them. When there are more than 10 to 15 elephants within the vicinity of the working area, two more estate guards are put on duty for the safety of the workers.

With centralized laws, people think that the forest and anything associated with it including the wild animals are the responsibility of the State or the Government (the Forest Department). People thus expect that the State is responsible to keep 'their' animals inside the boundaries of the protected areas and the main duties of the Forest guards are to keep the wild animals away from the people's settlements and land. With this attitude, even though people are largely aware of the financial and logistical constraints of the Forest Department in dealing with "conflict" incidences, they still expect the Government to take action. It is important to note here that people should be made aware of Forest Department's primary functions, and to recognize that an adaptive management system with many different stakeholders including elephants, especially in conjunction with the local communities, is more efficient than is just one stakeholder such as the Forest Department.

The Forest Department was responsible for three main deterrents: erecting and maintaining solar fences, digging trenches around the forest boundaries, and occasionally driving elephants away from fields or out of farms. Maintenance of these deterrents is important for their successful implementation and to reduce negative elephant-people interactions. Frequent breaking of fences by elephants and also by people for accessibility especially for livestock grazing makes it difficult to maintain functioning fences due to financial and logistic constraints of the Forest Department. However, interviewees in the pilot study and also discussions during this study suggested that people are willing to co-operate if they are convinced that Forest Department is undertaking sufficient action to reduce negative interfaces of elephants and people. Compensation payment (See Chapter 4), which is provided by State Forest Department to provide immediate relief to people who are affected by wildlife damage, has yet to be successful as effective mitigation method. Compensation payments are mostly paid for the crop-damage, property loss or for medical expenses for people injured or to the family of the person who had fatal encounter with the wild animals. Despite a rise in compensation over time, this has not reduced a negative perception of either the forest managers or the elephants. Compenstaion may be more effective for small and medium subsistence farmers if the tedious process and delay of application was reduced. However, in large coffee estates, most of the estate workers are dependent on the daily wage work and loss crop to the large estate owners economically are far less compared to the small or medium estate owners. Fear of life on the part of estate workers is their key concern and compensation payment has little role to play in minimising such impacts of elephant-people interaction. Inability of forest officials to take immediate action in driving the elephants out of the estate prompts negative attitudes towards Forest Department officials. Presence of elephants in an estate causes increased fear among people and possibly increased crop-loss that would impact on the annual production for that estate and potentially wages for workers

Removal of “problem” individuals is one method that may possibly reduce hostility but which is often affected through implementing lethal controls. This option was almost never expressed during my interviews. Simple removal by translocation of problem elephants to different elephant habitat has been suggested and is currently being attempted (Sukumar *et al*., 2012; Chandra, 2014). However, discussions with the local farmers and estate workers indicated that they were aware of the shortcomings of translocation method as there is a possibility of elephants returning to their original home range or new elephants occupying the now vacant available range. However, they stated that they favour capture and training of elephants. Recently, 22 elephants were captured in the Hassan district (and North Kodagu) in Karnataka State and were trained at different camps across the State. This method seemed to gain interest of local communities across Kodagu district, and few people expressed the view that similar methods should be implemented across the district. As the capture of 22 elephants was a region-specific decision to prevent further escalation of negative human-elephant interactions, some of the farmers felt that the ‘rogue’ elephants should be identified, captured and trained, and not translocate to a new area. It is important to create awareness among local communities about elephant ecology in relation to region-specific problems and to involve the local communities in developing and implementing management methods to prevent further negative interactions between people and elephants and to encourage better co-existence.

People were not aware of the conservation activities or studies that were being carried out in Kodagu district. They were only aware of research information that came from the immediate the vicinity of the person’s village or town or occasionally by word of mouth. Dissemination of the results of scientific studies, along with the involvement of local community is important for creating awareness and to present people with factual information. If multi-stakeholder management approach is to be successful all the actors need to be well-informed about the local conservation and activities.

Media can play an important role in informing people about the location of elephants in the region. Daily papers like Shakthi (Kodagu local newspaper) are known to report the different events of human-wildlife interactions across the region. Reports on the whereabouts or last location of animals, especially elephants, can be made every day so that people have a fair knowledge about the movement of elephants. Along with such reports, it is important for the local newspapers to publish thematic articles so that people understand wildlife issues which may encourage better understanding and positive attitudes towards wildlife. English language newspapers are known to carry more thematic articles than do regional newspapers (Bhatia *et al*., 2013). We know now that people living in close proximity to forests are the most affected by wildlife damage and thus local media’s role in raising awareness of human-wildlife interactions could help in developing positive attitudes towards wildlife and possibly better co-existence. Also, it is key for the conservation professionals and managers to develop communication strategies that are susceptible to societal and linguistic nature of the media outlets themselves (Bhatia *et al*., 2013). Dissemination of research studies can also be made available through local newspapers which ensure distribution of information.

8.4.3 Estate Guards

Each estate division employs guards to prevent coffee theft and cheating by both estate and non-estate workers. However, some estate divisions have only one guard for the entire division, which can be a very large area to patrol. The guards are usually retired army personnel or those who were working as security guards outside of Kodagu and returned to jobs back in their region. In recent years there has been shortage of guards taking up the jobs and some quit within the first few months. Elephant encounters may lie at the root of these job losses. Responsibilities of estate guards involve going on rounds early mornings before work and evening after work is over to check for thefts within the estates. This is a compulsory routine every day of the year especially carried out more rigorously during the coffee-picking season to prevent thefts. The rounds are usually early mornings (5.30 to 6.00 am) before work and late evenings (6.00 pm) after work.

During these rounds, another important responsibility of guards is to look for the presence of elephants within the estates. People's presence at these hours is relatively low or null, thus elephants are known to move through and use coffee estates during the dusk and dawn hours. This represents a high risk for any person who is walking these areas. Guards patrol in order to notify the estate managers so that they can take decisions on elephant-safe working patterns within the estate

If the day's work is scheduled to occur in the same area as that of an elephant(s) taking refuge, then often the working area will be shifted to a different area of the estate. But during coffee–picking seasons, the work has to occur throughout the estate and thus sometimes a decision to drive the elephants out of the estate (into the neighboring estate; See Section 8.4.2) is made, potentially resulting in the elephants not returning.

But, as the coffee-picking season occurs at the same time throughout the district, chances are that elephants are either chased back into the original estate or onto the next neighboring estate. Such actions may lead to distress and frustrated behavior on the part of the elephants, especially females with calves and males during musth, which in turn may lead to highly aggressive behavior towards people. Sometimes, while chasing the elephants from one place to another, accidents may occur leading to human injuries or fatalities when an unsuspecting passerby encounters these frightened elephants. At other times, elephants have been known to counter-attack those who are driving away which may also lead to unwanted consequences. The estate guards have expressed their concerns about the risks they have to face during the work. . Detection alarm systems such as mobile phone alerts or 'electronic fences' (See example Graham & Ocheing, 2008) can become a very useful tool for the estate guards to be able to determine more accurately elephant presence and may reduce the risk of unexpected encounters with elephants while they are moving across the estate. Guards believe that if estate workers follow certain routines and rules and avoid circumstances that cause encounters with the elephants, these actions will definitely reduce the negative interactions at the elephant-human interface.

8.5 Conclusions

Elephants were perceived of as a major crop pest and most of the respondents to my questionnaire were fearful of elephants either for threats to their lives and livelihoods or for crop losses, or both. It should be noted that in common with many other studies, wild pigs were highly rated as actual pests.

However, despite these perceived and stated threats, these respondents remained relatively positive when asked about elephants' rights to life and whether they should be culled.

Very few factors explained the intensity of negative interactions in this area; only the presence and closer proximity of Reserve Forests to mid to large sized farms were associated with high intensity of interactions. This lack of distinction may be due to the generalized forest cover available in patches throughout the region. Using GIS mapping of forest cover in relation to elephant occupancy and interaction intensity would be a potential future action to better understand the spatial and temporal determinants of elephant interactions in this region.

It was also clear that few of the activities of the Forest Department in managing or mitigating interactions and crop raiding were viewed positively; in general these were considered ineffective, neither did receiving compensation produce positive attitudes. As noted above, an integrated multi-stakeholder management plan might have more effect on attitudes and managing interactions with elephants than simple reliance on a single actor. Involvement of local communities (comprising farmers, estate workers, estate guards, large corporate workers, village communities), Forest Department, State Government, conservation scientists, media and also elephants as the stakeholders would aid in developing better management strategies to lower the risks of negative interactions of people and elephants. Such multi-stakeholder management will build trust between the actors and effective implementation of strategies creating positive attitudes towards elephant conservation and wildlife in general.

Chapter 9

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

CHAPTER 9: SUMMARY, CONCLUSIONS AND FUTURE DIRECTIONS

This thesis focused on Asian elephant (*Elephas maximus*) populations using the coffee agroforestry system in Kodagu and their behavioural adaptations and flexibility. Kodagu, a district of Karnataka, southern India, is 46% covered by forest and contains over 1000 wild elephants, making it a key conservation area for this highly endangered species. I present the nature of elephant use of coffee estates, identify the elephant population using the study sites and assess their effects on coffee crop production and on people's tolerance of elephants. As the first study to examine elephants on coffee estates as individuals and over a one year year period (or 3 year period including MSc data), I ultimately aim to develop management practices to aid in sustaining elephants in this vital area of their remaining range.

The first data chapter (Chapter 4) explores the location and frequency of crop-raiding events, based on claims made to the Forest Department for compensation for crop loss. As discussed (See Chapter 4) temporal and spatial patterns of crop-raiding may indicate how the elephants in this region were using the landscape, at least in relation to claims made. Are particular regions or areas within the *taluks* (or districts, See Chapter 2) more vulnerable to raids or more representative of elephant use of human crops? One further aim of this thesis was to move our discourse away from the paradigm of conflict, and to engage with all participants in the interactions between humans and elephants, using a stakeholder model which includes elephants in establishing land and species management priorities and needs. In order to achieve this aim, I started with a review of the nature of documented crop-raiding events (the human dimension of the consequences of an interaction) and then focused on the elephants as individuals within the large coffee estates that act as refuges for elephants in this region. As suggested by previous studies (Nath & Sukumar, 1998; Kulkarni *et al*., 2007; Bal *et al*., 2008), crop-raiding events, although spread across Kodagu district, appear to occur in villages closer to the forest boundaries and the intensity of events across these villages suggest that there is a pattern of movement by elephants that may have resulted in some villages being raided more than the others.

The next two data chapters (Chapter 5 and 6) look in detail at the use of large coffee estates (corporate coffee estate) by elephants. Coffee loss or damage by elephants, as the major cash crop in this region, could determine the attitudes of people towards elephants and predict the future of elephants using these resources. Furthermore, I aimed to explore whether the use of coffee estates was specific to individuals or small groups, or whether it was a general outcome of the population moving between forest areas (See Chapter 5). My study was the first attempt to survey the elephant population using these coffee estates and monitor their presence. Frequent use by certain individual and groups of elephants at a seasonal level suggested that there may be a pattern of use of these coffee estates by the elephants which are specific to those elephant populations using the area. The diurnal and monthly use of coffee estates was examined in relation to potential for travel routes, the presence and use of elephant foods in the estates and the occupation of safe refuges from human disturbance in these areas (See Chapter 6). In addition to the other fruits consumed by elephants, I used dung samples to re-assess whether elephants were consuming coffee as a resource during the period of my study (following Bal *et al*., 2008; See Chapter 7). Elephant consumption of coffee on estates could produce hostility over and above that of the risk to human life through elephant encounters, given the importance of coffee as a biodiversity friendly cash crop in this region.

Having provided the background portrait of the elephants and their use of the general area, and the specific “habitat” of coffee estates, I then related the elephants to the human perceptions of elephants, and the resulting attitudes towards elephants (See Chapter 8). This chapter builds on my pilot interviews with landholders and farmers (Narayana, 2009) with detailed analysis, and integrates that work with the current perspective on the elephant use of crops (See Chapter 4) and their presence on estates (See Chapters 5, 6 & 7). Attitudes were explored in the context of the general beliefs and history of development of Kodagu as set out in Chapter 2. Chapter 2 thus describes in detail the study area of Kodagu as well as the background to the elephant population, while Chapter 3 provided details of the methods and the rationale for the choice of the methods used in this study. The implications of elephants and their use of coffee habitats as well as the human attitudes towards them for the persistence of elephants into the future are discussed below. Understanding how the history and dynamics of the long and complex relationship between humans and elephants on the Indian subcontinent feeds into current and changing perceptions of elephants will determine the future of elephants in the wild.

Major findings of the thesis can be summarised as follows: Chapter 4 indicates that elephant crop-raiding events (a total of 17723 cases for which compensation was claimed from the Forest Department) are spread from north eastern to west part of the district. Over time, there have been an increasing number of reports of crop-raiding events across Kodagu district, recently with reports of elephant venturing into areas that had previously low or no elephant intrusions. However, the reports of crop-raiding event locations suggest that elephants appear to be using specific movement path across Kodagu. In Chapter 5 and 6, I show that elephants are using Kodagu’s coffee agroforestry landscape for movement and as refuge areas, and I made an effort to identify the elephant groups and individuals using these areas. During the study period, I was able to identify certain individuals and groups that used specific areas in my study sites. As my findings were specific to these study sites which were embedded within a number of estates, increasing sampling efforts across many coffee estates and various villages in order to help in evaluating the use of coffee estates by specific individual and groups of elephant. Using a citizen science method of reports of sighting provided wide ranging access to information on elephant presence within the coffee estates; it would be difficult to determine elephant presence in remote corners of the estates without the co-operation of the local people, especially with my small research team. Constant communication with the local people helped me to establish better rapport and trust about the elephants and the project aims. Information on elephant locations when disseminated to a larger extent will make people aware of possible elephant movements in the area (which is currently done through word of mouth or local contacts within the estate). Chapter 5 also uses sightings and photographic evidence to describe the group composition of elephants visiting coffee estates over the study period and the nature of the use of coffee estates by different elephant group types. Single male and all male groups were the most frequent users of coffee estates, but family groups with females and calves were present at higher frequencies during the peak season of elephant visits. This period was after the post - monsoon, when foraging opportunities for fruit, understory herbaceous vegetation, and crops were more available within the agroforestry areas. In Kodagu, crop-damage and fear of life are the two main negative impacts of people and elephant interactions. Fear for life is one of the main causes for negative attitude towards elephants in Kodagu. Knowledge of elephant whereabouts, the group composition, understanding their behavioural dynamics and their use of coffee estates will empower people to be able to better co-exist with elephants. With coffee estates suggested as being used by elephants as biodiversity 'corridors', damage to crops is perhaps inevitable. There is yet no study that assesses economic value of loss of coffee crop by elephants across the district. Studies of crop-loss due to 'deliberate' coffee consumption or accidental damage to coffee plants/berries when elephants are chased or losses due to different wild animals (for example, pigs monkeys, porcupine, etc.) will provide better understanding for designing appropriate management strategies to reduce crop loss.

Chapter 6 analyses the role of coffee estates as refuge areas for elephants during movements. Using various factors which could potentially attract elephants (fruits, paddy, proximity to natural forest), a significant relationship with the presence of fruiting trees was found for elephant presence but not for their choice for specific refuge areas. Other factors, such as traditional movement paths or local human activities, may influence the repeated choice of specific refuge spots by elephants. As mentioned above, information on elephants use of specific areas will enable people to be more aware and vigilant using these areas, avoiding negative or threatening encounters.

Chapter 7 indicates that the frequent use of agricultural lands may result in elephants adapting their foraging strategies to novel available resources. Using dung analysis as an indicator of diet choice, I attempted to assess whether coffee berry consumption was prevalent in the elephant population frequenting these estates, as had been suggested by Bal *et al*. (2008; 2011). My results were similar, suggesting that elephants may be consuming coffee berries during opportunistic but intentional raids, as well as incidentally when feeding on other resources.

Chapter 8 explores the local communities' attitudes to the human-elephant interface and the people's loss of faith in interaction mitigation methods used by the Forest Department. People seem to be gradually becoming intolerant towards the elephants and to conservation in general; repeated failure of mechanisms for preventing elephants from entering coffee estates may drastically change the perception and attitudes of people in Kodagu towards elephants. Fear for their lives and the financial and social consequences of crop damage are the major causes of people's diminishing levels of tolerance towards elephants.

During this study, I recognised that people in the locality were aware of frequent areas of elephant use and they could also identify certain specific individuals through the years of encounters. Information collected through reports from local workers gave me access to elephant locations and enabled me to identify and monitor elephant individuals whenever the opportunity arose. As Kodagu is a close-knit society, they show comraderies and involving local people in development of management strategies may result in effective implementation and reduce negative encounters with elephants and wildlife in general. For instance, living with elephants and/or wildlife everyday has resulted in people being less vigilant when elephants are in the vicinity. As a result, there appears to some resentment to research studies and the recommendations suggested by the conservation scientists to be able to create awareness about behavioural ecology of elephants and ensuring that local people understand the importance of applying certain guidelines while living amidst elephants increases their safety. For effective implementation of mitigation and management strategies associated with elephant presence on estates, a key aspect is to include local communities as stakeholders and involve them in the research. This should provide a sense of empowerment and possibly encourage positive perceptions and attitudes towards elephants and wildlife in general.

9.1 Coffee estates as Refuge areas

Elephants are mega-herbivores which consume a wide variety of food resources available within their habitats. In coffee estates, elephants gain access to many fruiting trees, green foliage and grasses as forage. Many previous elephant crop-raiding studies have examined crops like paddy rice, maize, and bananas where the estimation of losses to farmers is relatively easily calculated. In coffee estates, costs extend beyond the direct loss of coffee berries for that season, as when the coffee plants are destroyed, it takes about four to five years for the new plants to start producing coffee berries again. Paddy fields adjoin coffee estates and may act as attractant to the elephants. Thus, nature of crop loss in Kodagu needs to be examined more thoroughly in time and space to determine whether the interface between people and elephants is greater than simply those losses reported to the Forest Department. In addition, elephants were observed using coffee estates post-monsoon, when forage in forest areas should also be available suggesting that frequent visits of elephants to estates either allows easy access to highly palatable and nutritious crops or for the purposes of movement between different areas of their range.

There are no records of elephant movement patterns within the district that would explain the frequent use of coffee estates by elephants. Escalation of crop-raiding events has occurred only recently and whether elephant populations are exploring new areas because of degrading and fragmenting forest areas remains unknown. One of the explanations for increasing elephant presence could be that the existence of community-owned forests like sacred groves and other small forest patches may have previously prevented elephants from using agricultural lands to such an extent, but with these community forests dwindling in area, elephants may have started to explore the other viable habitats necessary for their survival. These are only assumptions about the causes of movement patterns of elephant population within the coffee estates which need to be evaluated and examined in the future.

Coffee berry consumption by elephants was indicated by the analysis of dung samples. With no prior records of coffee consumption by elephants and no direct observations of elephants consuming coffee, we may assume that elephants have adapted this as a novel foraging strategy (Bal *et al*., 2008). It is likely that young elephants will learn about consuming coffee berries from their experienced adult population, as seen in other populations (Lee & Moss, 1999). It might also be the case that the exploratory nature of young elephants towards new foraging resources may have resulted in all elephants consuming coffee berries. Similar behaviour has been found in chimpanzees, where young adults who were not yet exposed to the crop-raiding may incorporate new crops into their diets through experimentation (Takasaki, 1989; Lee, 2003). For future studies, it is important to examine the importance of coffee berries in these elephants' dietary repertoire to provide an insight into whether coffee berries will remain as opportunistic foods when raiding other crops or if they will become a main dietary component.

Understanding the group dynamics of the local elephant population and their movement patterns may reduce the potential for negative interactions between elephants and people, reducing crop-damage and the mortality of elephants and people. For example, the presence of family herds with a young vulnerable calf may increase the probability of people being attacked by the elephants when in close contact. In this study, family herds were mostly present during the peak season for elephant visits to coffee estates.

There has as yet been no study on overall density or the age structure and sex ratio of the elephant population in Kodagu. This urgently needs to be carried out.

The baseline data on individual elephant identification, prepared during this research, will be useful in determining the overall population and demographic status of the local population for future studies. Also, long-term studies may provide a better understanding of the age-sex class of elephants consuming coffee berries and the extent of damage caused depending on group type and size.

Even large tracts of protected areas do not always represent a pristine environment (Willis *et al.,* 2004). Thus, despite large tracts of forest cover in Kodagu, the importance of coffee agroforestry as a habitat for biodiversity conservation outside protected areas needs to be determined. Coffee agroforestry systems are considered to be viable habitat for wildlife because the heterogeneity of the landscape reduces the pressure on protected areas (Bhagwat *et al*., 2008). This landscape heterogeneity could also explain the use of large coffee estates as refuge areas during the movements between natural forest areas. The use of such refuge areas could thus be a function of the close proximity to traditional movement paths or of access to foraging and water resources, and they may sometimes also function as a "hideout" before nocturnal raids to the adjoining paddy lands (e.g. Graham *et al,*. 2009). The possibility of small coffee estates being used as refuge areas is minimal as elephants are known to avoid the risks encountering people. Thus, the role of the large coffee estates as linking corridors needs to be explored for the better management and conservation of elephants. However, this does not mean that the agroforestry landscape alone is sufficient for biodiversity conservation. But rather that it plays a key role in providing corridors and connectivity for wildlife species (Bhagwat *et al.,* 2005).

The potential for coffee agroforestry to act as corridors outside protected areas without resulting in a hostile human-elephant interface is questionable. With economic growth, damage to coffee yields can represent a significant market loss, and most importantly, the presence of these large bodied mammals within an estate can pose threats to life undermining the effect of agroforestry's role in biodiversity conservation. Thus, coffee agroforestry can be considered as an effective conservation area for smaller wildlife (such as birds), but large bodied mammals like elephants may be exposed to escalated effects of human and elephant interaction interface in these areas.

9.2 Coexistence: costs and benefits

To reduce animosity and strengthen conservation efforts, it is vital to reduce the elephant's access to cultivated lands (Ekanayaka *et al.*, 2011). However, with coffee agro-forestry being promoted as potential corridors for various wild species along with elephants, reducing negative interactions between people and elephants becomes challenging. My study was limited to a few specific study sites within Kodagu district. It is thus important to focus future studies on how people across Kodagu perceive elephants and on the elephants' use of coffee estates across the region to determine movement patterns and understand how elephants adapt their behaviour for survival in the human-dominated agroforestry.

Every region or site has specific characteristics that are important to take into consideration when designing mitigation methods for hostile human-elephant interactions (Osborn and Parker, 2003). Kodagu's landscape is unique with varying topography and a landscape mosaic. Mitigation methods like elephant-proof trenches or electric fences can be effective at the boundary of the forest areas and on flat lands. Elephant-proof trenches and electric fences may temporarily prevent the elephants from coming into the estates and but this does not eliminate peoples' fear for their lives. Should the elephants be fenced out or people fenced in? As Madhusudan (2003) has indicated, there is always some kind of interface between people and wildlife and it is important to recognise that "*... conflict can, at best, only be managed, and never eliminated (pg 472)"*.

9.2.1 Recommendations

Management measures could focus on passing on information of elephants' presence within a set range to all the residents through mobile networks and media (Kumar, personal communication; Graham *et al*., 2012). This is similar to communal guarding (Fernando *et al.*, 2005) or what has been called "electronic or e-fencing" and which could improve management by preventing encounters between elephants and people. Implementation of alarm system to detect elephant presence across Kodagu's coffee estates could prove to be an effective human-elephant interaction management solution for Kodagu. Knowledge of elephant whereabouts will empower people to be more aware of their surroundings and more confidence about their personal safety. This knowledge could be effective as safety was or is still the main concern raised by local people. Creating a safer environment by reducing fear on the part of people can encourage building positive attitudes of people towards elephants and conservation in general. Also, such alarm systems are considered to be cost-effective deterrents for negative human-elephant contacts. In large or corporate coffee estates where elephants seem to take refuge during their movements between feeding areas (See Chapter 6), such alarm system could help in the detection of elephants more frequently and with greater accuracy. For estate guards, it would provide more security on job; for instance, they don't have to go on time consuming searches across the entire estate, but can use the location points transmitted through such alarm systems to confirm elephants' presence. Unlike electric and/or solar fences, they do not deter the freedom of movement for the elephants across the agricultural lands. Although elephants are known to avoid people, reducing contact with people, especially when elephants are being chased from one area or estate to another, may lead to behavioural adaptations for improved people-elephant interaction. Coffee plants are also destroyed by elephants when they are driven from one place to another. Prior knowledge of elephant presence before the beginning of the day will provide better managerial decisions for farmers to allocate work to those areas with reduced risks of interactions with the elephants. During the course of this study, I was able to establish that the elephants used specific exit/entry points into the estates and specific areas as refuges; alarm systems can be first installed in these areas, and their effectiveness in reducing negative people-elephant interactions assessed. Future studies should focus on incorporating more coffee estates as study sites across Kodagu for better understanding of the effectiveness and potential for such solutions on a large extent.

Management strategies that include both well-being of people and conservation of elephants are the key for propagating people-elephant co-existence. It should be carried out on a small scale, based on region-specific village by village approaches, developing them further on the basis of results of initial experiences.

Along with compensation schemes, providing benefits through conservation activities to the local communities who share habitats and resources with elephants may aid in promoting higher tolerance and better management of the consequences of interactions between humans and elephants. Since agroforestry systems are being promoted as an important biodiversity conservation tool, it is important to provide costs and benefits in terms of incentives, or the certification of shade-grown products to famers who cultivate crops through agroforestry systems.

It is also important to create awareness among local communities about elephant as incomplete knowledge and incorrect information will exacerbate risks to elephant survival. Education about and awareness of wild elephants is necessary to encourage positive attitudes among local communities for successful conservation efforts (Mulder *et al*., 2009). Younger generations should be the target audience to convince the adult human population about the importance of elephant as a species and of their survival (Jayawardene, 2011). Increasing knowledge about wild elephants would reduce fear among people and increase their ability to cope with the general adversity of co-existing with wildlife. Including elephants as one of the stakeholders in designing management systems, with a right to co-existence alongside all the other local stakeholders, is needed to ensure their persistence into the future.

Thus the key for successful and effective management strategies is to manage the effects of the human-elephant interface for both people and elephants (Leimgruber *et al*., 2011). Ensuing the survival of elephant populations and finding solutions for managing negative human-elephant interactions require the implementation of innovative managerial tools for people to encourage community spirit, both ‘psychologically and tangibly’ (Seneviratne & Rossel, 2008) through providing economic and social opportunities for ownership of the problem and its solutions.

REFERENCES

- Albl, P., 1971. Studies on assessment of physical condition in African elephants. *Biological Conservation*, **3(2)**, 134-140.
- Arivazhagan, C., & Ramakrishnan, B., 2010. Conservation perspective of Asian Elephants (*Elephas maximus*) in Tamil Nadu, Southern India. *International Year of Biodiversity*, **1(Special Issue)**, 15-22.
- Athreya, V., Odden, M., Linnell, J. D. C., Krishnaswamy, J., & Karanth, U., 2013. Big Cats in our backyards: persistence of large carnivores in a human dominated landscape in India. *PLoS ONE*, **8(3)**, e57872. doi:10.1371/journal.pone.0057872.
- Amstrup, S. C., McDonald, T. L., & Manly, B. F. J., (Eds.), 2005. *Handbook of capture–recapture analysis*. Princeton: Princeton University Press.
- Asian Elephant Research and Conservation Centre, 1998. The Asian elephants in southern India: A GIS database for conservation of Project Elephant Reserves. Bangalore: Asian Elephant Research and Conservation Centre.
- Bal, P., Nath, C. D., & Garcia, C., 2008. *Drivers of human elephant interactions in Coffee agro-forestry landscapes in Kodagu (Western Ghatsm), India: An approach to understand the Human-Elephant Conflict*. French Institute of Pondicherry.
- Bal, P., Nath, C. D., Nanaya, K. M., Kushalppa, C. G., & Garcia, C., 2011. Elephants also like coffee: Trends and drivers of human-elephant conflicts in coffee agroforestry landscapes of Kodagu, Western Ghats, India. *Environmental Management*, **47(5)**, 789-801.
- Balasubramanian, M., Baskaran, N., Swaminathan, S., & Desai, A. A., 1995. Crop raiding by Asian elephant (*Elephas maximus*) in the Nilgiri Reserve, South

India. In: Daniel, J. C., & Datye, H. S., (Eds.). *A week with Elephants: Proceedings of the International Seminar on the Conservation of the Asian Elephant*. Bombay: Oxford University Press.

- Bali, A., Kumar, A., & Krishnaswamy, J., 2007. The mammalian communities in coffee plantations around a protected area in the Western Ghats, India. *Biological Conservation*, **139(1)**, 93-102.
- Balme, G. A., Slotow, R., & Hunter, L. T. B., 2010. Edge effects and the impact of non-protected areas in carnivore conservation: leopards in the Phinda-Mkhuze Complex, South Africa. *Animal Conservation*, **13(3)**, 315-323.
- Balmford, A., Moore, J. L., Brooks, T., Burgess, N., Hansen, L. A., Williams, P., & Rahbek, C., 2001. Conservation conflicts across Africa. *Science*, **291**, 2616–2619.
- Bandara, R., & Tisdell, C., 2002. Asian Elephants as Agricultural Pests: Damages, Economics of Control and Compensation in Sri Lanka. *Natural Resources Journal*, **42**, 491-519.
- Bandara, R., & Tisdell, C., 2004. The net benefit of saving the Asian elephant: A policy and contingent valuation study. *Ecological Economics*, **48(1)**, 93-107.
- Barua, M., Bhagwat, S. A., & Jadhav, S., 2013. The hidden dimensions of human-wildlife conflict: Health impacts, opportunity and transaction costs. *Biorlogical Conservation*, **157**, 309-316.
- Barua, P., & Bist, S. S., 1995. Changing patterns in the distribution and movement of wild elephants in North Bengal, pp. 66-84. In: Daniel, J. C., & Datye, H. S., (Eds.). *A week with elephants*. Proceedings of the International Seminar on the conservation of Asian Elephant. Mudumalai Wildlife Sanctuary, June 1993. Bombay: Bombay Natural History Society.

- Barnes, R., 1996. Estimating forest elephant abundance by Dung counts, pp 38-48. In *Studying Elephants*, African Wildlife Foundation Technical Handbook Series 7: 58-74. Kangwana, K., (Ed.). Nairobi: AWF.
- Barnes, R. F., Barnes, K. L., Alers, M. P. T., & Blom, A., 1991. Man determines the distribution of elephants in the rain forests of northeastern Gabon. *African Journal of Ecology*, **29(1)**, 54-63.
- Barnes, R. F. W., Asika, S., & Asamoah-Boateng, B., 1995. Timber, cocoa and crop-raiding elephants: a preliminary study from southern Ghana. *Pachyderm*, **19**, 33-38.
- Barnes, R. F. W., Dubiure, U. F., Danquah, E., Boafo, Y., Nandjui, A., Hema, E. M., & Manford, M., 2006. Crop-raiding elephants and the moon. *African Journal of Ecology*, **45(1)**, 112-115.
- Baskaran, N., 2013. An overview of Asian elephants in the Western Ghats, Southern India: Implications for the conservation of Western Ghats ecology. *Journal of Threatened Taxa*, **5(14)**, 4854-4870.
- Baskaran, N., & Desai, A. A., 2013. Frugivory and seed dispersal by the Asian Elephant *Elephas maximus* in the tropical forests of Nilgiri Biosphere Reserve, southern India. *Journal of Threatened Taxa*, **5(14)**, 4893-4897.
- Baskaran, N., & Sukumar, R., 2010. Karnataka Elephant Census 2010. *Technical Report to the Karnataka Forest Department*. Asian Nature Conservation Foundation, Bangalore.
- Baskaran, N., Varma, S., Sar, C. K., & Sukumar, R., 2011. Current status of Asian Elephants in India. *GAJAH*, **35**, 47-54.

- Baskaran, N., & Venkatesh, P., 2009. Human Elephant Conflict in Hosur Forest Division, Tamilnadu, India. *Interim Report to Hosur Forest Division, Tamil Nadu Forest Department*. Asian Nature Conservation Foundation, Bangalore.
- Bates, L. A., Sayialel, K. N., Njiraini, N. W., Poole, J. H., Moss, C. J., & Byrne, R. W., 2008. African elephants have expectations about the locations of out-of-sight family members. *Biology Letters*, **4(1),** 34-36.
- Beaune, D., Bretagnolle, F., Collache, L., Hohmann, G., Surbeck, M., & Fruth, B., 2013. Seed dispersal strategies and the threat of defaunation in a Congo forest. *Biodiversity and Conservation*, **22(1)**, 225-238.
- Beliappa, C. B., 2008. *Nuggets from Coorg History*. New Delhi: Roopa and Co.
- Bell, R. H. V., 1984. The man-animal interface: an assessment of crop damage and wildlife control pp. 387-416. In *Conservation and Wildlife Management in Africa*, Bell, R. H. V., & McShane-Caluzi, E., (Eds.). Washington, DC: US Peace Corps Office of Training and program, Support. Liongwe, Malawi.
- Benítez-Malvido, J., & Martínez-Ramos, M., 2003. Impact of forest fragmentation on understory plant species richness in Amazonia. *Conservation Biology*, **17(2)**, 389-400.
- Bennett, E., Neiland, A., Anang, E., Bannerman, P., Rahman, A. A., Huq, S., Bhuiya, S., Day, M., Fulford-Gardiner, M., & Clerveaux, W., 2001. Towards a better understanding of conflict management in tropical fisheries: evidence from Ghana, Bangladesh and the Caribbean. *Marine Policy*, **25(5)**, 365-376.
- Berger, J., Stacey, P. B., Bellis, L., & Johnson, M. P., 2001. A mammalian predator–prey imbalance: grizzly bear and wolf extinction affect avian neotropical migrants. *Ecological Applications*, **11(4)**, 947-960.

- Bhagwat, S., 2002. *Biodiversity and conservation of a cultural landscape in the Western Ghats of India*. Unpublished doctoral thesis, University of Oxford, Oxford, UK.
- Bhagwat, S. A., Kushalappa, C. G., Williams, P. H., & Brown, N. D., 2005. The role of informal protected areas in maintaining biodiversity in the Western Ghats of India. *Ecology and Society*, **10(1)**, 8. http://www.ecologyandsociety.org/vol10/iss1/art8/.
- Bhagwat, A. S., & Rutte, C., 2006. Sacred groves: potential for biodiversity management. *Frontiers in Ecology and the Environment*, **4(10)**, 519-524.
- Bhagwat, S. A., Wills, K. J., Birks, J. B., & Whittaker, R. J., 2008. Agroforestry: a refuge for tropical biodiversity? *Trends in Ecology and Evolution*, **23(5)**, 261-267.
- Bhatia, S., Athreya, V., Grenyer, R., & Macdonald, D. W., 2013. Understanding the role of representations of human-leopard conflict in Mumbai through media-content analysis. *Conservation Biology*, **27(3)**, 588-594.
- Bhattacharya, P., 2014. Sacred Groves at Risk as Faith Erodes. *The New Indian Express*, Retrieved 20th January, 2014 from www.newindianexpress.com.
- Bhoominathan, D., Mohanraj, N., Aziz, T., & Desai, A., 2008. *Management of the Asian elephants in the Nilgiris and Eastern Ghats: Human elephant conflict in Somwarpet division (Madikeri Forest division)*. WWF Report. India.
- Bist, S. S., 2002. An Overview of Elephant Conservation in India. *The Indian Forester*, **128(2)**, 121-136.
- Bist, S. S., 2006. Elephant conservation in India – an overview. *Gajah*, **25**, 27-35.

- Blair, J. A. S., Boon, G. G., & Noor, N. M., 1979. Conservation or Cultivation: the confrontation between the Asian elephant and land development in Peninsular Malaysia. *Land Development Digest*, **2(1)**, 25-58.
- Blake, S., 2002. The ecology of forest elephant distribution and its implication for conservation. PhD Thesis. University of Edinburgh.
- Blake, S., Deem, S. L., Mossimbo, E., Maisels, F., & Walsh, P., 2009. Forest elephants: tree planters of the Congo. *Biotropica*, **41(4)**, 459-468.
- Blake, S., Douglas-Hamilton, I., & Karesh, W. B., 2001. GPS telemetry of forest elephants in Central Africa: results of a preliminary study. *African Journal of Ecology*, **39(2)**, 178-186. doi: 10.1046/j.1365-2028.2001.00296.x.
- Blake, S., & Hedges, S., 2004. Sinking the Ffagship: the case of forest elephants in Asia and Africa. *Conservation Biology*, **18(5)**, 1191-1202. doi: 10.1111/j.1523-1739.2004.01860.x.
- Blake, S., & Inkamba-Nkulu, C., 2004. Fruit, minerals, and forest elephant trails: do all roads lead to Rome?. *Biotropica*, **36(3)**, 392-401.
- Boppanna, P. T., 2010. *Dateline Coorg*. Bangalore: Rollingstone Publications, Jayanagar.
- Browne-Nunez, C., 2011. The Maasai-elephant relationship: the evolution and influence of culture, land-use and attitudes, pp. 291-307. In In Moss, C. J., Croze, H., & Lee, P. C., (Eds.) *The Amboseli Elephants*. Chicago: University of Chicago Press.
- Bukland, S. T., Anderson, D. R., Burnham, K. P., & Laake, J. L., 1993. *Distance sampling: estimating abundance of biological populations*. Chapman and Hall, London.

- Buij, R., McShea, W. J., Campbell, P., Lee, M. E., Dallmeier, F., Guimondou, S., Mackaga, L., Guisseougou, N., Mboumba, S., Hines, J. E., Nichols, J. D., & Alonso, A., 2007. Patch-occupancy models indicate human activity as major determinant of forest elephant *Loxodonta cyclotis* seasonal distribution in an industrial corridor in Gabon. *Biological Conservation*, **135(2)**, 189-201.
- Campos-Arceiz, A., 2009. Shit happens (to be useful)! Use of elephant dung ashabitat by amphibians. *Biotropica*, **41(4)**, 406-407.
- Campos-Arceiz, A., & Blake, S., 2011. Megagardeners if the forest–the role of elephants in seed dispersal. *Acta Oecologica*, **37(6)**, 542-553.
- Campos-Arciez, A., Larrinaga, A., Weerasinghe, U. R., Takatsuki, S., Pastorini, J., Leimgruber, P., Fernando, P., & Santamaría, L., 2008a. Behavior rather than diet mediates seasonal differences in seed dispersal by Asian elephants. *Ecology*, **89(10**), 2684-2691.
- Campos-Arceiz, A., Lin, T. Z., Htun, W., Takatsuki, S., & Leimgruber, P., 2008b. Working with mahouts to explore the diet of work elephants in Myanmar (Burma). *Ecological Research*, **23(6)**, 1057-1064. doi: 10.1007/s11284-008-0466-4.
- Campos-Arciez, A., Takatsuki, S., Ekanayaka, S. K. K., & Hasegawa, T., 2009. The human-elephant conflict in Southeastern Sri Lanka: type of damage, seasonal patterns, and sexual differences in the raiding behavior of elephants. *GAJAH, Journal of the Asian Elephant Specialist Group*, **31**, 5-14.
- Census of India, 2001. Retrieved on 30th November, 2013 from http://censusindia.gov.in/.

- Chartier, L., Zimmermann, A., & Ladle, R. J., 2011. Habitat loss and human–elephant conflict in Assam, India: does a critical threshold exist? *Oryx*, **45(4)**, 528-533.
- Chan, K. M. A., Pringle, R. M., Ranganathan, J., Boggs, C. L., Chan, Y, L., Ehrlich, P. R., Haff, P. K., Heller, N. E., Al-Khafaji, K., & Macmynowski, D. P., 2007. When agendas collide: human welfare and biological conservation. *Conservation Biology*, **21**, 59-68.
- Chandra, S., 2014. Operation underway to capture 23 rogue jumbos. *Deccan Herald*, Retrieved on 28th January, 2014 from www.deccanherald.com.
- Chelliah, K., Kannan, G., Kundu, S., Abilash, N., Madhusudan, A., Baskaran, N., & Sukumar, R., 2010. Testing the efficacy of a chilli-tobacco rope fence as a deterrent against crop-raiding elephants. *Current Science*, **99(9)**, 1239-1243.
- Chen, J., Deng, X., Zhang, L., & Bai, Z., 2006. Diet composition and foraging ecology of Asian elephants in Shangyong, Xishuangbanna, China. *Acta Ecologica Sinica*, **26(2)**, 309-316.
- Chiyo, P, I., Cochrane, E. P., Naughton, L., & Bastua, G. I., 2005. Temporal patterns of crop raiding by elephants: a response to changes in forage quality or crop availability? *African Journal of Ecology*, **43(1)**, 48-55.
- Chiyo, P. I., Lee, P. C., Moss, C. J., Archie, E. A., Hollister-Smith, J. A., & Alberts, S. C., 2011. No risk, no gain: effects of crop raiding and genetic diversity on body size in male elephants. *Behavioral Ecology*, **22(3)**, 552-558.
- Chiyo, P. I., Moss, C. J., & Alberts, S. C., 2012. The influence of life history milestones and association networks on crop-raiding behaviour in male African elephants. *PloS one*, **7(2)**, 1-11. doi:10.1371/journal.pone.0031382.

- Choudhury, A., Lahiri Choudhury, D. K., Desai, A., Duckworth, J. W., Easa, P. S., Johnsingh, A. J. T., Fernando, P., Hedges, S., Gunwardena, M., Kurt, F., Karanth, U., Lister, A., Menon, V., Riddle, H., Rübel, A., & Wikramanayake, E., 2008. *Elephas maximus*. In: IUCN 2013. IUCN Red List of Threatened Species. Version 2013.2 www.iucnredlist.org accessed on 15th January, 2014.
- Chowdhury, A. N., & Jadhav, S., 2012. Eco-psychiatry: culture, mental health and ecology with special reference to India. In Chavan, B. S., Gupta, N., Arun, P., Sidana, A., & Jadhava, S., (Eds.) *Community Mental Health in India*. pp 521-542. Jaypee Brothers, India.
- Conover, M. R., 2002. *Resolving human–wildlife conflicts: the science of wildlife damage management*. Florida: Lewis Publishers, Boca Raton.
- Corlett, R. T., 1998. Frugivory and seed dispersal by vertebrates in the Oriental (Indomalayan) region. *Biological Reviews*, **73**, 413-448.
- Croze, H., 1972. A modified photogrammetric technique for assessing age-structures of elephant populations and its uses in Kidepo National Park. *African Journal of Ecology*, **10(2),** 91-115.
- Czech, B., Krausman P. R., & Borkhataria, R., 1998. Social construction, political power and the allocation of benefits to endangered species. *Conservation Biology*, **12(5)**, 1103-1112.
- Dagar, J. C., Singh, A. K., & Arunachalam, A., 2014. *Agroforestry Systems in India: Livelihood Security & Ecosystem Services*. Springer, India.
- Dawson, S., & Dekker, A. J. F. M., 1992. Counting Asian Elephants in Forests, pp: 56. FAO, Bangkok.

- De Boer, W. F., & Baquete, D., 1998. Natural resource use, crop damage and attitudes of rural people in the vicinity of Maputo Elephant Reserve, Mozambique. *Environmental Conservation*, **25(3)**, 208-218.
- De Silva, M., 1998. Status and conservation of the elephant and the alleviation of man-elephant conflict in Sri Lanka. *Gajah*, **19**, 1-24.
- De Silva, S., Ranjeewa, A. D. G., & Kryazhimsky, S., 2011. The dynamics of social networks among female Asian elephants. *BMC Ecology*, **11(1)**, 17. doi:10.1186/1472-6785-11-17.
- De Silva, S., & Wittemyer, G., 2012. A comparison of Social Organization in Asian Elephants and African Savannah Elephants. *International Journal of Primatology*, **33(5)**, 1125-1141.
- Deepika, M. G., & Jyotishi, A., 2013. Assessing risk and risk mitigation strategies of small coffee growers: A study of Kodagu district in Karnataka. *NRPPD Discussions Paper. No. 21*. http://cds.edu/wp-content/uploads/2013/08/NRPPD21.pdf.
- Desai, A. A., 1991. The home range of elephants and its implications for management of the Mudumalai Wildlife Sanctuary, Tamil Nadu. *Journal of the Bombay Natural History* Society, **88(2)**, 145-156.
- Desai, A. A., & Baskaran, N., 1996. Impact of human activities on the ranging behaviour of elephants in the Niligiri biosphere Reserve, South India. *Journal of the Bombay Natural History Society*, **93(3)**, 559-569.
- Donaldson, R., Finn, H., Bejder, L., Lusseau, D., & Calver, M., 2012. The social side of human-wildife interaction: wildlife can learn harmful behaviours from each other. *Animal Conservation*, **15(5)**, 427-435. doi:10.1111/j.1469-1795.2012.00548.x.

- Douglas-Hamilton, I., & Douglas-Hamilton, O., 1975. *Among the elephants*. London: Collins & Harvill.
- Douglas-Hamilton, I., 1998. Tracking elephants using GPS technology. *Pachyderm*, **25**, 81-92.
- Douglas-Hamilton, I., Krink, T., & Vollrath, F., 2005. Movements and corridors of African elephants in relation to protected areas. *Naturwissenschaften,* **92(4)**, 158-163.
- Doyle, S., Groo, M., Sampson, C., Songer, M., Jones, M., & Leimgruber, P., 2010. Human-elephant conflict–What can we learn from the news? *GAJAH*, **32**, 14-20.
- Dudley, J. P., 1999. Seed dispersal of *Acacia erioloba* by African bush elephants in Hwange National Park, Zimbabwe. *African Journal of Ecology*, **37(4)**, 375-385.
- Ekanayaka, S. K. K., Campos-Arceiz, A., Rupasinghe, M., Pastorini, J., & Fernando, P., 2011. Patterns of crop raiding by Asian elephants in a human-dominated landscape in Southeastern Sri Lanka. *GAJAH*, **34**, 20-25.
- Elouard, C., 2000. Landscape and society. pp 25-42. In: Ramakrishnan, P. S., Chandrashekara, U. M., Elouard, C., Guilmoto, C. Z., Maikhuri, R. K., Rao, K. S., Sankar, S., & Saxena, K. G., (Eds.). *Mountain Biodiversity, Demographic and Environmental Changes*. New Delhi: Oxford and IBH Publishing Co. Pvt. Ltd.
- Fernando, P., Janaka, H. K., Prasad, T., & Pastorini, J., 2010. Identifying elephant movement patterns by direct observation. *GAJAH,* **33**, 41-46.
- Fernando, P., Kumar, M. A., Williams, A. C., Wikramanayake, E., Aziz, T., & Singh, S. M., 2008a. Review of Human-Elephant Conflict Mitigation Methods

Practiced in South Asia. *AREAS technical support document submitted to World Bank. WWF-World Wide Fund for Nature*. Accessed on 22nd July, 2010 from http://www.ccrsl.org/Downloads/Fernando-ReviewHEC.pdf.

- Fernando, P., Wikramanayake, E. D., Janaka, H. K., Jayansinghe, L. K. A., Gunawardena, M., Kotagama, S. W., Weerakoon, D., & Pastorini, J., 2008b. Ranging behavior in Sri Lanka. *Mammalian Biology*, **73(1)**, 2-13.
- Fernando, P., Wikramanayake, E., Weerakoon, D., Jayasinghe, L. K. A., Gunawardene, M., & Janaka, H. K., 2005. Perceptions and patterns of human–elephant conflict in old and new settlements in Sri Lanka: insights for mitigation and management. *Biodiversity & Conservation*, **14(10)**, 2465-2481.
- Field, A., 2005. *Discovering Statistics Using SPSS (and sex, drug and rock 'n'roll)*. 2nd Edition, SAGE Publications, London.
- Fleming, T. H., Breitwisch, R., & Whitesides, G. H., 1987. Patterns of tropical vertebrate frugivore diversity. *Annual Review of Ecology and Systematics*, **18**, 91-109.
- Foley, C. A. H., 2002. *The effects of poaching on elephant social systems*. Unpublished doctoral thesis, Princeton University.
- Forest Survey of India, 1995. Report on the Inventory of Forest Resources of Kodagu District (Karnataka). In Forest survey of India (Southern zone), Bangalore.
- Galanti, V., Preatoni, D., Martinoli, A., Wauters, L. A., & Tosi, G., 2006. Space and habitat use of the African elephant in the Tarangire–Manyara ecosystem, Tanzania: implications for conservation. *Mammalian Biology*, **71(2)**, 99-114.
- Galef Jr, B. G., & Laland, K. N., 2005. Social learning in animals: empirical studies and theoretical models. *Bioscience*, **55(6)**, 489-499.

- Garcia, C., Marie-Vivien, D., Kushalappa, C. G., Chengappa, P. G., & Nanaya, K. M., 2007. Geographical Indications and Biodiversity in the Western Ghats, India: Can labelling benefit producers and the environment in a Mountain Agroforestry Landscape? *Mountain Research and Development*, **27(3)**, 206-210.
- Gautier-Hion, A., Duplantier, J. M., Quris, R., Feer, F., Sourd, C., Decoux, J. P., Dubost, G., Emmons, L., Erard, C., Hecketsweiler, P., Moungazi, A., Roussilhon, C., & Thiollay, J. M., 1985. Fruit characters as a basis of fruit choice and seed dispersal in a tropical forest vertebrate community. *Oecologia*, **65(3)**, 324-337.
- Gillingham, S. G., & Lee, P. C., 2003. A preliminary assessment of perceived and actual patterns of wildlife crop-damage in an area bordering the Selous Game Reserve, Tanzania. Or People and protected areas: a study of local perceptions of wildlife crop-damage conflict in an area bordering the Selous Game Reserve, Tanzania. *Oryx*, **37**, 316-325.
- Gillingham, S. G., 1998. *Giving wildlife value: a case study of community wildlife management around the Selous Game Reserve, Tanzania*. Unpublished doctoral thesis, University of Cambridge, Cambridge, UK.
- Gonthier, D. J., 2009. Notes on seeds deposited in elephant dung at Tarangire National Park, Tanzania. *African Journal of Ecology*, **47**, 252-256.
- Gore, M. L., W. F., Siemer, J. E., Shanahan, D., Scheufele, & Decker, D. F., 2005. Effects on risk perception of media coverage of a black bear-related human fatality. *Wildlife Society Bulletin*, **33**, 507–516.
- Gore, M., & Knuth, B. A., 2009. Mass media effect on the operating environment of a wildlife-related risk-communication campaign. *Journal of Wildlife Management*, **73**, 1407-1413.

- Goswami, V. R., 2006. *Estimation of adult male elephant (Elephas maximus indicus) population size in Nagarahole-Bandipur National Parks using capture–recapture methods*. Unpublished master's thesis, Manipal Academy of Higher Education, India.
- Goswami, V. R., Lauretta, M. V., Madhusudan, M. D., & Karanth, K. U., 2012. Optimizing individual identification and survey effort for photographic capture–recapture sampling of species with temporally variable morphological traits. *Animal Conservation*, **15(2)**, 174-183. doi: 10.1111/j.1469-1795.2011.00501.x.
- Goswami, V. R., Madhusudan, M. D., & Karanth, K. U., 2007. Application of photographic capture–recapture modelling to estimate demographic parameters for male Asian elephants. *Animal Conservation*, **10(3)**, 391-399. doi: 10.1111/j.1469-1795.2007.00124.x.
- Goswami, V. R., Vasudev, D., & Oli, M. K., 2014. The importance of conflict-induced mortality for conservation planning in areas of human-elephant co-occurrence. *Biological Conservation*, **176**, 191-198.
- Graham, M. D., 2006. Coexistence in a land use mosaic? Land use, risk and elephant ecology in Laikipia District, Kenya. Unpublished doctoral thesis, University of Cambridge, UK.
- Graham, M. D., Adams, W. M. & Kahiro, G. N., 2012. Mobile phone communication in effective human elephant–conflict management in Laikipia County, Kenya. *Oryx*, **46(01)**, 137-144.
- Graham, K., Beckerman A. P., & Thirgood, S., 2005. Human-predator-prey conflicts: ecological correlates, prey losses and patterns of management. *Biological Conservation*, **122(2)**, 159-171.

- Graham, M. D., Douglas-Hamilton, I., Adams, W. M., & Lee, P. C., 2009. The movement of African elephants in a human dominated land-use mosaic. *Animal Conservation*, **12(5)**, 445-455.
- Graham, M. D., Notter, B., Adams, W. M., Lee, P. C., & Ochieng, T. N., 2010. Patterns of crop-raiding by elephants, *Loxodonta africana*, in Laikipia, Kenya, and the management of human-elephant conflict. *Systematics and Biodiversity*, **8(4)**, 435-445.
- Graham, M. D., & Ochieng, T., 2008. Uptake and performance of farm-based measures for reducing crop raiding by elephants *Loxodonta africana* among smallholder farms in Laikipia District, Kenya. *Oryx*, **42(01)**, 76-82.
- Granados, A., Weladji, R. B., & Loomis, M. R., 2012. Movement and occurrence of two elephant herds in a human-dominated landscape, the Bénoué Wildlife Conservation Area, Cameroon. *Tropical Conservation Science*, **5(2),** 150-162.
- Gubbi, S., 2012. Patterns and correlated of human-elephant conflict around a south Indian reserve. *Biological Conservation*, **148(1)**, 88-95.
- Gunn, J., 2009. *Human elephant conflict around Mikumi National Park, Tanzania: a quantitative evaluation.* Unpublished doctoral thesis, Anglia Ruskin University, UK.
- Gunn, J., Hawkins, D., Barnes, B. F. W., Mofulu, F., Grant, R. A., & Norton, G. W., 2014. The influence of lunar cycles on crop-raiding elephants; evidence for risk avoidance. *African Journal of Ecology*, **52(2)**, 129-137. doi: 10.1111/aje.12091.
- Hansen, A. J., & DeFries, R., 2007. Ecological mechanisms linking protected areas to surrounding lands. *Ecological Applications*, **17(4)**, 974-988.

- Harris, G. M., Russell, G. J., van Aarde, R. I., & Pimm, S. L., 2008. Rules of habitat use by elephants *Loxodonta africana* in southern Africa: insights for regional management. *Oryx*, **42(01)**, 66-75.
- Hart, B. L., Hart, L. A., & Pinter-Wollman, N., 2009. Large brains and cognition: where do elephants fit in? *Neuroscience and Biobehavioral Reviews*, **32(1)**, 86-98.
- Haturusinghe, H. S., & Weerakoon, D. K., 2012. Crop raiding behaviour of elephants in the northwestern region of Sri Lanka. *Gajah*, **36**, 26-31.
- Hayward, M. W., & Kerley, G. I. H., 2009. Fencing for conservation: Restriction of evolutionary potential or a riposte to threatening processes. *Biological Conservation*, **142(1)**, 1-13.
- Hedges, S., & Gunaryadi, D., 2010. Reducing human–elephant conflict: do chillies help deter elephants from entering fields? *Oryx*, **44(01)**, 139-146.
- Henderson, M. T., Merriam, G., & Wegner, J., 1985. Patchy environments and species survival: chipmunks in an agricultural mosaic. *Biological Conservation* **31(2)**, 95-105.
- Henein, K., & Merraim, G., 1990. The elements of connectivity where corridor quality is variable. *Landscape Ecology*, **4(2-3)**, 157-170.
- Hill, C. M., 1998. Conflicting attitudes towards elephants and conservation around the Budongo Forest Reserve, Uganda. *Environmental Conservation*, **25(03)**, 244-250.
- Hill, C. M., 1999. Conflict of interest between people and baboons: crop raiding in Uganda. *International Journal of Primatology*, **21(2)**, 299-315.
- Hill, C. M., 2002. Primate conservation and local communities–ethical issues and debates. *American Anthropologist*, **104(4)**, 1184-1194.

- Hill, C. M., 2005. People, crops and primates: A conflict of interests. pp. 40-59. In Paterson, J. D., & Wallis, J., (Eds.) *Commensalism and Conflict*: *The Human–Primate Interface*. The American Society of Primatologists, Oklahoma.
- Hill, C. M., & Webber, A. D., 2010. Perceptions of nonhuman primates in human–wildlife conflict scenarios. *American Journal of Primatology*, **72(10)**, 919-924.
- Hoare, R. E., 1997. The effects of interaction with people on elephant populations of the Sebungwe region, Zimbabwe. Unpublished DPhil Thesis, University of Zimbabwe.
- Hoare, R. E., 1999a. Determinants of human–elephant conflict in a land-use mosaic. *Journal of Applied Ecology*, **36(5)**, 689-700.
- Hoare, R. E., 1999b. Data collection and analysis protocol for human–elephant conflict situations in Africa. *Document prepared for the IUCN African Elephant Specialist Group's Human–Elephant Conflict Working Group, Nairobi*.
- Hoare, R. E., 2000. African elephants and humans in conflict: the outlook for co-existence. *Oryx*, **34(1)**, 34-38.
- Hoare, R. E., 2001a. A decision support system for managing human-elephant conflict situations in Africa. *IUCN/SSC African Elephant Specialist Group, Nairobi*, Kenya, 105.
- Hoare, R., 2001b. Management implication of new research on problem elephants. *Pachyderm*, **30**, 44-48.
- Hoare, R. E., & Du Toit, J., 1999. Coexistence between people and elephants in African savannas. *Conservation Biology*, **13(3)**, 633-639.
- Howe, H. F., & Smallwood, J., 1982. Ecology of seed dispersal. *Annual review of Ecology and Systematics*, **13**, 201-228.

- IUCN 2014. Nature Serve and IUCN (International Union for Conservation of Nature) 2008. *Elephas maximus.* In IUCN 2014. *IUCN Red List of Threatened Species. Version 2014.1*. http://www.iucnredlist.org. Downloaded on 21st August, 2014
- Imam, E., Yahya, H. S. A., & Malik, I., 2002. A successful mass translocation of commensal rhesus monkeys *Macaca mulatta* in Vrindaban, India. *Oryx*, **36(01)**, 87-93.
- Inskip, C., & Zimmermann, A., 2009. Human-felid conflict: a review of patterns and priorities worldwide. *Oryx*, **43(01)**, 18-34.
- Isack, H. A., & Reyers, H. U., 1989. Honeyguides and honey gatherers: interspecific communication in a symbiotic relationship. *Science*, **243**, 1343-1346.
- Jachmann, H., & Bell, R. H. V., 1984. The use of elephant droppings in assessing numbers, occupance, and age-structure: a refinement of the method. *African Journal of Ecology*, **22(2)**, 127-141.
- Jadhav, S., & Barua, M., 2012. The elephant vanishes: impact of human-elephant conflict on people's wellbeing. *Health & Place*, **18(6)**, 1356-1365.
- Jayewardene, J., 2011. Creating awareness among school children for wild elephant conservation. *GAJAH*, **34**, 41-45.
- Jones, T., Bamford, A. J., Ferrol-Schulte, D., Hieronimo, P., McWilliam, N., & Rovero, F., 2012. Vanishing wildlife corridors and options for restoration: a case study from Tanzania. *Tropical Conservation Science*, **5(4)**, 463-474.
- Jones, T., Caro, T., & Davenport, T. R. B., (Eds.). 2009. *Wildlife corridors in Tanzania*. Tanzania Wildlife Research Institute, Arusha, Tanzania. http://www.tzwildlifecorridors.org/ .Accessed on 05.08.14.

- Joshi, A. A., Mudappa, D., & Raman, T. S., 2009. Brewing trouble: coffee invasion in relation to edges and forest structure in tropical rainforest fragments of the Western Ghats, India. *Biological invasions*, **11(10)**, 2387-2400.
- Joshi, R., 2009. Asian elephant's *Elephas maximus* behaviour in the Rajaji National Park, North-West India: eight years with Asian elephant. *Nature and Science*, **7(1)**, 49-77.
- Joshi, R., & Singh, R., 2007. Asian elephants are losing their seasonal traditional movement tracks: A decade of study in and around the Rajaji National Park, India. *Gajah*, **27**, 15-26.
- Joshua, J., & Johnsingh, A. J. T., 1993. Ranging patterns of elephants in Rajaji National Park: Implications for reserve design. pp 256-260. In *A week with elephants* – Proceedings of the International Seminar on the Conservation of the Asian Elephant: Daniel, J. C., & Datye, H. S., (Eds.). Bombay, India: Oxford University Press.
- Jothish, P. S., 2013. Frugivory and seed dispersal of woody species by the Asian elephant (*Elephas maximus*) in a mid-elevation tropical evergreen forest in India. *Journal of Tropical Ecology*, **29(02)**, 181-185.
- Kalam, M. A., 2001. *Sacred groves in Kodagu district of Karnataka (South India): a socio-historical study*. Revised edition. Papers in Social Sciences, Institute Français de Pondichéry, Pondicherry.
- Kaltenborn, B. P., Bjerke, T., Nyahongo, J. W., & Williams, D. R., 2006. Animal preferences and acceptability of wildlife management actions around Serengeti National Park, Tanzania. *Biodiversity & Conservation*, **15(14)**, 4633-4649.

- Kangwana, K., 2011. The behavioral responses of elephants to the Maasai in Amboseli. pp. 307-317. In Moss, C. J., Croze, H., & Lee, P. C., (Eds.), *The Amboseli Elephants*. Chicago: University of Chicago Press.
- Kanwana, K. F., 1993. Elephants and Maasai: conflict and conservation in Amboseli, Kenya. Unpublished doctoral thesis, University of Cambridge, UK.
- Karanth, K. K., Gopalaswamy, A. M., Prasad, P. K., & Dasgupta, S., 2013. Patterns of human–wildlife conflicts and compensation: insights from Western Ghats protected areas. *Biological Conservation*, **166**, 175-185.
- Karanth, K. U., 1995. Estimating tiger *Panthera tigris* populations from camera-trap data using capture–recapture models. *Biological Conservation*, **71(3)**, 333-338.
- Karanth, K. U., & Nichols, J. D., 1998. Estimation of tiger densities in India using photographic captures and recaptures. *Ecology*, **79(8)**, 2852-2862.
- Karanth, K. U., Nichols, J. D., Kumar, N. S., & Hines, J. E., 2006. Assessing tiger population dynamics using photographic capture–recapture sampling. *Ecology*, **87(11)**, 2925-2937.
- Karanth, K. U., & Sunquist, M. E., 1992. Population structure, density and biomass of large herbivores in the tropical forests of Nagarahole, India. *Journal of Tropical Ecology*, **8(01)**, 21-35.
- Karanth, K. U., & Sunquist, M. E., 2000. Behavioural correlates of predation by tiger (*Panthera tigris*), leopard (*Panthera pardus*) and dhole (*Cuon alpinus*) in Nagarhole, India. *Journal of Zoological Society of London*, **250(02)**, 255-265.
- Kemf, E., & Santiapillai, C., 2000. *Asian Elephants in the Wild*. A WWF Species status report. WWF, International Species Conservation Unit, Gland, Switzerland.

- King, L. E., 2010. The interaction between the African elephant (*Loxodonta africana africana*) and the African honey bee (*Apis mellifera scutellata*) and its potential application as an elephant deterrent. Unpublished D. Phil Thesis, University of Oxford, Oxford.
- King, L. E., 2011. Beehive fence construction manual (First Edition). Elephants and Bees Project, Save the elephants, Kenya.
- King, L. E., 2012. Beehive fence construction manual (Second Edition). Elephants and Bees Project, Save the elephants, Kenya. Retrieved from http://elephantsandbees.com/wp-content/uploads/2013/08/Beehive-Fence-Construction-Manual-2012.pdf on 15th July, 2014.
- King, L. E., Douglas-Hamilton, I., & Vollrath, F., 2007. African elephants run from the sound of disturbed bees. *Current Biology*, **17(19)**, R832-R833.
- King, L. E., Douglas-Hamilton, I., & Vollrath, F., 2011. Beehive fences as effective deterrents for crop-raiding elephants: field trials in Northern Kenya. *African Journal of Ecology*, **49(4)**, 431-439.
- King, L. E., Lawrence, A., Douglas-Hamilton, I., & Vollrath, F., 2009. Beehive fence deters crop-raiding elephants. *African Journal of Ecology*, **47(2)**, 131-137.
- King, L. E., Soltis, J., Douglas-Hamilton, I., Savage, A., & Vollrath, F., 2010. Bee threat elicits alarm call in African elephants. *PloS One*, **5(4)**, e10346. doi:10.1371/journal.pone.0010346.
- Kioko, J., Muruthi, P., Omondi, P., & Chiyo, P. I., 2008. The performance of electric fences as elephant barriers in Amboseli, Kenya. *South African Journal of Wildlife Research*, **38(1)**, 52-58.

- Kitamura, S., Yumoto, T., Poonswad, P., Chuailua, P., Plongmai, K., Maruhashi, T., & Noma, N., 2002. Interactions between fleshy fruits and frugivores in a tropical seasonal forest in Thailand. *Oecologia*, **133(4)**, 559-572.
- Kitamura, S., Yumoto, T., Poonswad, P., & Wohandee P., 2007. Frugivory and seed dispersal by Asian elephants, *Elephas maximus*, in a moist evergreen forest of Thailand. *Journal of Tropical Ecology*, **23(03)**, 373-376.
- Kulkarni, J., Mehta P., Bhoominathan, D., & Chaudhuri S., 2007. *A study of man-elephant conflict in Nagarhole National Park and surrounding areas of Kodagu district in Karnataka, India: Final Report*. Envirosearch, Pune.
- Kumar, A., Mudappa, D., & Raman, T. S., 2010. Asian elephant *Elephas maximus* habitat use and ranging in fragmented rainforest and plantations in the Anamalai Hills, India. *Tropical Conservation Science*, **3(2)**, 143-158.
- Kuriyan, R., 2002. Linking local perceptions of elephants and conservation: Samburu pastoralists in Northern Kenya. *Society & Natural Resources*, **15(10)**, 949-957.
- Laurance W. F., & Bierregaard R. O., 1997. *Tropical Forest Remnants: Ecology, Management and Conservation of Fragmented Communities*. Chicago, IL: The University of Chicago Press.
- Laws, R. M., 1966. Age criteria for the African elephant, *Loxodonta africana*. *African Journal of Ecology*, **4(1)**, 1-37
- Laws, R. M., 1969. Aspects of reproduction in the African Elephant, *Loxodonta africana*. *Journal of Reproduction and Supplement*, **6**, 193-217.
- Laws R. M., Parker I. S. C., & Johnstone R. C. B., 1975. *Elephants and their habitats: the ecology of elephants in North Bunyoro, Uganda*. Oxford: Clarendon Press.

- Lee, P. C., 2004. Who wins? Human-primate conflict in the context of conservation, development and gender. *Primate Eye*, **84,** 15-16.
- Lee, P. C., 2010. Sharing space: can ethnoprimatology contribute to the survival of nonhuman primates in human-dominated globalized landscapes? *American Journal of Primatology*, **72(10)**, 925-931.
- Lee, P. C., & Graham, M. D., 2006. African elephants *Loxodonta africana* and human-elephant interactions: implications for conservation. *International Zoo Yearbook*, **40(1)**, 9-19.
- Lee, P. C., & Priston, N. C., 2005. Human attitudes to Primates: perceptions of pests, conflict and consequences for primate conservation. In Paterson, J. D., & Wallis, J., (Eds.), *Commensalism and conflict: the human-primate interface*. Volume 4, pp. 1-23. The American Society of Primatologists, Norman, Oklahoma.
- Lee, P. C., & Moss, C. J., 1986. Early maternal investment in male and female African elephant calves. *Behavioural Ecological and Sociobiology*, **18**, 353-361.
- Lee, P. C., & Moss, C. J., 1995. Statural growth in known-age African elephants (*Loxodonta africana*). *Journal of Zoology*, **236,** 29–41. doi: 10.1111/j.1469-7998.1995.tb01782.x.
- Lee, P. C. & Moss, C. J., 1999. The social context for learning and behavioural development among wild African elephants. In Box, H. O., & Gibson, K. R., (Eds.) *Mammalian Social Learning; Symposium of the Zoological Society of London* 72, pp. 102-125. Cambridge University Press, Cambridge.
- Lee, P. C., (In Press). People, Perceptions and “pests”: human-wildlife interactions and the politics of conflict. In Understanding the social dimension

of human-wildlife conflict in the 21st Century. Hill, K., Webber, A., & Priston, N. (Eds.) Berghahn Press, Oxford.

- Leimgruber, P., Azmi, W., Baishya, H., Campos-Arceiz, A., Fernando, P., Jitvijak, W., Maltby, M., Pastorini, J., Pradhan, N. M. B., Ritthrat, J., Stewart-Cox, B., & Williams, C., 2011. Workshop on developing adaptive management for mitigating human-elephant conflict across Asia. *GAJAH*, **34**, 63-66.
- Lenin, J., & Sukumar, R., 2011. Action Plan for the Mitigation of Elephant-Human Conflict in India. Final Report to the U.S. Fish and Wildlife Service. Asian Nature Conservation Foundation, Bangalore.
- Linkie, M., Dinata, Y., Nofrianto, A., & Leader-Williams, N., 2007. Patterns and perceptions of wildlife crop raiding in and around Kerinci Seblat National Park, Sumatra. *Animal Conservation*, **10**, 127-135.
- Loarie, S. R., Aarde, R. J. V., & Pimm, S. L., 2009. Fences and artificial water affect African savannah elephant movement patterns. *Biological Conservation*, **142(12)**, 3086-3098.
- Madhusudan, M. D., 2003. Living amidst large wildlife: livestock and crop depredation by large mammals in the interior villages of Bhadra Tiger Reserve, south India. *Environmental Management*, **31**, 466-475.
- Magliocca, F., Querouil, S., & Gautier-Hion, A., 2003. Seed eating in elephant dung by two large mammals in the Congo Republic. *La Terre et la Vie-Revue d’Ecologie*, **58**, 143-149.
- Mahanty, S., 2003. Insights from a cultural landscape: Lessons from landscape history for the management of Rajiv Gandhi (Nagarhole) National Park. *Conservation Science*, **1(1)**, 23-47.

- Margules, C., & Pressey, R., 2000. Systematic conservation planning. *Nature*, **405(6783)**, 243-253.
- Marshall, K., White R., & Anke, F., 2007. Conflicts between humans over wildlife management: on the diversity of stakeholder attitudes and implications for conflict management. *Biodiversity Conservation*, **16**, 3129-3146.
- Matthiopoulos, J., Smout, S., Winship, A. J., Thompson, D., Boyd, I. L., & Harwood, J., 2008. Getting beneath the surface of marine mammal–fisheries competition. *Mammal Review*, **38**, 167-188.
- McComas, K. A., 2006. Defining Moments in Risk Communication Research: 1996-2005. *Journal of Health Communication*, **11**, 75-91.
- McComb, K., Moss, C., Durant, S. M., Baker, L., & Sayialel, S., 2001. Matriarchs as repositories of social knowledge in African elephants. *Science*, **292**, 491-494.
- McKay, G. M., 1973. The ecology and behaviour of the Asiatic elephant in southeastern Ceylon, *Smithsonian Contribution to Zoology*, **125**, 1-113.
- McQuail, D., 2010. *McQuail's mass communication theory*. 6th Edition. Sage, London.
- Mehta, P., & Kulkarni, J., 2013. Past, Present and future of Wild Elephants in Maharshtra, India. *Gajah*, **39**, 3-11.
- Mishra, C., Allen, P., McCarthy, T., Madhusudan, M., Bayarjargal, A., & Prins, H., 2003. The role of incentive programmes in conserving the snow leopard. *Conservation Biology*, **17**(6), 1512-1520.
- Morgan, B. J., 2009. *Sacoglottis gabonensis*–a keystone fruit for forest elephants in the Réserve de Faune du Petit Loango, Gabon. *African Journal of Ecology*, **47(2)**, 154-163.

- Morgan, B. J., & Lee, P. C., 2003. Forest elephant (*Loxodonta africana cyclotis*) stature in the Réserve de Faune du Petit Loango, Gabon. *Journal of Zoology*, **259,** 337–344. doi: 10.1017/S0952836902003291.
- Morgan, B., & Lee, P. C., 2007. Forest elephant group composition, frugivory and coastal use in the Réserve de Faune du Petit Loango, Gabon. *African Journal of Ecology*, **45(4)**, 519-526.
- Morrison, T. A., Chiyo, P. I., Moss, C. J., & Alberts, S. C., 2005. Measures of dung bolus size for known-age African elephants (*Loxodonta africana*): implications for age estimation. *Journal of Zoology*, **266**, 89-94. doi: 10.1017/S0952836905006631.
- Moss, C. J., 1996. Getting to know a population. In Studying elephants, African Wildlife Foundation Technical Handbook Series 7: 58–74. Kangwana, K., (Ed.). Nairobi: AWF.
- Moss, C. J., 2001. The demography of an African elephant (*Loxodonta africana*) population in Amboseli, Kenya. *Journal of Zoology*, **255**, 145-156. doi: 10.1017/S0952836901001212.
- Moss, C. J., & Poole, J. H., 1983. Relationships and social structure of African elephants. In: Hinde RA (Ed.) *Primate social relationships*. Sinauer, Sunderland, pp 315-325.
- Mulder, M. B., Schacht, R., Caro, T., Schacht, J., & Caro, B., 2009. Knowledge and attitudes of children of the Rupununi: Implications for conservation in Guyana. *Biological Conservation*, **142(4)**, 879-887.
- Muthuramkumar, S., Ayyappan, N., Parthasarthy, N., Mudappa, D., Raman, T. R., Selwyn, M. A., & Pragasan, L. A., 2006. Plant community structure in

tropical rain forest fragments of the Western Ghats, India. *Biotropica*, **38(2)**, 143-160.

- Myers, N., Mittermeier, R. A., Mittermeier, C. G., da Fonseca, G. A. B., & Kent, J., 2000. Biodiversity hotspots for conservation priorities. *Nature*, **403**, 853-858.
- Nair, P. K. R., 1992. *An introduction to agroforestry*. Kluwer Academic Publishers, The Netherlands.
- Nair, P. V., & Gadgil, M., 1978. The status and distribution of elephant populations of Karnataka. *Journal of Bombay natural History Society*, **75(Suppl.)**, 1000-1016.
- Nair, P. V., Sukumar, R., & Gadgil, M., 1980. The elephant in South India – A review. In: Daniel, J. C., (Ed.). *The status of the Asian Elephant in the Indian sub-continent*. IUCN/SSC Report. *Bombay Natural History Society*. 9-19.
- Narayana, M. H., 2009. The cultural and socio-economic impact on the attitudes of people towards elephants in Kodagu, Southern India. Unpublished M. Sc Thesis, Stirling University.
- Nath, C., & Sukumar, R., 1998. Elephant-human conflict in Kodagu, Southern India: distribution patterns, people's perceptions and mitigation methods. *Unpublished report*, Asian Elephant Conservation Centre, Bangalore.
- Naughton-Treves, L., 1997. Farming the forest edge: vulnerable places and people around Kibale National Park, Uganda. *The Geographical Review*, **87**, 27-46.
- Naughton-Treves, L., 1998. Predicting patterns of crop damage by wildlife around Kibale National Park, Uganda. *Conservation Biology*, **12**, 156-168.
- Naughton-Treves, L., Alvarez-Berríos, N., Brandon, K., Bruner, A., Holland, M. B., Ponce, C., Saenz, M., Suarez, L., & Treves, A., 2006. Expanding protected

areas and incorporating human resources use: A study of 15 forest parks in Ecuador and Peru. *Sustainability: Science, Practice, and Policy*, **2(2)**, 32-44.

- Naughton-Treves, L., Rose, R., & Treves, A., 1999. *The Social Dimension of Human–Elephant Conflict in Africa: A Literature Review and Case Studies from Uganda and Cameroon*. Gland, Switzerland: IUCN African Elephant Specialist Group.
- Naughton-Treves, L., & Treves, A., 2005. Socio-ecological factors shaping local support for wildlife: crop-raiding by elephants and other wildlife in Africa In: Woodroffe, R., Thirgood, S., and Rabinowitz, A., (Eds.). *People and Wildlife: Conflict or Coexistence?* Cambridge University Press, Cambridge. pp 252-277**.**
- Neilson, J., 2008. Environmental governance in the coffee estates of Kodagu, South India. *Transforming Cultures ejournal*, **3(1)**, 185-195.
- Nelson, A., Bidwell, P., & Sillero-Zubiri, C., 2003. *A review of human elephant conflict management strategies*. People and Wildlife Initiative. Wildlife Conservation Research Unit, Oxford University.
- Newby, J. R., Scott Mills, L., Ruth, T. K., Pletscher, D. H., Mitchell, M. S., Quigley, H. B., Murphy, K. M., & DeSimone, R., 2013. Human-caused mortality influences spatial population dynamics: Pumas in landscapes with varying mortality risks. *Biological Conservation*, **159**, 230-239.
- Newmark, W. D., Boshe, J. I., Sariko, H. I., & Makumbule, G. K., 1996. Effects of a highway on large mammals in Mikumi National Park, Tanzania. African *Journal of Ecology,* **34**, 15-31.
- Ninan, K. N., & Sathyapalan, J., 2005. The economics of biodiversity conservation: a study of a coffee growing region in the Western Ghats of India. *Ecological Economics*, **55(1)**, 61-72.

- Normand, E., & Boesch, C., 2009. Sophisticated Euclidean maps in forest chimpanzees. *Animal Behaviour*, **77**, 1195-1201.
- Nyhus, P. J., Tilson, R., & Sumianto, P., 2000. Crop Raiding Elephants and conservation Implication at Way Kambas National Park, Sumatra, Indonesia. *Oryx*, **43,** 262.
- Ogada, M. O., Woodroffe, R., Oguge, N. O., & Frank, L. G., 2003. Limiting depredation by African carnivores: the role of livestock husbandry. *Conservation Biology*, **17**, 1521-1530.
- Ogra, M. V., 2008. Human-wildlife conflict and gender in protected area borderlands: A case study of costs, perceptions, and vulnerabilities from Uttarakhand (Uttaranchal), India. *Geoforum*, **39**, 1408-1422.
- Ogutu, J. O., Owen-Smith, N., Pipeho, H. P., & Said, M. Y., 2011. Continuing wildlife population declines and range contraction in the Mara region of Kenya during 1977-2009. *Journal of Zoology*, **285(2)**, 99-109.
- Olson, D. M., Dinerstein, E., Wikramanayake, E. D., Burgess, N. D., Powell, G. V. N., Underwood, E. C., D'Amico, J. A., Itoua, I., Strand, H. E., Morrison, J. C., Loucks, C. J., Allnutt, T. F., Ricketts, T. H., Kura, Y., Lamoreux, J. F., Wettengel, W. W., Hedao, P., & Kassem, K. R., 2001. Terrestrial ecoregions of the worlds: a new map of life on Earth. *Bioscience*, **51**, 933-938.
- Osborn, F. V., 1998. The ecology of crop-raiding elephants in Zimbabwe. Unpublished doctoral thesis. University of Cambridge, UK,
- Osborn, F. V., 2004. Seasonal variation of feeding patterns and food selection by crop-raiding elephants in Zimbabwe. *African Journal of Ecology*, **42**, 322–327. doi: 10.1111/j.1365-2028.2004.00531.x

- Osborn, F. V., & Parker, G. V., 2003. Towards an integrated approach for reducing the conflict between elephants and people: a review of current research. *Oryx*, **37**, 80-84.
- Osborn, F. V., & Hill, C. M., 2005. Techniques to reduce crop loss: human and technical dimensions in Africa. In: Woodroffe, R., Thirgood, S., and Rabinowitz, A., (Eds.). *People and Wildlife: Conflict or Coexistence?* Cambridge University Press, Cambridge.
- Parker, I. S. C., & Graham, A. D., 1989. Elephant decline: Downward trends in African elephant distribution and numbers. Parts I & II. *International Journal of Environmental Studies*, **34**, 13-26 & 287-305.
- Parker, G., & Osborn, F., 2006. Growing chilli as a means of reducing human–wildlife conflict in Zimbabwe. *Oryx*, **40**, 343-346.
- Pascal, J. P., & Meher-Homji, V. M., 1986. Phytochorology of Kodagu (Coorg) district, Karnataka. *Journal of BombayNatural History Society*, **83**, 43-56.
- Patterson, B. D., Kasiki, S. M., Selempo, E., & Kays, R. W., 2004. Livestock predation by lions (*Panthera leo*) and other carnivores on ranches neighbouring Tsavo National Parks, Kenya. *Biological Conservation*, **119(4)**, 507-516.
- Paugy, M., Bailon, F., Chevaler, D., & Duponnois, R., 2004. Elephants as dispersal agents of mycorrhizal spores in Burkina Faso. *African Journal of Ecology*, **42**, 225-227.
- Peterson, M. N., Peterson, T. R., Peterson, M. J., Lopez, R. R., & Silvy, N. N., 2002. Cultural conflict and the endangered Florida key Deer. *Journal of Wildlife Management*, **66**, 947-968.
- Peterson, M. N., Chen X. D., & Liu J. G., 2008. Household location choices: implications for biodiversity conservation. *Conservation Biology*, **22**, 912-921.

- Peterson, M., Brickhead, J. L., Leong, K., Peterson, M. J., & Peterson, T. R., 2010. Rearticulating the mytho of human-wildlife conflict. *Conservation Letters*, **3**, 74-82. doi: 10.1111/j.1755-263X.2010.00099.x.
- Pittiglio, C., Skidmore, A. K., van Gils, H. A., McCall, M. K., & Prins, H. H., 2014. Smallholder farms as stepping stone corridors for crop-raiding elephant in northern Tanzania: integration of Bayesian expert system and network simulator. *AMBIO*, **43(2)**, 149-161.
- Priston, N. E. C., 2005. Crop raiding by *Macaca ochreata brunnescens* in Sulawesi: Reality, perceptions and outcomes for conservation. Unpublished doctoral thesis. University of Cambridge, UK.
- Pouchepadass, J., 1990. The ecological history of the central Western Ghats in the modern period: A preliminary survey. Pondy Papers in Social Sciences, Department of Social sciences, French Institute, Pondicherry.
- Power, R. J., & Compion, R. S., 2009. Lion predation on elephants in the Savuti, Chobe national park, Botswana. *African Zoology*, **44(1)**, 36-44.
- Ramakrishnan, P. S., Chandrashekar, U. M., Elouard, C., Guilmoto, C. Z., Maikhuri, R. K., Rao, K. S., Sankar, S., & Saxena, K. G., (Eds.), 2000. *Mountain Biodiversity, Land Use Dynamics, and Traditional Ecological Knowledge*. New Delhi, India, UNESCO, Oxford and IBH Publishing Co. Pty. Ltd.
- Ramakrishnan, U., Santosh, J. A., Ramakrishnan, U., & Sukumar, R., 1998. The population and conservation status of Asian elephants in the Periyar Tiger Reserve, southern India. *Current Science*, **74**, 110-113.
- Ramkumar, K., Ramakrishnan, B., Karthick, S., & Saravanamuthu, R., 2014. Human and Elephant (*Elephas maximus*) deaths due to conflict in Coimbatore

Forest Division, Tamil Nadu, India. *Magazine of Zoo Outreach Organization - Zoo's Print*, **29(8)**, 12-19.

- Ramsbotham, O., Woodhouse, T., & Miall, H., 2011. *Contemporary Conflict Resolution*. Third Edition, Polity Press, Cambridge.
- Rangarajan, M., Desai, A., Sukumar, R., Easa, P. S., Menon, V., Vincent, S., Suparna Ganguly, Talukdar, B. K., Brijendra, S., Mudappa, D., Chowdhary, S., & Prasad, A. N., 2010. *Gajah: Securing the Future for Elephants in India*. Report of the Elephant Task Force, Ministry of Environment and Forests, August 31, 2010.
- Reddy, B. D. R., 2013. *Database on coffee*. Coffee Board of India, Bangalore. Retrieved from http://www.indiacoffee.org/CoffeeBoard/DATABASEOct13_I.pdf on 15th July, 2014.
- Redpath, S. M., Steve, M., Young, J., Evely, A., Adams, W. M., Sutherland, W. J., Whitehouse, A., Amar, A., Lambert, R. A., Linnell, D. C., Watt, A., & Guitiérrez, R. J., 2013. Understanding and managing conservation conflicts. *Trends in Ecology & Evolution*, **28(2)**, 100-109.
- Redpath, S. M., Bhatia, S., & Young, J., 2014. Tilting at wildlife: reconsidering hiuman-wildlife conflict. *Oryx*, 1-4. doi: http:// dx.doi.org/10.1017/S0030605314000799.
- Reilly, J., 2002. Growth in the Sumatran elephant (*Elephas maximus sumatranus*) and age estimation based on dung diameter. *Journal of Zoology*, **258**, 205-213. doi: 10.1017/S0952836902001322.
- Ricketts, T. H., 2001. The matrix matters: effective isolation in fragmented landscapes. *The American Naturalist*, **158(1)**, 87-99.

- Riley, E. P., 2006. Ethnoprimatology: Toward reconciliation of biological and cultural anthropology. *Ecological and Environmental Anthropology*, **2**, 75-86.
- Riddle, H. S., Schulte, B. A., Desai, A. A., & Meer, L. V. D., 2010. Elephants – a conservation overview. *Journal of Threatened Taxa*, **2**, 653-661.
- Samansiri, K. A. P., & Weerakoon, D. K.,. 2008. A study on the seed dispersal capability of Asian elephants in the northwestern region of Sri Lanka. *GAJAH*, **28**, 19-24.
- Santiapillai, C., & Jackson, P., 1990. *The Asian elephant: An action plan for its conservation*. IUCN/SSC Asian Elephant Specialist Group, IUCN, Galnd.
- Santiapillai, C., & Read, B., 2010. Would masking the smell of ripening paddy-fields help mitigate human–elephant conflict in Sri Lanka?. *Oryx*, **44(04)**, 509-511.
- Santiapillai, C., & Widodo, S. R., 1993. Why do elephants raid crops in Sumatra. *GAJAH*, **11**, 55-58.
- Sathish, B. N., & Kushalappa, C. G., 2006. An insight into the Socio-economic view of Coffee based agro forestry systems of Kodagu: a small scale forestry. In *Small-scale forestry and rural development: the intersection of ecosystems, economics and society*. *Proceedings of IUFRO 3.08 Conference, hosted by Galway-Mayo Institute of Technology, Galway, Ireland, 18-23 June 2006*. (pp. 433-436). National Council for Forest Research and Development (COFORD).
- Saunders, D. A., Hobbs, R. J., & Margules, C. R., 1991. Biological consequences of ecosystem fragmentation: a review. *Conservation Biology*, **5(1)**, 18-32.

- Sekhar, N. U., 1998. Crop and livestock depredation caused by wild animals in protected areas: the case of Sariska Tiger Reserve, Rajasthan, India. *Environmental Conservation*, **25**, 160-171.
- Seneviratne, L., & Rossel, G. D., 2008. Restoring Interdependence between people and elephants. In Wemmer, C., & Christen, C. A., (Eds.) *Elephants and ethics: Toward a morality of coexistence*, pp 349-360. The John Hopkins University Press, Baltimore.
- Sha, A. A., 1987. Working plan for Kodagu forest division, Karnataka State Forest Department, Working Plan Division, Mysore. Part I (1987 - 1996), Part II (1987 - 1996).
- Short, J., 1981. Diet & feeding-behavior of the forest elephant. *Mammalia* **45**,177-185.
- Shoshani, J., 1998. Understanding proboscidean evolution: a formidable task. *Trends in Ecology and Evolution*. **13**, 480-487.
- Shrader, A. M., Ferreira, S. M., McElveen, M. E., Lee, P. C., Moss, C. J., & Van Aarde, R. J., 2006. Growth and age determination of African savanna elephants. *Journal of Zoology*, **270(1)**, 40-48.
- Siex, K. S., & Struhsaker, T. T., 1999. Colobus monkeys and coconuts: as study of perceived human-wildlife conflict. *Journal of Applied Ecology*, **36**, 1009-1020
- Sitati, N. W., Walpole, M. W., Leader-Williams, N., & Stephenson, P. J., 2012. Human–elephant conflict: Do elephants contribute to low mean grades in schools within elephant ranges? *International Journal of Biodiversity and Conservation*, **4(15)**, 614-620.

- Sitati, N. W., Walpole, M. J., Smith, R. J., & Leader-Williams, N., 2003. Predicting spatial aspects of human–elephant conflict. *Journal of Applied Ecology*, **40(4)**, 667-677.
- Sivaganesan, N., & Johnsingh, A. J. T., 1995. Food resources crucial to the wild elephants in Mudumalai wildlife sanctuary, south India. Pages 405-423 in J. C. Daniel. J. C., & Datye, H., (Eds.). *A week with elephants*. Bombay Natural History Society, Bombay and Oxford University Press, New Delhi, India.
- Smith, R. J., & Kasiki, S. M., 2000. A spatial analysis of human-elephant conflict in the Tsavo ecosystem, Kenya. A Report to the African Elephant Specialist Group, Human-Elephant Conflict Task Force, of IUCN. Gland.
- Stokke, S., & du Toit, J. T., 2002. Sexual segregation in habitat use by elephant in Chobe National Park, Botswana. *African Journal of Ecology*, **.40**, 360-371.
- Sukumar, R., 1986. Elephant-man conflict in Karnataka. In: Saldanha, C. J., (Ed.) Karnataka – State of Environment 1984-85 Report. Centre for Taxonomic Studies, Bangalore.
- Sukumar, R., 1989. *The Asian Elephant: Ecology and Management*. Cambridge University Press, Cambridge.
- Sukumar, R., 1990. Ecology of the Asian elephant in southern India. II. Feeding habits and crop raiding patterns. *Journal of Tropical Ecology* **6**, 33-53.
- Sukumar, R., 1991. The management of large mammals in relation to male strategies and conflict with people. *Biological Conservation*, **55**, 93-102.
- Sukumar, R., 1994. Elephant Days and Nights: Ten Years with the Indian Elephant. Oxford University Press, New Delhi.
- Sukumar, R., 2003. *The Living Elephants: Evolutionary ecology, Behaviour, and Conservation*. Oxford University Press, Oxford.

- Sukumar, R., 2006: A brief review of the status, distribution and biology of wild Asian elephants *Elephas maximus*. *International Zoo Yearbook*, **40**, 1-8. Sukumar, R., 2011. *The story of Asia's elephants*. The Marg Foundation, Mumbai.
- Sukumar, R., & Gadgil, M., 1988. Male-female differences in foraging on crops by Asian elephants. *Animal Behaviour*, **36,** 1233-1255.
- Sukumar, R., Desai, A., Lele, S., Basappanavar, C. H., Bist, S. S., Kamath, R. N., Deepak, B. R., Angadi, V. V., Madhusudan, M. D., Principal Chief Conservator of Forests (Karnataka), Principal Chief Conservator of Forests (Kerala), Principal Chief Conservator of Forests (Tamil Nadu), and Chief Conservator of Forests and Field Director, Mysore Elephant Reserve, 2012. Report of the Karnataka Elephant Task Force. Submitted to Honourable High Court of Karnataka.
- Sukumar, R., & Santiapillai, C., 1996. *Elephas maximus*: status and distribution. Pp.327-331. In: Shoshani, J., & Tassy, P., (Eds.) The Proboscidea: Evolution and Palaeoecology of Elephants and Their Relatives, Oxford University Press, Oxford. Part VI, Chapter 33
- Suryawanshi, K. R., Bhatnagar, Y. V., Redpath, S., & Mishra, C., 2013. People, predators and perceptions: Patterns of livestock depredation by snow leopards and wolves. *Journal of Applied Ecology*, **50(3)**, 550-560.
- Takasaki, H., 1989. Mahale chimpanzees taste mangoes – toward acquisition of a new food item? *Primates*, **24**, 273-275.
- Tchamba, M., 1996. History and present status of the human/elephant conflict in the Waza-Logone region, Cameroon, West Africa. *Biological Conservation*, **75**, 35-41.

- Theuerkauf, J., Ellenberg, H., Waitkuwait, W. E., & Mühlenberg, M., 2001. Forest elephant distribution and habitat use in the Bossematié Forest Reserve, Ivory Coast. *Pachyderm*, **30**, 37-43.
- Theurekauf, J., Waitkuwait, W. E., Guiro, Y., Ellenberg, H., & Porembski, S., 2000. Diet of forest elephants and their role in seed dispersal in the Bossematié Forest Reserve, Ivory Coast. *Mammalia*, **64(4)**, 447-460.
- Thompson, W., (Ed.). 2004. *Sampling rare or elusive species: concepts, designs, and techniques for estimating population parameters*. Island Press.
- Thouless, C., 1994. Conflict between humans and elephants on private land in northern Kenya. *Oryx*, **28(2)**, 119-127.
- Thouless, C. R., 1995. Long distance movements of elephants in northern Kenya. *African Journal of Ecology*, **33**, 321-334.
- Vanak, T. A., Thaker, M., & Slotow, R., 2010. Do fences create an edge-effect on the movement patterns of a highly mobile mega-herbivore? *Biological Conservation*, **143(11)**, 2631-2637.
- Vanleeuwe, H., & Gautier-Hion, A., 1998. Forest elephant paths and movements at the Odzala National Park, Congo: the role of clearings and Marantaceae forests. *African Journal of Ecology*, **36(2)**, 174-182.
- Varma, S., Avinash, K.G., & Vinay, L., 2011. Human-elephant conflict in Mysore Forest Division: patterns, causes and responses. Asian Nature Conservation Foundation, Bangalore, India.
- Varma, S., Baskaran, N., & Sukumar, R., 2012. Field key for Elephant Population estimatin and Age and Sex Classification. Resource material for synchronized elephant population count using block count, line transect dung count method and waterhole count.Asian Nature Conservation Foundation,

Innovation Centre, Indian Institute of Science, Bangalore - 560 012, Karnataka and Centre for Ecological Sciences, Indian Institute of Science, Bangalore - 560 012, Karnataka.

- Varma, S., Dang, N. X., Thanh, V., & Sukumar, R., 2008. The Asian elephants *Elephas maximus* of Cat Tien National Park, Vietnam: status and conservation of a vanishing population. *Oryx*, **42**, 92-99.
- Vattam, S. S., 2014. 101 Jumbos Dead in Last 9 Months. *The New Indian Express*, Retrieved from http://www.newindianexpress.com/states/karnataka/101-Jumbos-Dead-in-Last-9-Months/2014/01/21/article2011406.ece on 31st January, 2014.
- Venkataraman, A. B., Saandeep, R., Baskaran, N., Roy, M., Madhivanan, A., & Sukumar, R., 2005. Using satellite telemetry to mitigate elephant–human conflict: an experiment from northern West Bengal, India. *Current Science*, **88**, 1827-1831.
- Vilojen, P. J., 1989. Spatial distribution and movements of elephants (*Loxodonta africana*) in the northern Namib Desert region of the Kaokoveld, South West Africa/Namibia. *South African Journal of Zoology*, **219,** 1-19.
- Vollrath, F., & Douglas-Hamilton, I., 2002. African bees to control African elephants. *Naturwissenschaften*, **89(11)**, 508-511.
- Wakanakar, S. Y., & Mhasikar, V. B., 2006. *Maharsi Pālakāpya's Gajaśāstram*, Bharatiya Kala Prakashan, Delhi, India.
- Walpole, M. J., Nabaala, M., & Matankory, C., 2004. Status of the Mara Woodlands in Kenya. *African Journal of Ecology*, **42**, 180-188. doi: 10.1111/j.1365-2028.2004.00510.x.

- Wasser, S., Poole, J., Lee, P., Lindsay, K., Dobson, A., Hart, J., Douglas-Hamilton, I., Wittemyer, G., Granli, P., Morgan, B., Gunn, J., Alberts, S., Beyers, R., Chiyo, P., Croze, H., Estes, R., Gobush, K., Joram, P., Kikoti, A., Kingdon, J., King, L., Macdonald, D., Moss, C., Mutayoba, B., Njumbi, S., Omondi, P., Nowak, K., 2010. Elephants, ivory, and trade. *Science,* **327**, 1331-1332.
- Webber, A., 2006. Primate crop raiding in Uganda: actual and perceived risks around Budongo Forest Reserve. Unpublished doctoral thesis. Oxford Brookes University.
- Webber, E. C., Sereivathana, T., Maltby, M. P., & Lee. P. C., 2011. Elephant crop-raiding and human–elephant conflict in Cambodia: crop selection and seasonal timings of raids. *Oryx*, **45**, 243-251. doi:10.1017/S0030605310000335.
- Wegner, J., & Merriam, G., 1990. Use of spatial elements in a farmland mosaic by a woodland rodent. *Biological Conservation*, **54**, 263-276.
- Western, D., Moss, C. J., & Georgiadis, N., 1983. Age estimation and population age structure of elephants from footprint dimensions. *Journal of Wildlife Management*, **47,** 1192-1197.
- White, L. J. T., 1994. *Sacoglottis gabonensis* fruiting and the seasonal movements of elephants in the Lopé Reserve, Gabon. *Journal of Tropical Ecology*, **10(1)**, 121-125.
- White, L. J. T., Tutin, C. E. G., & Fernandez, M., 1993. Group composition and diet of forest elephants, *Loxodonta africana cyclotis* Matschie 1900, in the Lope Reserve, Gabon. *African Journal of Ecology*, **31**, 81-199.
- White, R. M., Fischer, A., Marshall, K., Travis, J. M. J., Webb, T. J., di Falco, S., Redpath, S. M., & van der Wal, R., 2009. Developing an integrated

conceptual framework to understand biodiversity conflicts. *Land Use Policy*, **26**, 242 – 253.

- Williams, A. C., 2009. Space Use by Asian Elephants (*Elephas maximus*) in Rajaji National Park, North West India: Implications for elephants held in captivity. In: *An Elephant in the Room: The Science and Well-being of Elephants in Captivity*. Edited by Forthman, D. L., Kane, L. F., Waldau, P. F., and Atkinson, R. P. D. Tufts Center for Animals and Public Policy, USA
- Williams, A. C., Johnsingh, A. J. T., & Krausman, P., 2001. Elephant-human conflicts in Rajaji National Park, north western India. *Wildlife Society Bulletin*, **29**, 1097-1104.
- Williams, B. K., Nichols, J. D., & Conroy, M. J., 2002. *Analysis and management of animal populations*. San Diego: Academic Press
- Willis, K., Gillson, L., & Brncic, T. M., 2004. How "virgin" is virgin rainforest? *Science*, **34**, 402-403.
- Wilson, S., Davies, T. E., Hazarika, N., & Zimmerman, A., 2013. Understanding spatial and temporal patterns of human–elephant conflict in Assam, India. *Oryx*, 1-10.
- Wittemyer, G., Douglas-Hamilton, I., & Getz, W. M., 2005. The socioecology of elephants: analysis of the processes creating multitiered social structures. *Animal Behaviour*, **69(6)**, 1357-1371.
- Woodroffe, R., & Ginsberg, J. R., 1998. Edge effects and the extinction of populations inside protected areas. *Science*, **280(5372)**, 2126-2128.
- Woodroffe, R., Thirgood, S., & Rabinowitz, A., (Eds.) 2005. *People and Wildlife: conflict or coexistence?* Cambridge University press, Cambridge.

- Yamakoshi, G., 2005. What is happening on the border between humans and chimpanzees? Wildlife conservation in West African rural landscape. In: Hiramatsu, K. (Ed.) *Coesixtence with nature in a 'Globalising' World: Field Science Perspectives*, pp.91-97. Proceedings of the 7th Kyoto University International Symposium, 2005. Kyoto University, Kyoto.
- Yasmi, Y., Schanz, H., & Salim, A., 2006. Manifestation of conflict escalation in natural resource management. *Environmental Science & Policy*, **9**, 538-546.
- Young, J. C., Marzano, M., White, R. M., McCracken, D. I., Redpath, S. M., Carss, D. N., Quine, C. P., & Watt, A. D., 2010. The emergence of biodiversity conflicts from biodiversity impacts: characteristics and management strategies. *Biodiversity and Conservation*, **19(14)**, 3973-3990.
- Zhang, L., & Wang, N., 2003. An initial study on habitat conservation of Asian elephant (*Elephas maximus*), with a focus on human elephant conflict in Simao, China. *Biological Conservation*, **112**, 453-459.

APPENDICES

APPENDIX 1: Terms

Terms	General	This Study
District Forest	*'includes all land at the disposal of Government not included within the limits of any reserved or village forest nor assigned at the survey settlement as free grazing ground or for any other public or communal purposes: Provided that it shall be competent for the State Government to modify or set aside such assignment and constitute any such land as reserved, village or district forest or devote the same to any other purposes it may deem fit.'**	-
Village Forests	**any land notified by State Government as such in accordance with the provisions of Chapter III of Karnataka Forest Act 1963, any land at the disposal of the Government, as a village forest for the benefit of village community or group of village communities and may in like manner vary or cancel any such notification.'** *'The State Government may assign to any village-community the rights of Government to or over any land which has been constituted a reserved forest, and may cancel such assignment. All forest so assigned shall be called village forests.' ***	-
Reserve Forests	*'The State Government may constitute any forest-land or waste-land which is the property of Government, or over which the Government has proprietary rights, or to the whole or any part of the forest-produce of which the Government is entitled, reserved forest in the manned hereinafter provided.'(Section 20) ***	-

Protected Forests	*'The State Government may, by notification in the Official Gazette, declare the provisions of the Chapter IV applicable to any forest-land or waste-land which is not included in a reserve forest, but which is the property of Government, or over which the Government has proprietary rights, or to the whole or any part of the forest-produce of which the Government is entitled. The forest-land and waste-lands comprised in any such notification shall be called a 'protected forest.'***	-
Sanctuary	*'The State Government may, by notification, declare its intention to constitute any area other than area comprised with any reserve forest or the territorial waters as sanctuary if it considers that such is of adequate ecological, faunal, floral, geomorphological, natural or zoological significance, for the purpose of protecting, propagating or developing wildlife or its environment.'***	-
National Parks	*'Whenever it appears to the State Government that an area, whether within a sanctuary or not is, by reason of its ecological, faunal, floral, geomorphological, or zoological association or importance, needed to be constituted as a National Park for the purpose of protecting and propagating or developing wildlife therein or its environment, it may, by notification, declare its intention to constitute such area as a National Park.'****	-
Village Forest Committee	*a village Forest Committee constructed under Section 31 A 'for the purpose of Joint Forest Planning and Management of*	-

	*forest, the State Government may, by notification constitute a Village Forest Committees in respect of a village or group of village.'****	
Agroforestry	'*Agroforestry is a collective name for land-use systems and technologies where woody perennials (trees, shrubs, palms, bamboos, etc.) are deliberately used on the same land-management units as agricultural crops and/or animals, in some form of spatial arrangement or temporal sequence. In agroforestry systems there are both ecological and economical interactions between the different components' (Lundgren and Raintree, 1982, c.f Nair 1992).* In other words, it '*is a specific local example of a practice, characterized by environment, plant species, and their arrangement, management, and socio-economic functioning*' (Dagar *et al*., 2014). The words 'system' and 'practices' are used as synonyms while referring to agroforestry (Dagar *et al*., 2014).	Coffee plantations in Kodagu are known for their agroforestry system of cultivation.
Districts	India is a country of federal union of states and union of territories. These states are divided into smaller administrative units called districts.	Kodagu is a district in Karnataka state of India
Taluks	Administrative units consisting group of several villages for revenue purposes.	Three *taluks* of Kodagu are Virajpet, Madikeri and Somwarpet
Hobli	Subdivision of *taluk* where adjoining villages are clustered into groups for administrative purposes	
Gram Panchayat	Cluster of villages governed by local self-governments (or Rural self-government). People elect the head of these self-governing	

	bides within the local community.	
Karnataka Forest Department	Forest forces of the state Karnataka and headed by the Principal Chief Conservator of Forests (PCCF)	Karnataka Forest Department
Territorial and Wildlife divisions	State Forest Department is divided into two main management wings, Territorial and Wildlife Divisions for administrative purposes which are under the Chief Conservator of Forests (CCF) or Conservator of Forests (CF).	In Kodagu, protected areas are managed under the Wildlife Divisions of the Karnataka Forest Department and Reserve Forests are managed by the Territorial Divisions. However, there is an overlap of the management of certain areas. For example few Protected Areas buffer zone and Reserve Forests areas are managed through participatory management with eco-development committees (EDCs) and Village Forest Committees (VFCs) (Laval, 2008). Crop compensation events are recorded at both territorial and wildlife divisions. Private-owned lands within five kilometre of Protected areas are recorded in Wildlife divisions and the others in Territorial Divisions.
Forest Divisions	Administrative units of Forest Department of each district which are headed by Deputy Conservator of Forests (DCF) and Assistant Conservator of Forests (ACF)	In Kodagu, Forest divisions are not synonymous to the three *taluks*, but are divided into two divisions, Madikeri Forest Divisions and Somwarpet Forest Divisions.
Forest Ranges	Each forest divisions are divided into further subdivisions for administrative purposes headed by the Range Forest Officers	Example: Virapet Forest Division is divided into five ranges (See Chapter 3, Section 4).
Sections/ Beats	Managed by the Foresters	For example: Thithimathi

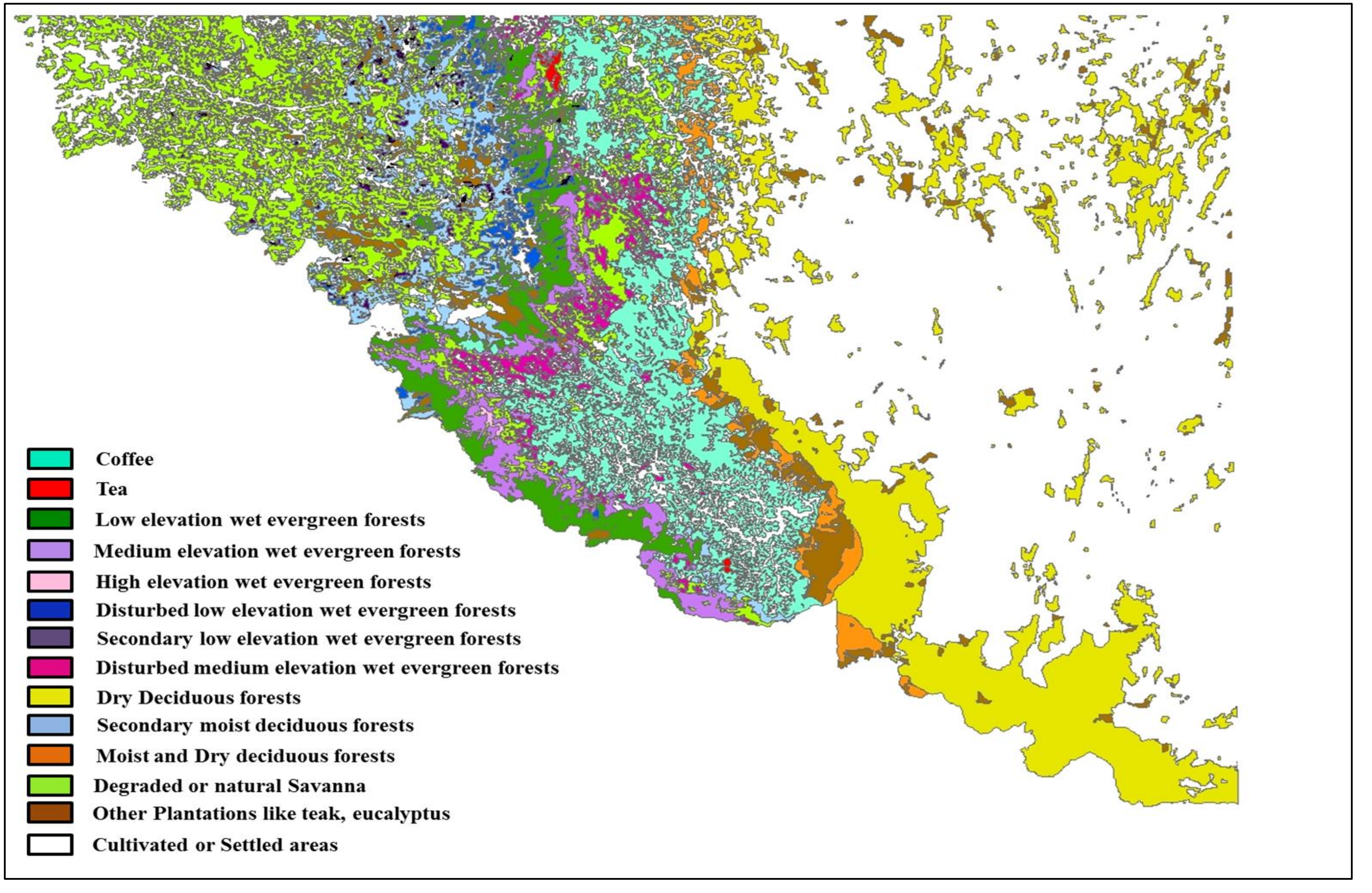
	(sections) and Forest Guards and Watcher (Beat), these are subunits of Forest Ranges	range has one section (Thithimathi) and 4 beats (CPT – 16,17,18,19)
Coffee estate divisions	Divisions when referring to coffee estates are those locations of coffee estate where one estate owned by the same farmer (Private) or corporate-owned (e.g. TATA Coffee Limited) are located at different locations across the Kodagu district.	For example: Owner: TATA Coffee Ltd Division: Yemmegoondi
Coffee estates subdivisions and block numbers	Subdivisions and blocks within the coffee estate divisions are those areas created for efficient managerial purposes Subdivisions usually are referred with different names and sometimes are locally referred by their abbreviations. Blocks are referred with numbers or alphabets along with the subdivisions	Sub-division: Doddayemmegoondi (DYG) Block numbers: DYG 17, DYG 18, DYG 19, etc.

*** The Karnataka Forest Act, 1963**

**** The Indian Forest Act, 1927**

***** The Wildlife (Protection) Act, 1972**

APPENDIX 2: Mercara (Kodagu) - Mysore Vegetation Map. (G. Muthu Sankar, French Institute Pondicherry. Shape file Data downloaded from The Western Ghats Biodiversity Portal on 27th August, 2014, http://thewesternghats.indiabiodiversity.org/map).



APPENDIX 3: Coffee cultivation at the 7 study sites

There are two main varieties of coffee, Robusta (*Coffea canephora*) and Arabica (*Coffea arabica*), grown in the region. Another variety of coffee, Liberica coffee (*Coffea liberica*) is also present, mostly at boundaries of the estates, but not cultivated as an agricultural crop. Both varieties of coffee species originate from Africa (Clay, 2004). In their native ranges (DaMatta, 2004), Arabica is grown under native understorey of Ethiopian tropical forests at elevations between 1,600 – 2800 m, while Robusta is a mid-storey tree growing under dense equatorial forests of Congo basin between sea level and 1,200 m (See Table 1). Their difference in their elevation origin has resulted in difference in their ecology and difference in cultivation requirements like temperature, humidity and shade requirements. Arabica is thus a montane origin species whereas Robusta variety is a low-land origin species and in India, Arabica is grown at elevations of 1,000 and 1,500 whereas Robusta is cultivated at elevations below 1,000 m (Peter, 2002; Clay, 2004).

Table 1: Requirements for cultivating two varieties of Coffee.

Coffee Type	**Arabica** (***Ccffea arabica***)	**Robusta** (***Ccffea canephora***)
Elevation	1000 – 1500 m	Below 1000 m
Slopes	Gentle to moderate	Gentle to relatively flat
Temperature	18 to 12° C	22 – 20° C
Humidity	70 – 80%	80 - 90%
Shade	Medium to light	Uniform Thin
Plant Spacing	Closer spacing	Not close

I have chosen 7 large coffee estates belonging to TATA Coffee Limited which have mixed cultivation of both Arabica and Robusta Coffee. While few estates continue to cultivate cardamom within these estates, others have abandoned cardamom and have replaced it with arabica plants. Table 2 provided the study estate names along with their subdivisions.

Table 2: Study estate names and their subdivisions.

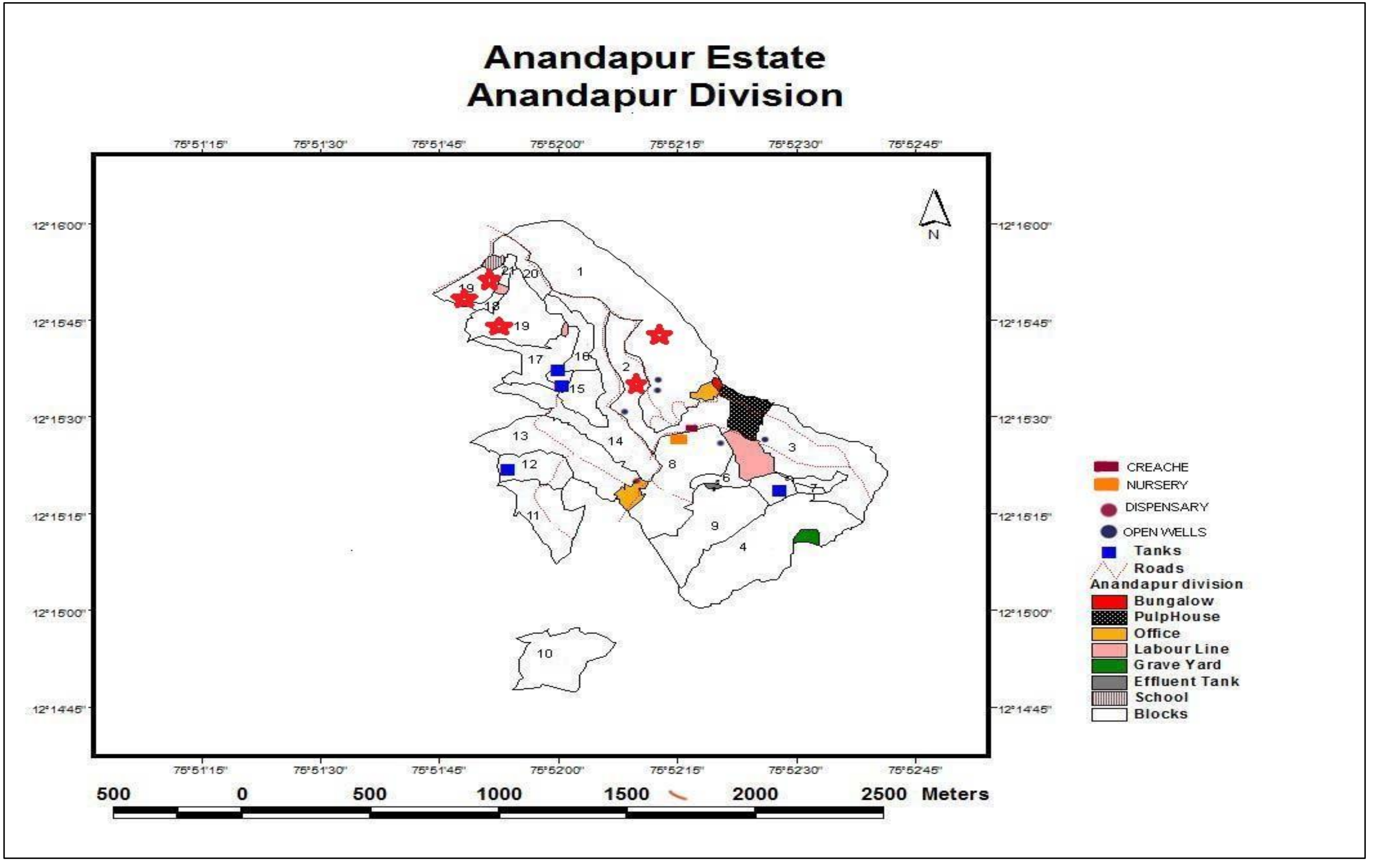
Estate names	Subdivisions	Presence of Refuge Areas
Anandapur	Anandapur (AP)	Yes
	Charlote (CH)	No
	Pallakere (PA)	No
Balmany	Balmany (BA)	Yes
	Devarakadoo (DEV)	Yes
Pollibetta	Poillbetta (PO)	Yes
	Mattaparambu (MP)	Yes
Yemmigoondi	Chennainkote (CKY)	Yes
	Chikka Yemmigoondi (CYG)	Yes
	DoddaYemmigoondi (DYG)	Yes
	Siddapura (SP)	Yes
Cottabetta	Cottebetta (CO)	Yes
	Nullagotte (NG)	Yes
	Wosnallagotte (WNG)	Yes
	Mocha (MO)	Yes
Margolly	Margolly (MG)	Yes
	Malugamalai (MM)	Yes
	Gattadhulla (GH)	Yes
Woshully	Woshully (WO)	Yes
	Hope (HP)	No
	Taneerhulla (TH)	Yes
Estate A[88]	-	Yes (but documented as large data pool in GIS map, but not on individual maps)

[88] See Footnote 17 referred in Table 3.2, Chapter 3, Section 2(3.2.3)

Below are the maps of refuge areas in each subdivisions of the seven study coffee estates. Some of the estates have no marked refuge areas as there was no information on elephants using these areas on regular basis for long-term refugia. For example, in Anandapur Estate, elephants visitation were reported to be only recently as two to three years during the time of the field work of this study.

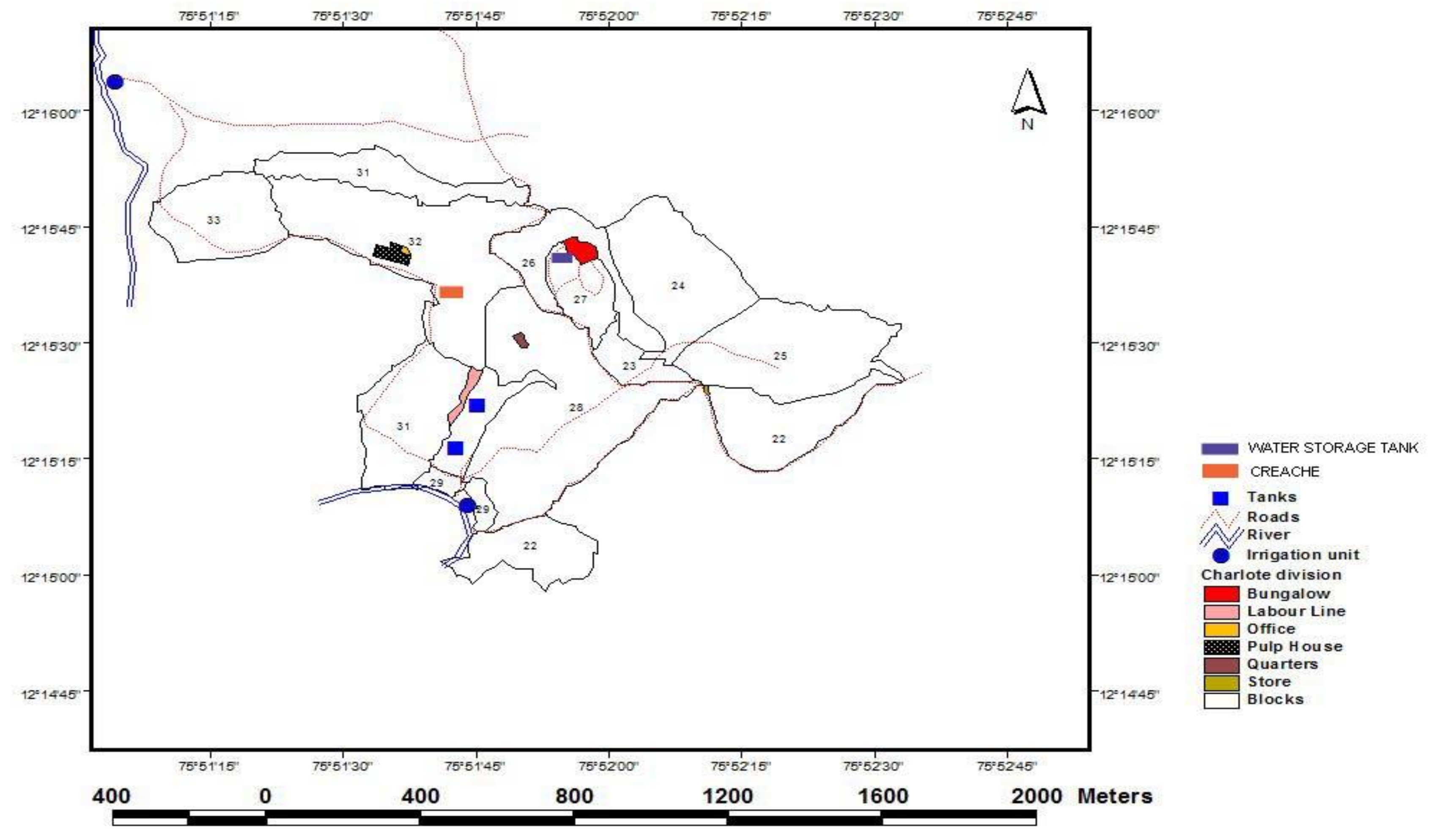
Maps Legend

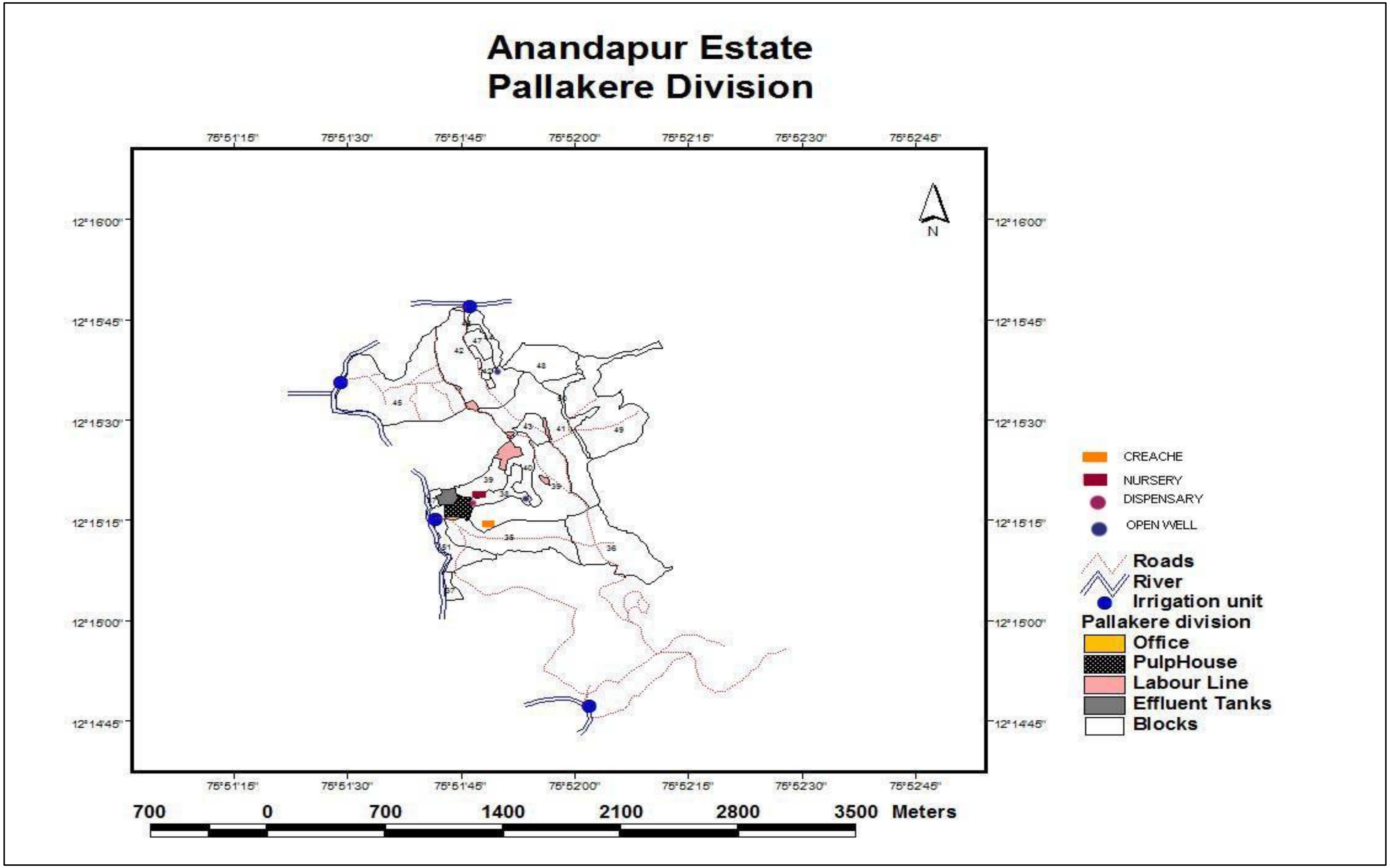
Refuge areas 



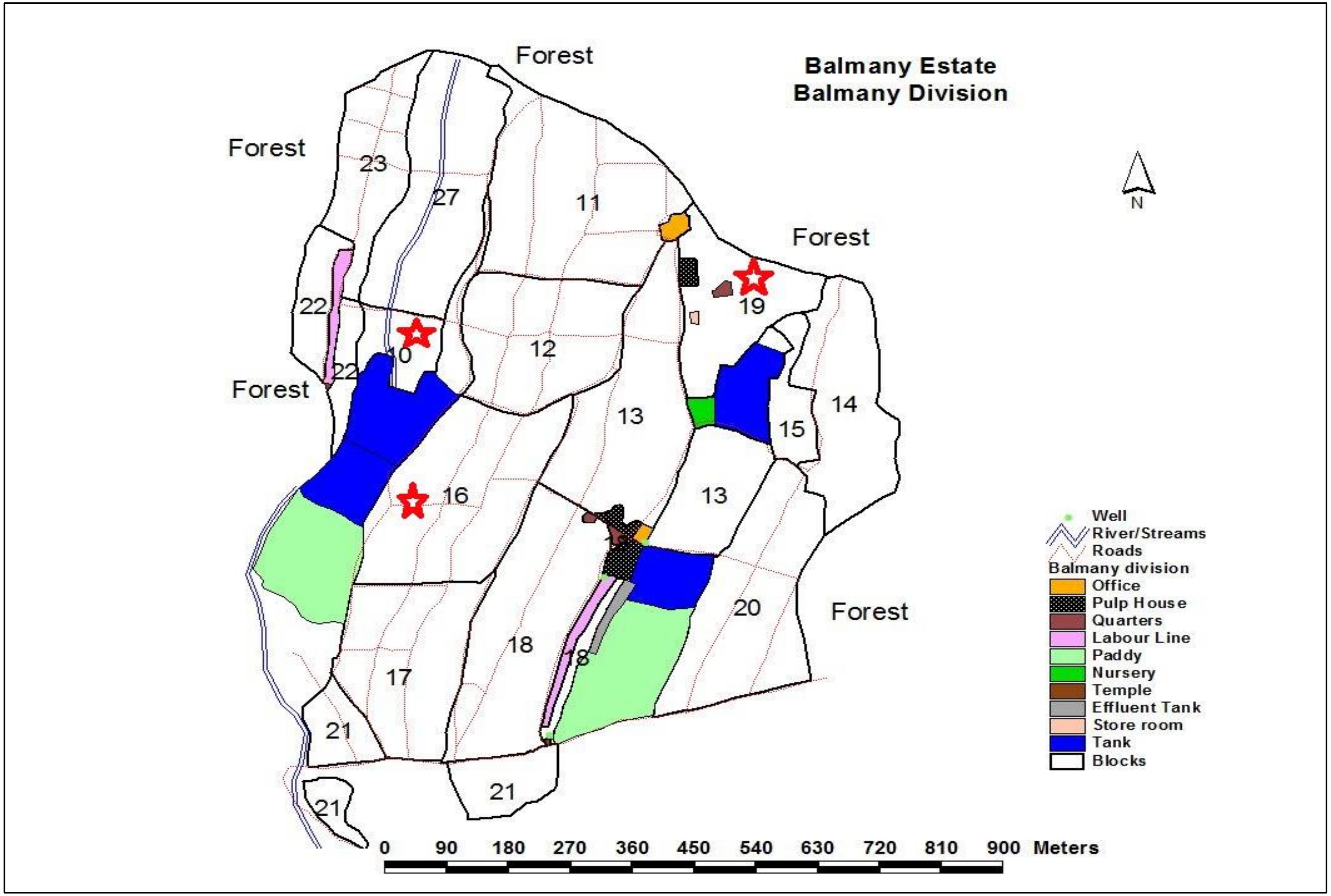
Anandapur Estate
Anandapur Division
75°51'15"
75°51'30"
75°51'45"
75°52'00"
75°52'15"
75°52'30"
75°52'45"
12°16'00"
12°15'45"
12°15'30"
12°15'15"
12°15'00"
12°14'45"
N
CREACHE
NURSERY
DISPENSARY
OPEN WELLS
Tanks
Roads
Anandapur division
Bungalow
PulpHouse
Office
Labour Line
Grave Yard
Effluent Tank
School
Blocks
500 0 500 1000 1500 2000 2500 Meters

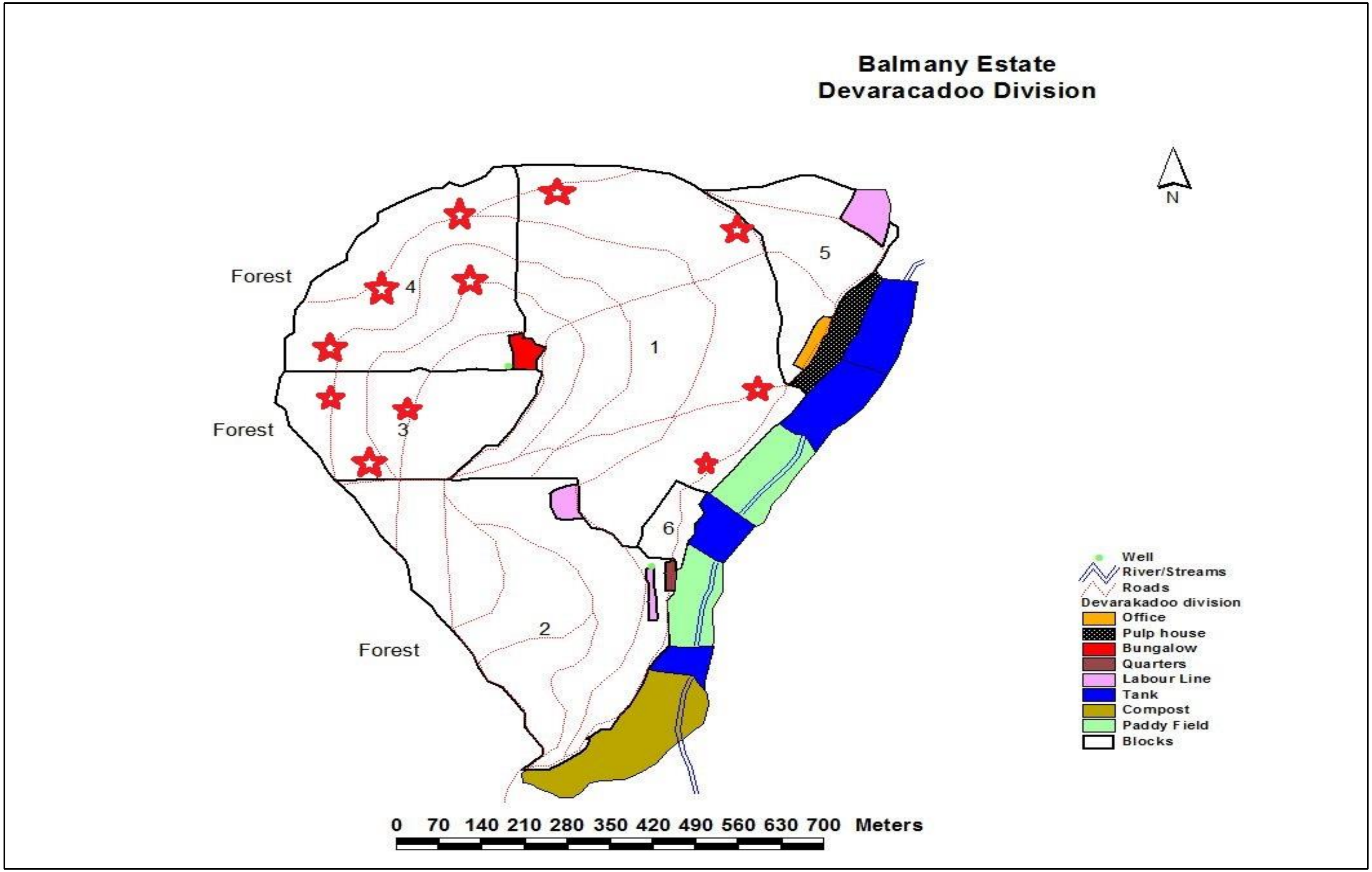
Anandapur Estate
Charlote Division





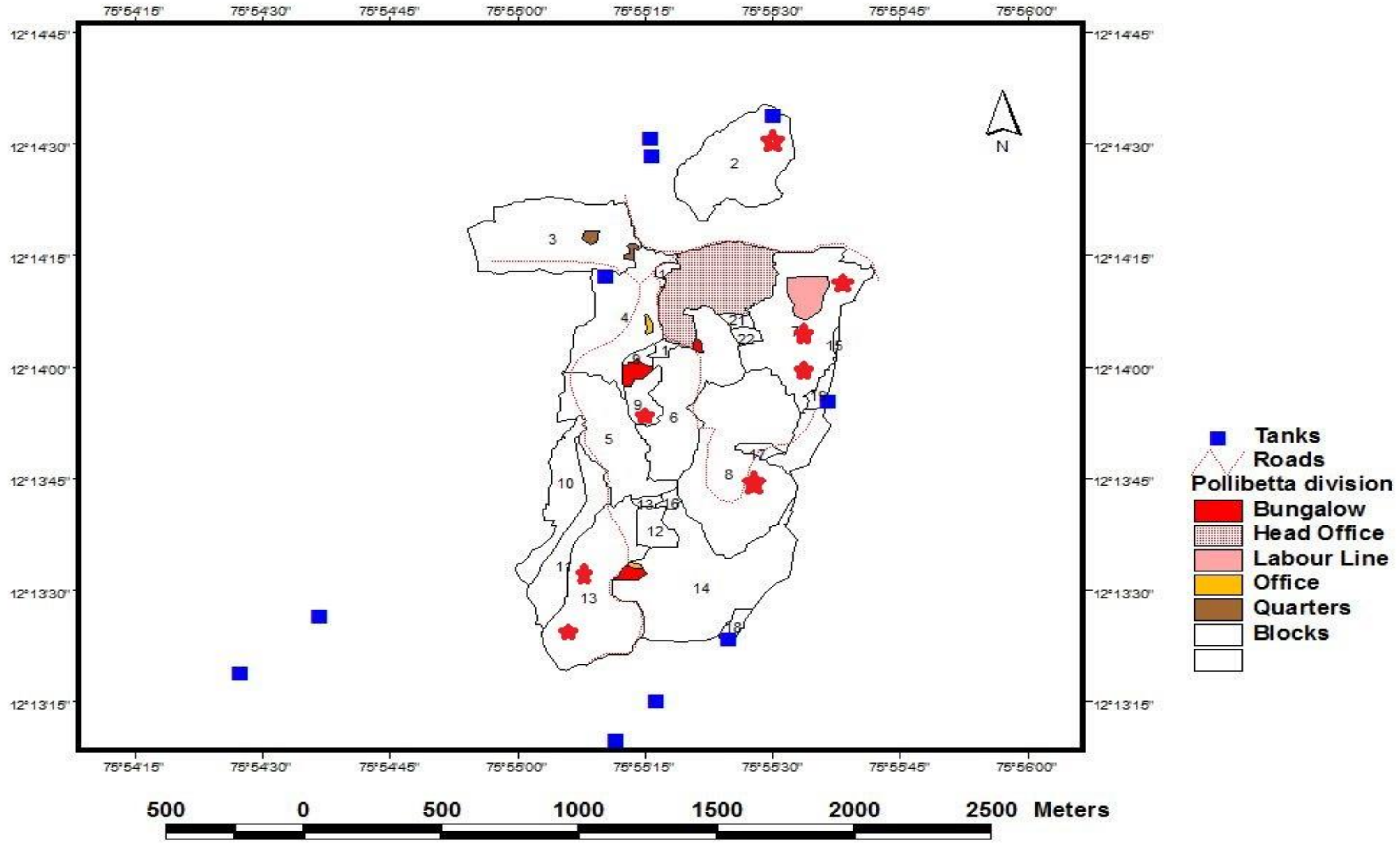
Anandapur Estate
Pallakere Division
75°51'15"
75°51'30"
75°51'45"
75°52'00"
75°52'15"
75°52'30"
75°52'45"
12°16'00"
12°15'45"
12°15'30"
12°15'15"
12°15'00"
12°14'45"
N
CREACHE
NURSERY
DISPENSARY
OPEN WELL
Roads
River
Irrigation unit
Pallakere division
Office
PulpHouse
Labour Line
Effluent Tanks
Blocks
700 0 700 1400 2100 2800 3500 Meters

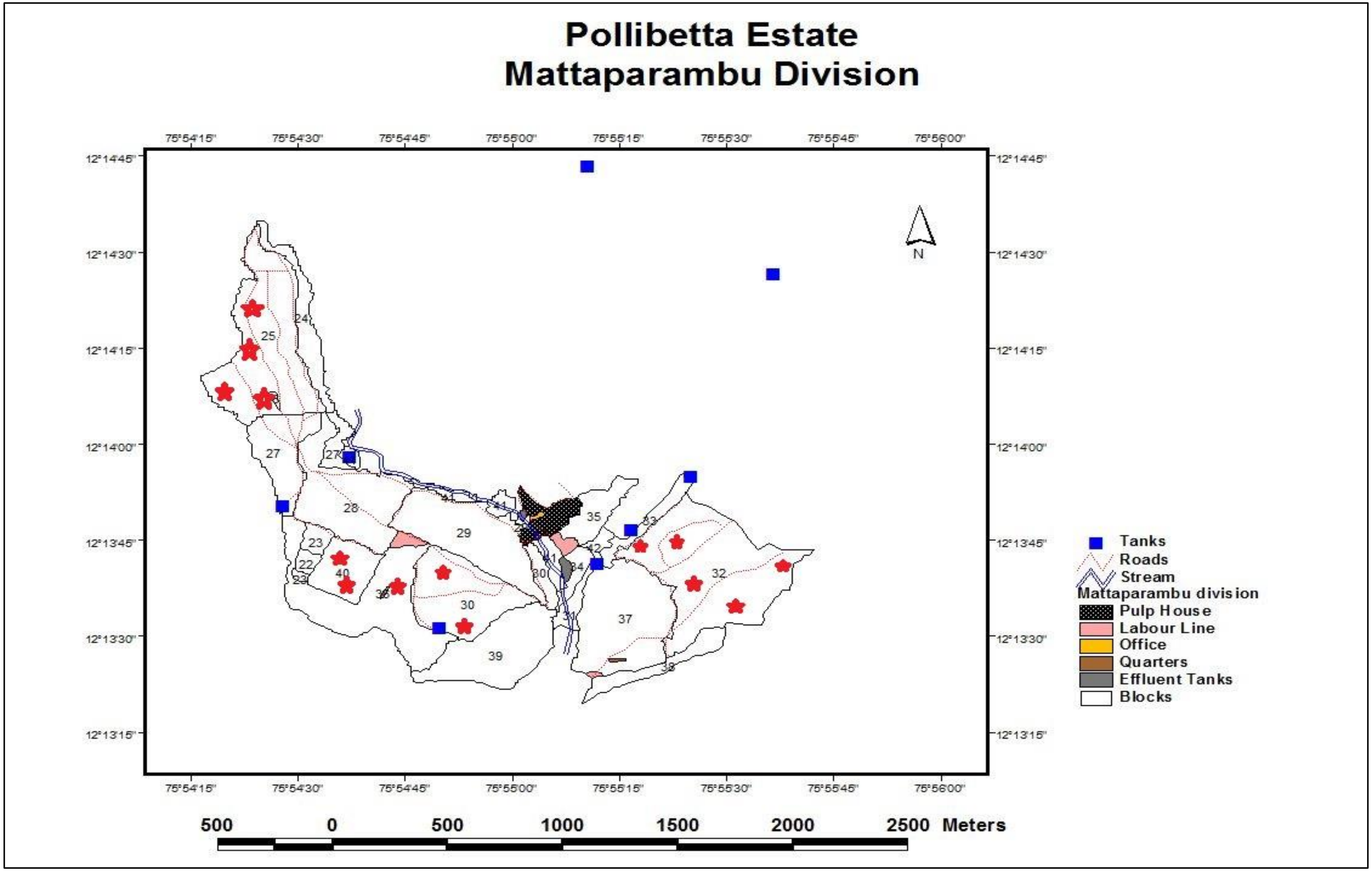

Balmany Estate
Balmany Division
Forest
Forest
Forest
Forest
Forest
N
23
27
11
22
10
12
22
19
13
14
15
16
13
20
18
18
17
21
21
21
Well
River/Streams
Roads
Balmany division
Office
Pulp House
Quarters
Labour Line
Paddy
Nursery
Temple
Effluent Tank
Store room
Tank
Blocks
0 90 180 270 360 450 540 630 720 810 900 Meters

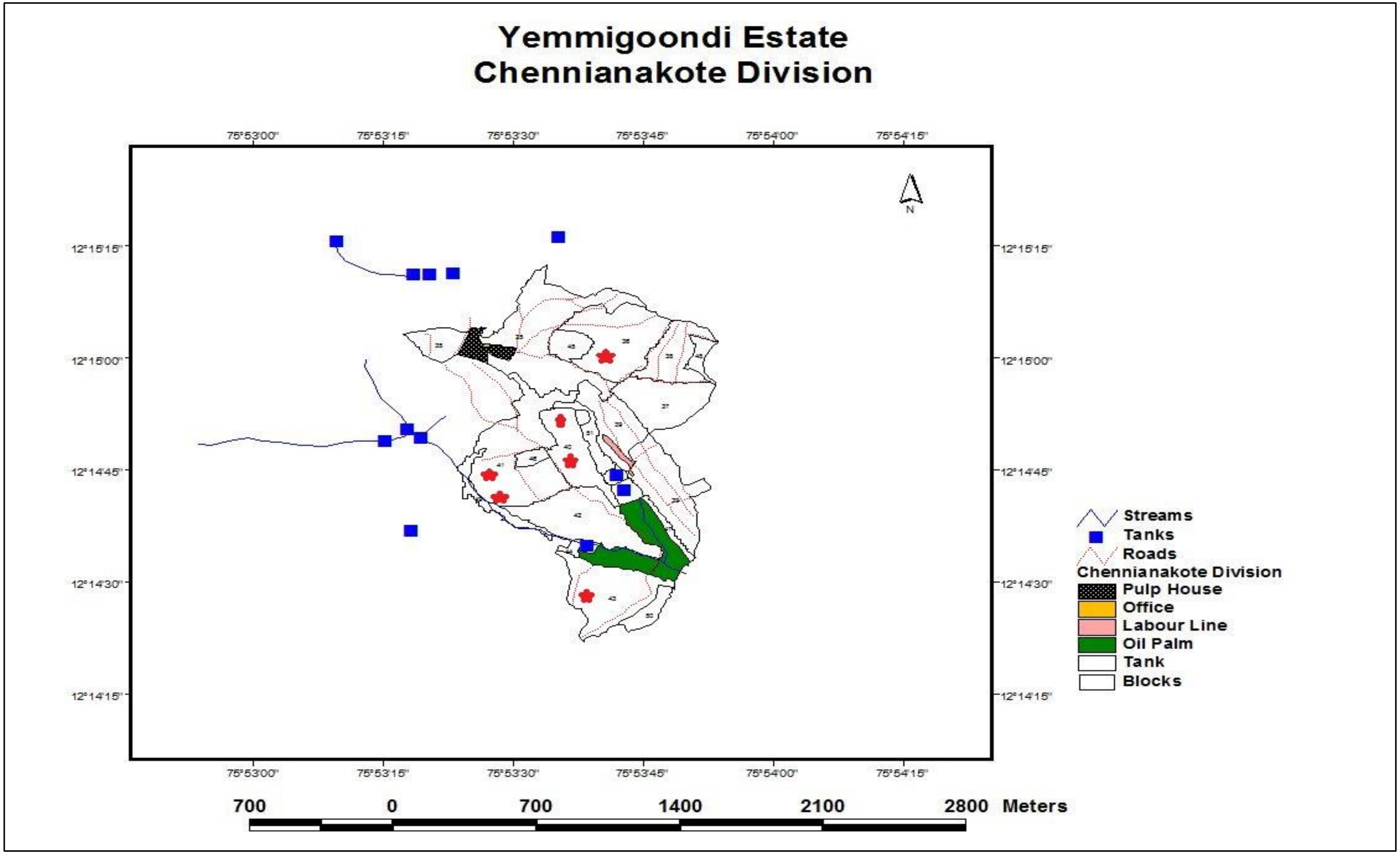


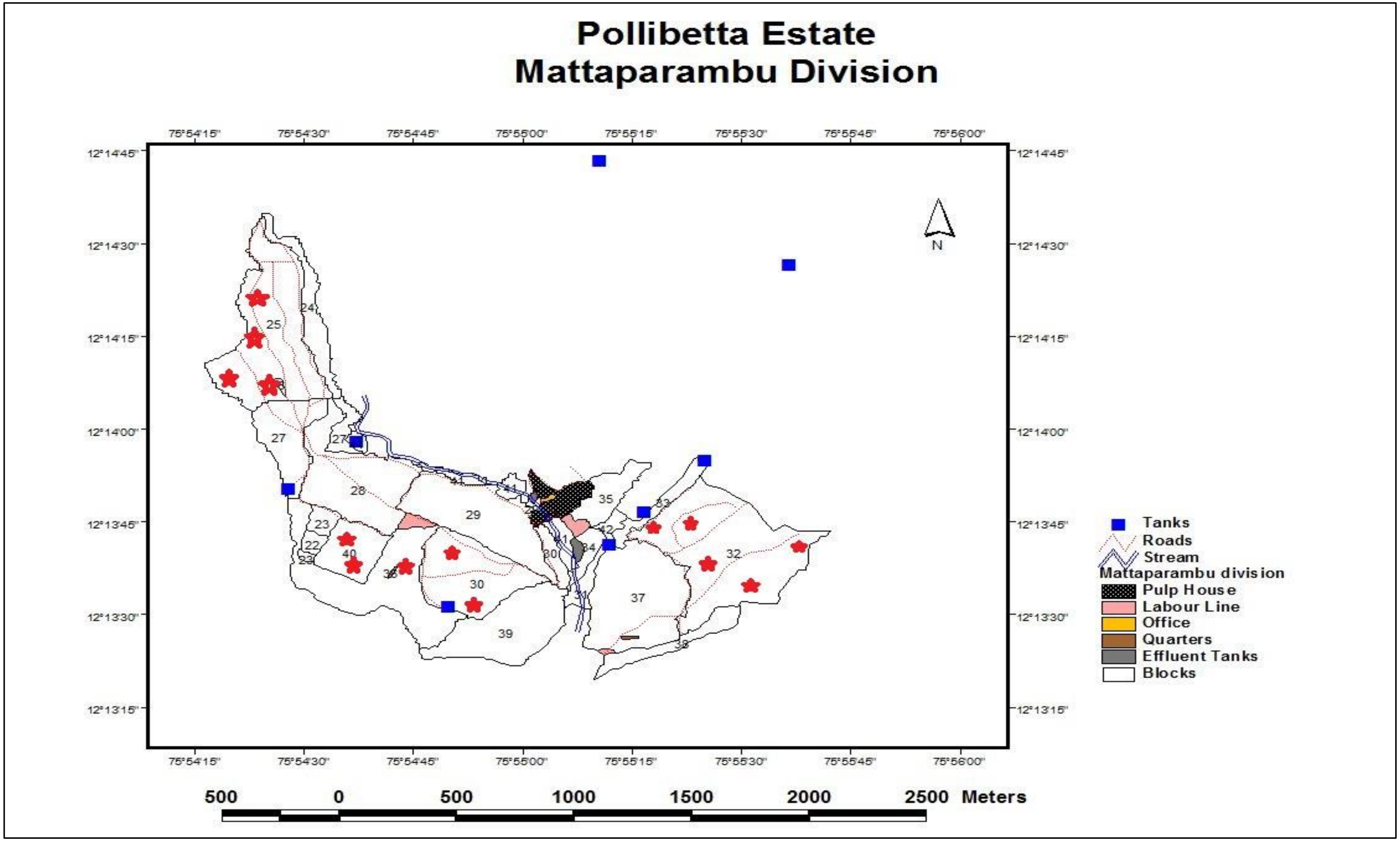
Balmany Estate
Devaracadoo Division
N
Forest
Forest
Forest
1
2
3
4
5
6
Well
River/Streams
Roads
Devarakadoo division
Office
Pulp house
Bungalow
Quarters
Labour Line
Tank
Compost
Paddy Field
Blocks
0 70 140 210 280 350 420 490 560 630 700 Meters

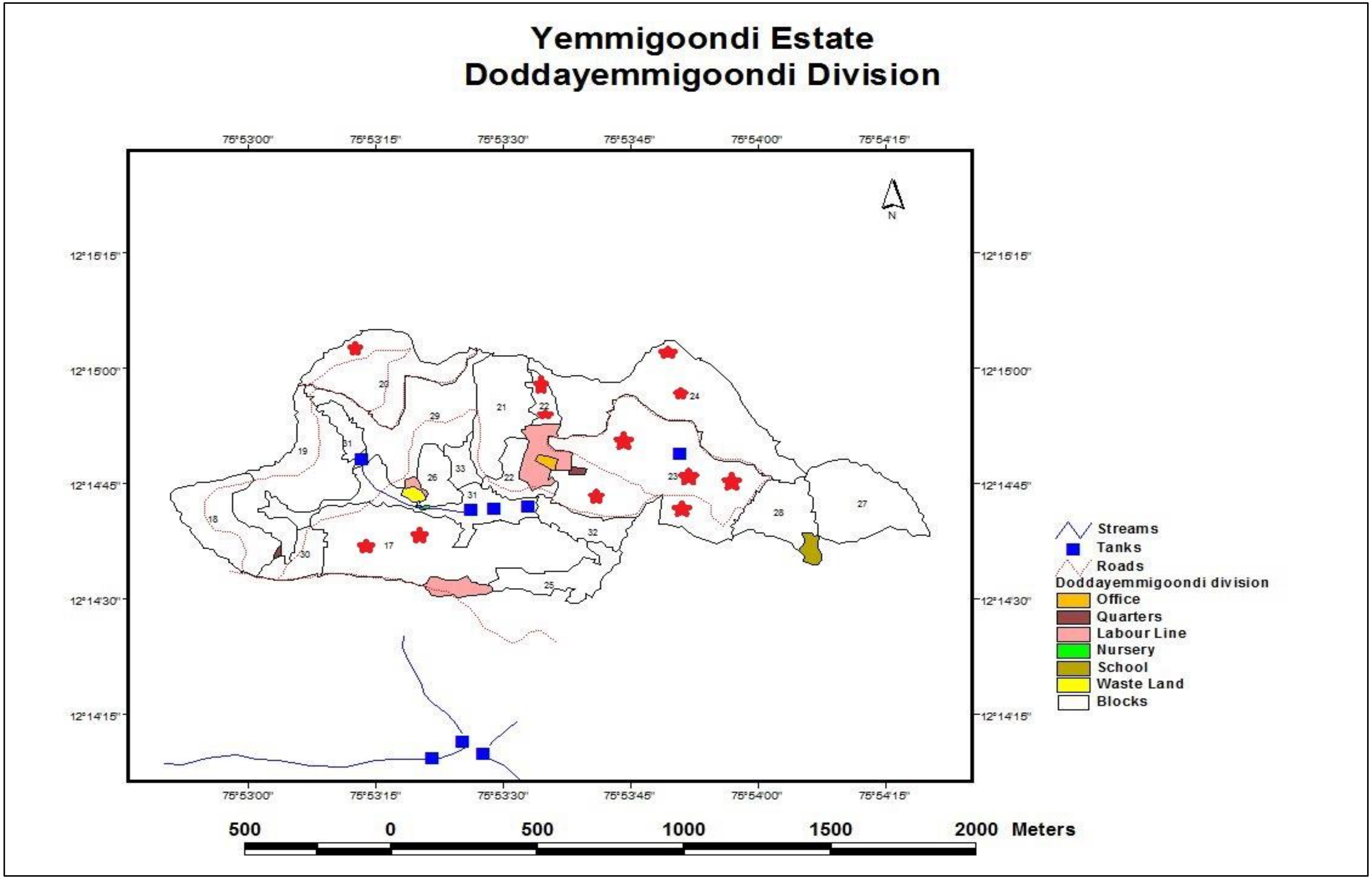
Pollibetta Estate
Pollibetta Division

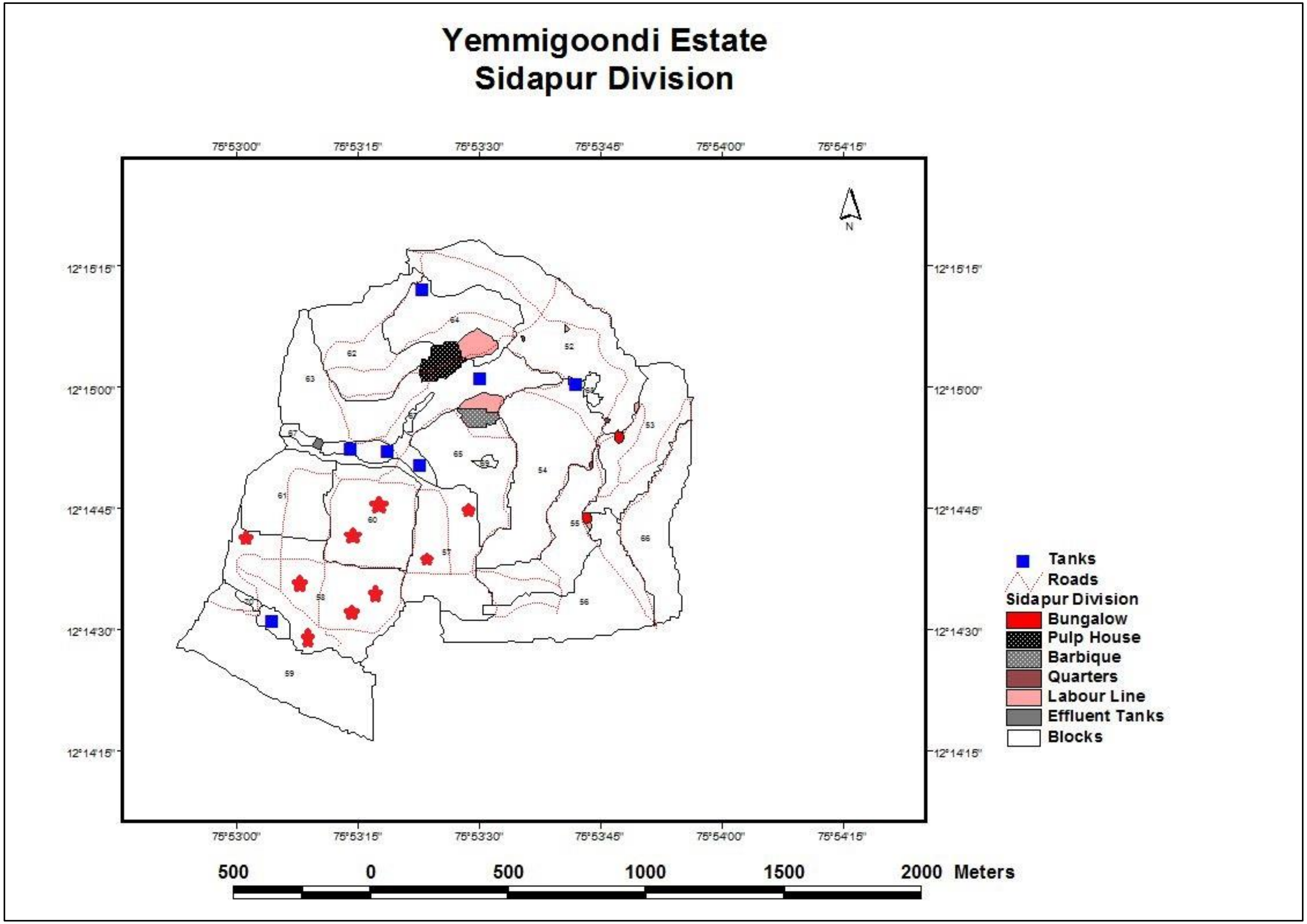



Pollibetta Estate
Mattaparambu Division
75°54'15"
75°54'30"
75°54'45"
75°55'00"
75°55'15"
75°55'30"
75°55'45"
75°56'00"
12°14'45"
12°14'30"
12°14'15"
12°14'00"
12°13'45"
12°13'30"
12°13'15"
N
24
25
27
28
29
23
22
40
30
39
35
42
34
37
32
Tanks
Roads
Stream
Mattaparambu division
Pulp House
Labour Line
Office
Quarters
Effluent Tanks
Blocks
500
0
500
1000
1500
2000
2500 Meters


Yemmigoondi Estate
Chennianakote Division
75°53'00"
75°53'15"
75°53'30"
75°53'45"
75°54'00"
75°54'15"
12°15'15"
12°15'00"
12°14'45"
12°14'30"
12°14'15"
N
Streams
Tanks
Roads
Chennianakote Division
Pulp House
Office
Labour Line
Oil Palm
Tank
Blocks
700 0 700 1400 2100 2800 Meters


Pollibetta Estate
Mattaparambu Division
75°54'15" 75°54'30" 75°54'45" 75°55'00" 75°55'15" 75°55'30" 75°55'45" 75°56'00"
12°14'45" 12°14'30" 12°14'15" 12°14'00" 12°13'45" 12°13'30" 12°13'15"
N
Tanks
Roads
Stream
Mattaparambu division
Pulp House
Labour Line
Office
Quarters
Effluent Tanks
Blocks
500 0 500 1000 1500 2000 2500 Meters


Yemmigoondi Estate
Doddayemmigoondi Division
75°53'00"
75°53'15"
75°53'30"
75°53'45"
75°54'00"
75°54'15"
12°15'15"
12°15'00"
12°14'45"
12°14'30"
12°14'15"
N
Streams
Tanks
Roads
Doddayemmigoondi division
Office
Quarters
Labour Line
Nursery
School
Waste Land
Blocks
500 0 500 1000 1500 2000 Meters


Yemmigoondi Estate
Sidapur Division
Tanks
Roads
Sidapur Division
Bungalow
Pulp House
Barbique
Quarters
Labour Line
Effluent Tanks
Blocks
500 0 500 1000 1500 2000 Meters

APPENDIX 4: Virajpet *taluk* and *range* maps

As mentioned in Chapter 2, Kodagu district has three administrative units called *taluks* namely Virajpet, Madikeri and Somwarpet. Mdaikeri town is the head-quarters for the entire Kodagu district. These *taluks* are further sub-divided into *range* by Forest Department for administrative purposes. The *taluk*s and their names have been mentioned in Chapter 2. In this section, only Virapet *taluk* will be considered as the focus of the study coffee estates are selected only within this *taluk*.

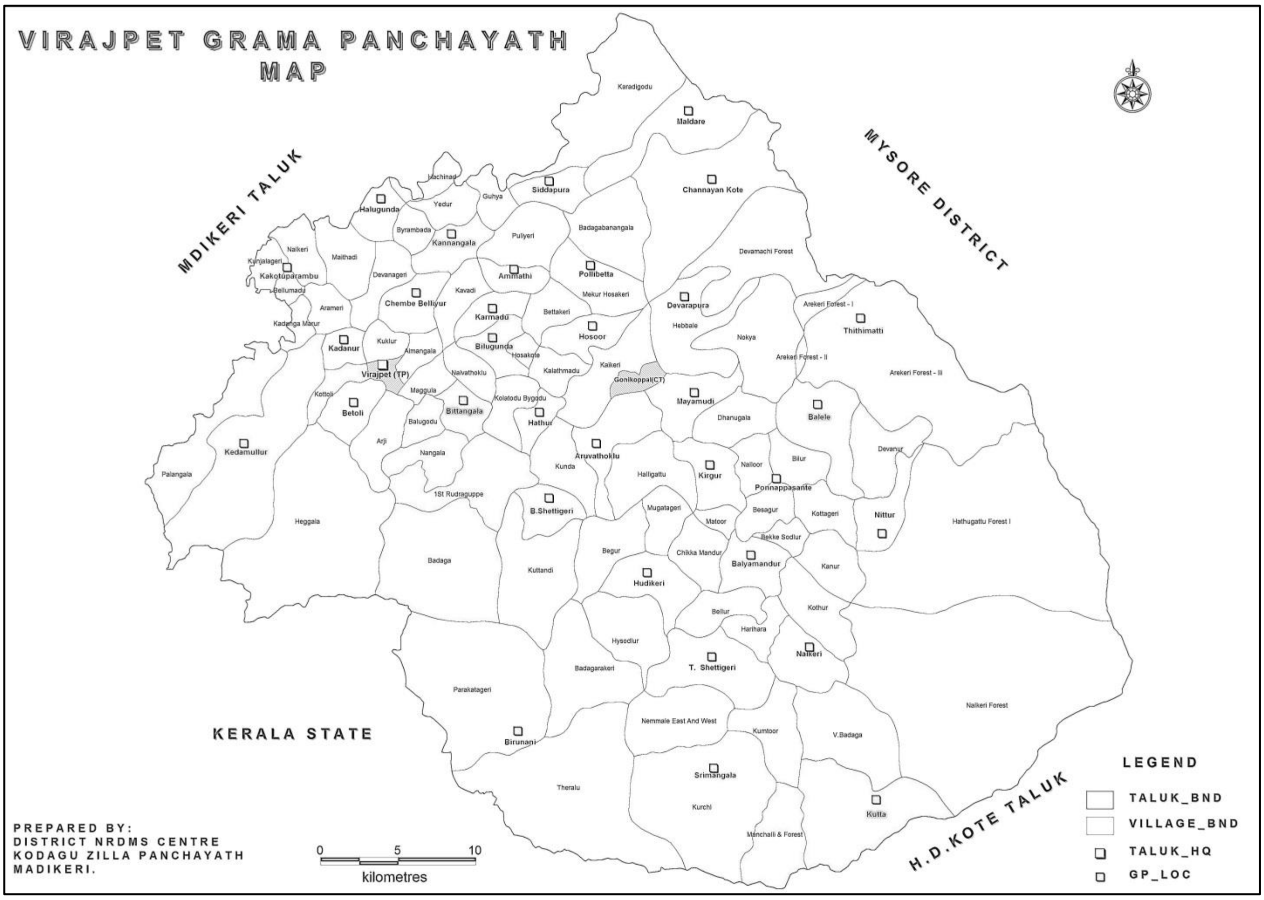


Figure 2.1 Map of Virajpet *taluk* with villages.

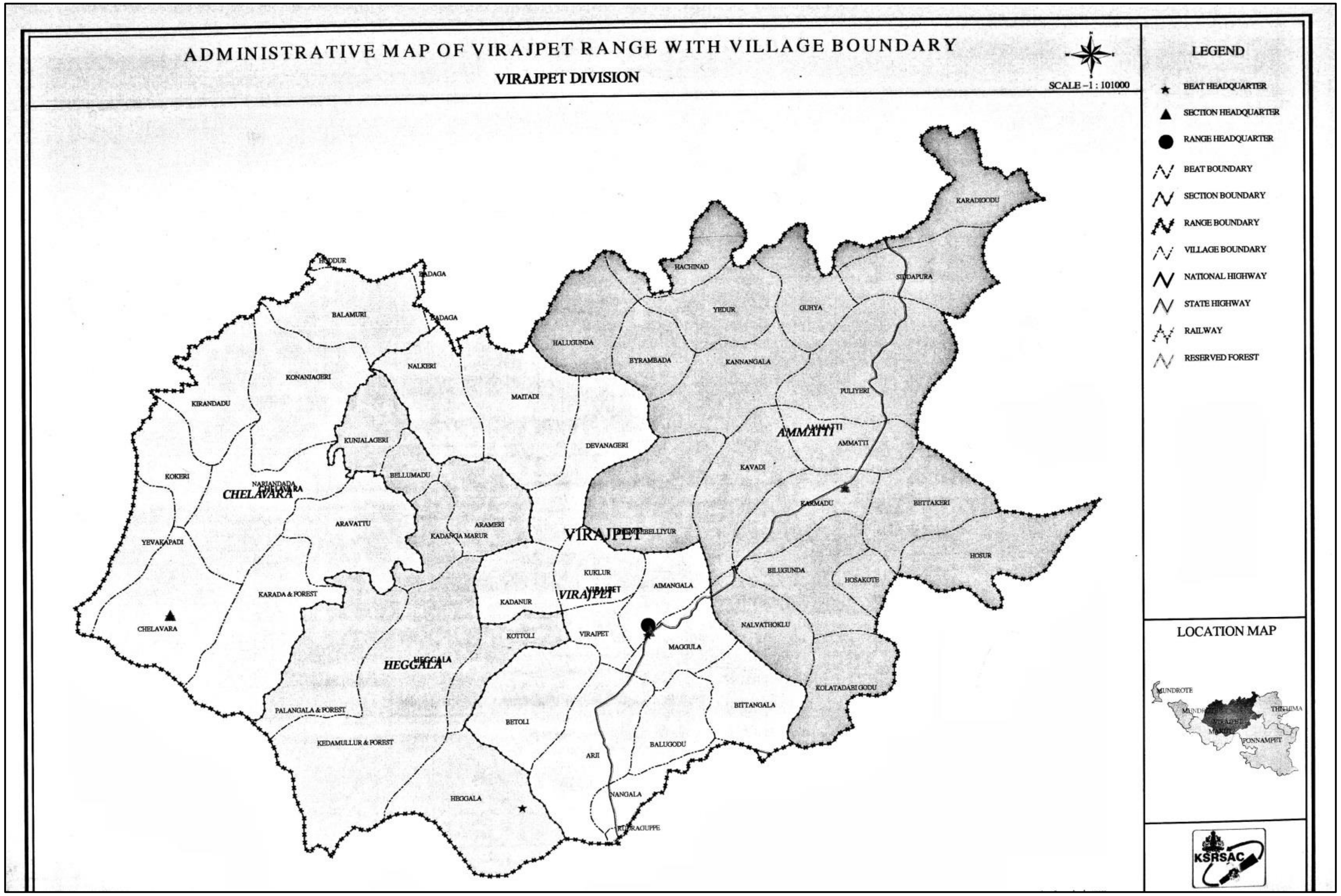


Figure 1.2 Map of Virajpet *range* with villages.

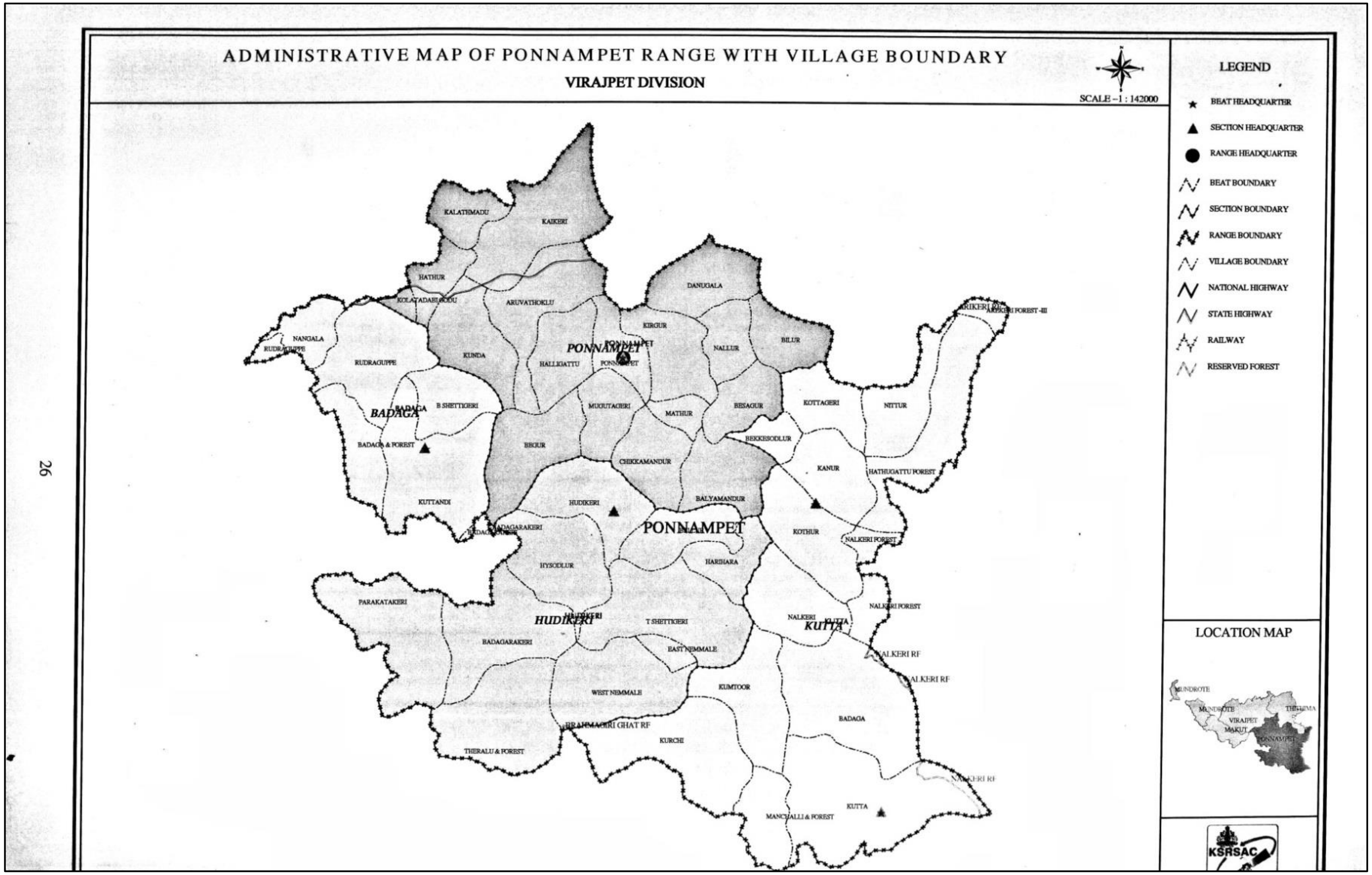


Figure 1.3 Map of Ponnampet with villages.

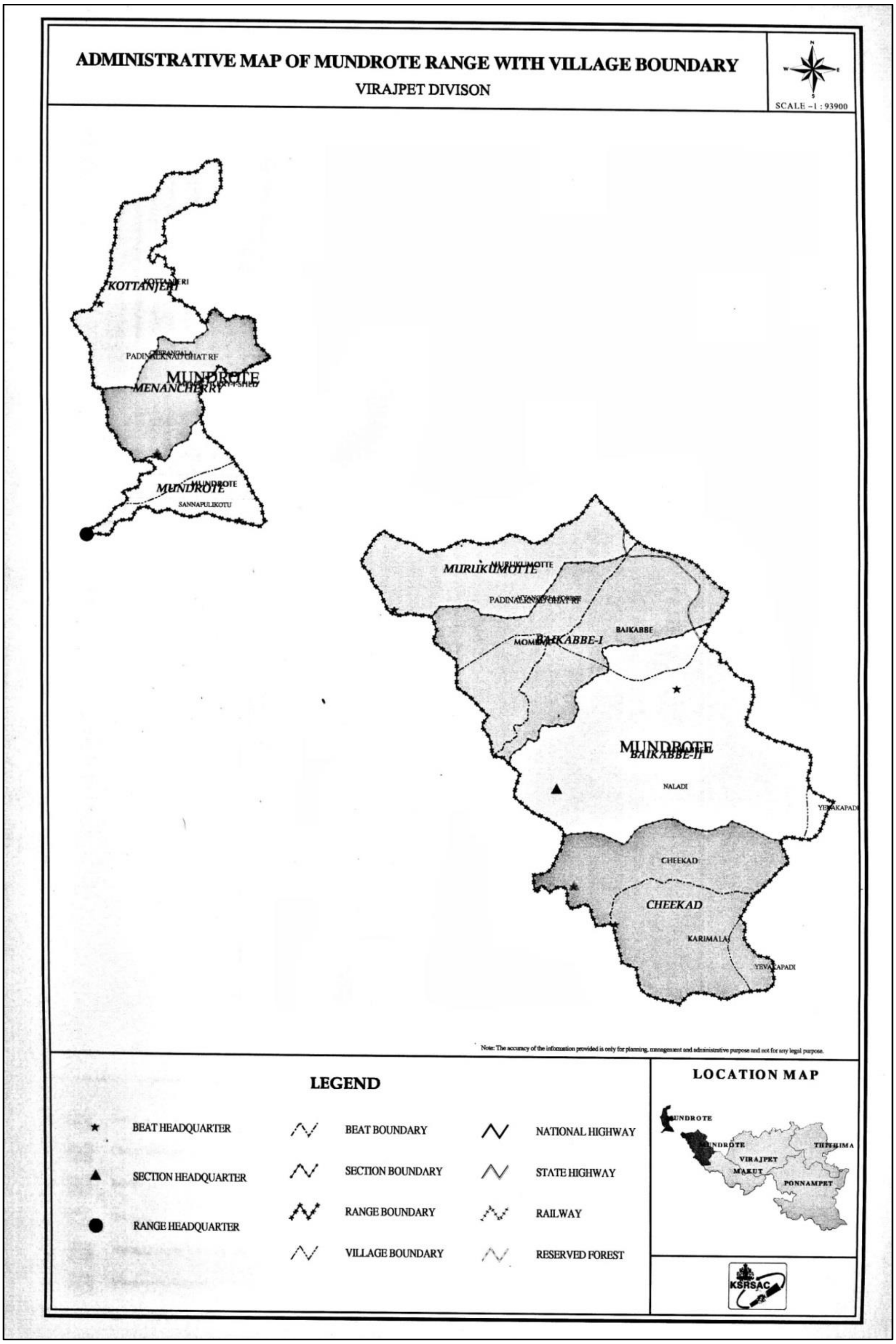


Figure 1.4 Map of Mundrote raneg with villages.

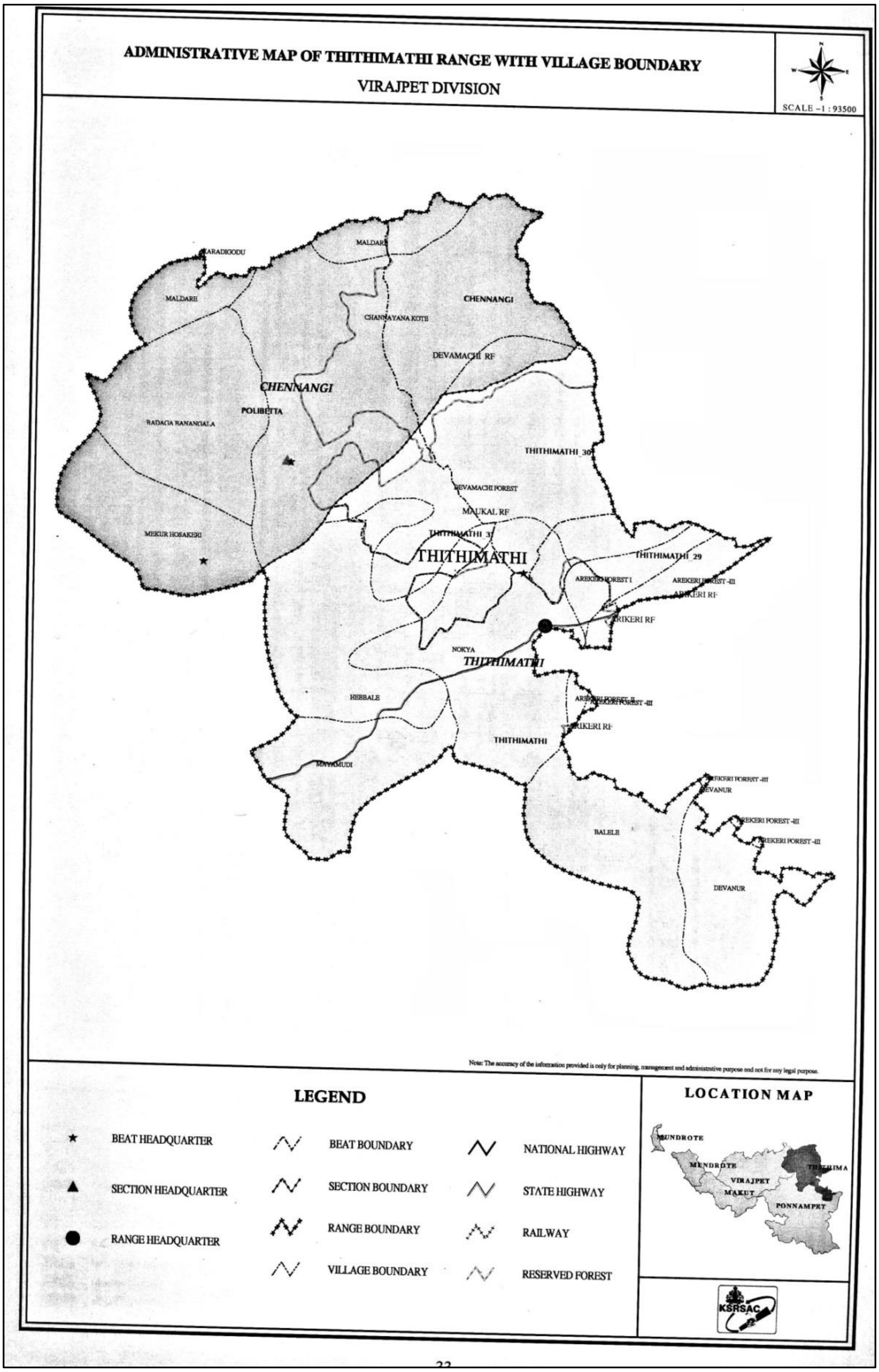


Figure 1.5 Map of Thithimathi range with villages.

APPENDIX 5: Line transect method

This is one of the most commonly used indirect methods for population estimation for many species, especially for elephants. One of the key assumption in the line transect method is that an object lying directly on the line will never be missed giving it a probability of 1. The probability of detection reduces with the object's distance from the observer (Barnes, 1996). The other assumptions are that the objects before detection do not move and are never counted twice, all detections are independent and lastly all the measurements are accurate. When dung pile was sighted, the perpendicular distance to the line was recorded.

Transects were of 3 Km each in 3 estates of varying lengths due to the shape and size of the estates (See Figure 1). It was difficult to establish a long transect without reaching the boundary of the estate. In line-transect method, I walked slowly on the center of the line and fixed a maximum distance of 5 m on either sides of transect to detect elephant dung and any other indirect signs (foot prints, feeding signs, damage to coffee plants, arecanut and other fruiting trees like orange, chickoo, etc.) of elephant presence was noted down. GPS location of the start and end point of transects were taken. Also, the state of dung piles based on the classification of dungs by their shape (See Table 3.1) were also noted down (Barnes & Jensen, 1987; cited by Barnes, 1996)

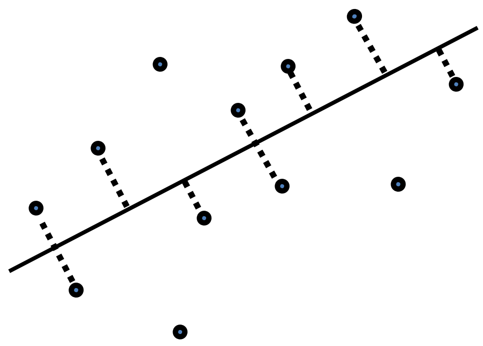


Figure 1: Illustration of Line transect where I or one of my research assistant walked at center of the line, when the dung pile was detected perpendicular distance was noted from the dung pile to the line.

Table 1: Barnes and Jensen (1987) classification of dung piles.

Category	Description
A	Boli intact, very fresh, moist, with odour
B	Boli intact, fresh but dry, no odour
C	Some of the boli have disintegrated; other are still recognizable as boli
D	All boli completely disintegrated; dung-pile now forms an amorphous flat mass
E	Decayed to the stage where it would be unlikely to be detected at a range of two meters in the undergrowth

However, by the end of the first phase, the need for estimating the number of elephants was not relevant to this study as the aim was not estimation of the number of elephants in coffee estates, but the extent of use of coffee estates by elephants and identifying the hotspots and elephant groups using the study sites. Further discussions and reviews with my supervisors, line transects were discontinued from the second phase of the study.

This provided more time to observe and identify the elephant groups. In the second phase I only recorded data on fresh dungs (less than 48 hours) to estimate and evaluate coffee consumption of elephants. So, whenever there was a visit to the area where the elephants were reported, if fresh dung was found the weight, contents of dung, dung bolus diameter and the GPS location were recorded.

APPENDIX 6: Crop damage events and compensations paid for Kodagu (Virajpet and Madikeri Division) and Hunsur Division from the year 1992 – 2011.

Year	Madikeri Division		Virjapet Division		Hunsur Division		Overall		Kodagu District	
	No. of cases	Compensation (Lakh[89] Rs.)	No. of cases	Compensation (Lakh Rs.)	No. of cases	Compensation (Lakh Rs.)	No. of cases	Compensation (Lakh Rs.)	No. of cases	Compensation (Lakh Rs.)
90-91	146	-	-	-	-	-	146	0	146	0
91-92	239	-	-	-	-	-	239	0	239	0
92-93	338	6.03	89	1.37	-	-	427	7.4	427	7.4
93-94	260	1.31	61	1.77	-	-	321	3.08	321	3.08
94-95	427	4.67	186	6.51	-	-	613	11.18	613	11.18
95-96	483	4.89	57	1.75	-	-	540	6.64	540	6.64
96-97	471	3.76	63	1.22	71	1.9	605	6.88	534	4.98
97-98	364	3.69	145	2.37	101	2.18	610	8.24	509	6.06
98-99	302	2.48	108	2.04	131	3.06	541	7.58	410	4.52
99-00	659	5.49	146	4.26	140	4.63	945	14.38	805	9.75
00-01	371	3.28	86	2.81	8	1.63	465	7.62	457	6.09
01-02	199	2.36	121	4.17	113	1.68	433	8.21	320	6.53
02-03	173	2.56	157	5.05	250	3.72	580	11.33	330	7.61

[89] INR 1 Lakh (100,000)= GBP 960 .682 (as of 30th January, 2014).

03-04	335	6.2	189	4.11	408	4.97	932	15.28	524	10.31
04-05	311	4.77	169	3.14	173	3.11	653	11.02	480	7.91
05-06	584	8.56	155	3.31	337	4.24	1076	16.11	739	11.87
06-07	711	9.16	387	10.05	617	9.3	1715	28.51	1098	19.21
07-08	2474	2.54	461	14.1	90	22.3	2472	60.81	2935	16.64
08-09	2590	4.19	880	19.69	2130	30.17	4410	70.07	3470	23.88
09-10	1296	4.11	395**	13.72	515	18.78	1691	17.83	1691	17.83
10-11	895*	2.10	-	-	396	15.11	895	2.10	895	2.1
TOTAL	13628	82.15	3855	101.44	5480	126.78	20309	323.6	17483	183.59
AVG/Year	648.95	3.91	183.57	4.83	260.95	6.04	967.1	14.97	832.5238	8.742381

* up to 31st July 2010

**up to 31st March 2010

Time series analysis was carried out on the data of compensation events recorded in the Virajpet Forest Divisions to examine if there is any trend in the number of events occurring across the years. Analysis was done in SPSS (IBM SPSS Statistics Version 19). The results indicated a presence of significant time signal of events occurring across the years but there is no consistent trend for an increase or decrease over time (See Figure 2).

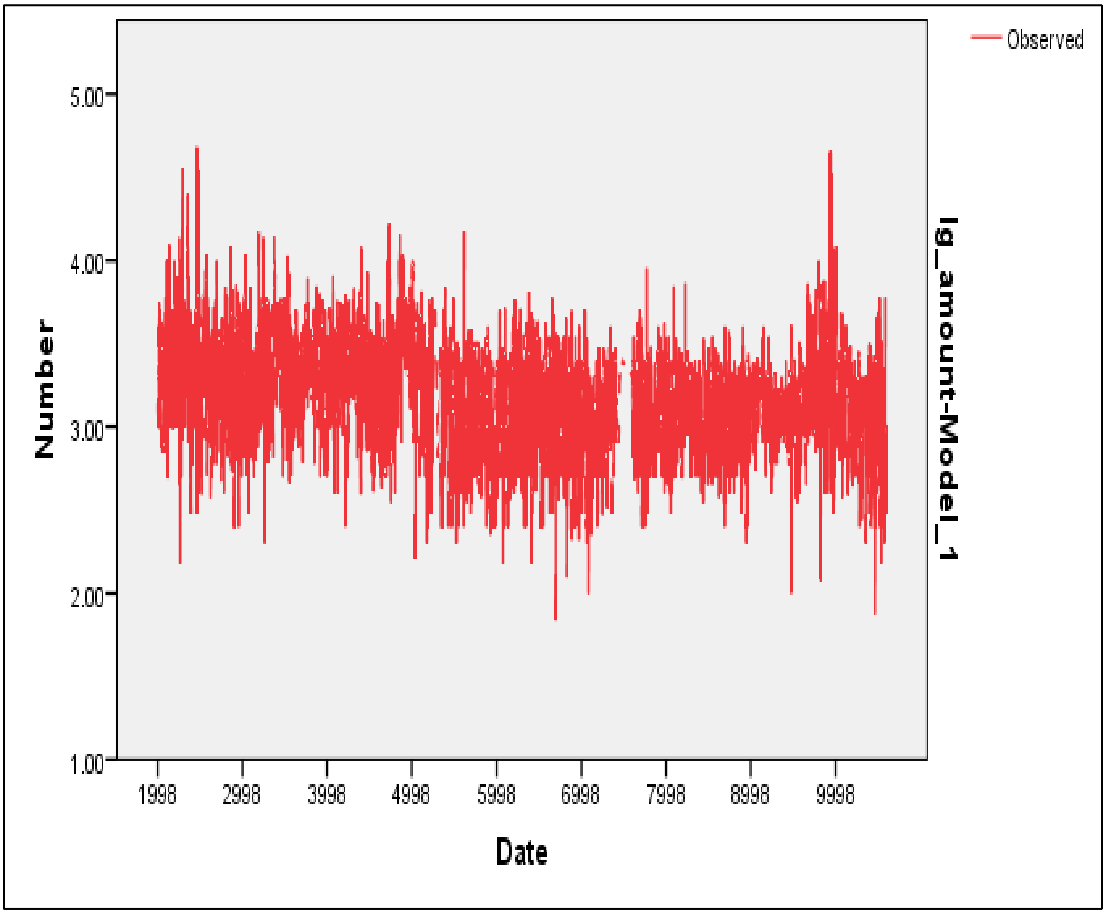


Figure 2: Time-series Analysis on the data of compensation events recorded in the Virajpet Forest Divisions.

APPENDIX 7: Elephant death records from 1991-2011[90] of both Virajpet and Madikeri Division, Kodagu District.

Year	Virajpet	Madikeri	Total
1991-1992	-	5	5
1992-1993	8	2	10
1993-1994	5	1	6
1994-1995	1	3	4
1995-1996	2	2	4
1996-1997	2	7	9
1997-1998	-	3	3
1998-1999	6	4	10
1999-2000	2	1	3
2000-2001	3	4	7
2001-2002	2	4	6
2002-2003	-	4	4
2003-2004	11	5	16
2004-2005	3	3	6
2005-2006	3	7	10
2006-2007	3	4	7
2007-2008	5	7	12
2008-2009	7	7	14
2009-2010	8	4	12
2010-2011	3	1	4
Total	**74**	**78**	**152**

[90] See Chapter 4, Section 2.1 for further details on financial year of Forest Department.

APPENDIX 8: Compensation Rate Plan of Various crops

As per the Government Order (2009)

Crop	Quantity	Compensation rate (Rs)[91]
Coconut	1-5 years of plant	15
	5-10 years of plant	100
	More than 10 years	250
Arecanut	< 5 years of plant	200
	7-9 years of plant	400
	10 and More than 10 years	1000
Coffee	1 plant	100
Banana	1 plant	80
Orange	<5 years of plant	100
	5 and above 5 years	160
Paddy	1 Quintal	660
Pepper	1 Kilogram	90
Cardamom	1 Kilogram	400
Ginger	1 Quintal	1935
Ragi	1 Quintal	600
Jowar	1 Quintal	620

[91] 1 INR (RS) = GBP 0.00961

APPENDIX 9: Individual identification of elephants based on their morphological characters and traits

Identity	Tusk	Tusk	Tusk Arrangement	Tusk Angle	Tusk Length in feet	Tusk thickness	Tail length	Brush type	Ear Lobe shape	Ear fold	Ear tear	Ear Hole	Age (years)	Other traits	Other Remarks
Oldie	Present	Both	Converge	Downward pointing	>3	Thick	Stump (tail above penis sheath)	Absent	Right – L shaped, Left – ear tear	Right and left ear- U shaped	Left ear tear	No	>30	right tusks chipped; tusks converge and overlap each other	Died April 2011 by electrocution; Recognised as 'oldie' in the study area and known to be habituated to people; was in musth during the month of October and had moved from Yemmigundi towards Gattadhulla estate and then disappeared only to re appear in the month of December at Gattadhulla
Makhna (M1)	Absent	NA	NA	NA	NA	NA	Below knee above ankle	Both continuous	Right- U round	Right-U shaped (inwards)	Tear	No	>30	Scar on middle of trunk as if cut by a wire	Bulky and has a distinctive feature at neck region - i.e. neck region is not very distinctive
Splayed Brushless (M2)	Present	Both	Splayed	Downward	<1	Medium	Below knee and above ankle	Absent	Right-V shaped	Right-U shaped	No	No	15	Round tip tusk	Sighted with M1
Tiny	Present	Both	Parallel	Straight	<1	Slender	Below	Both	Right-V	Right-L	No	No	10	Sharp tips (tusk)	Tusks were very short, and brush type

tusks (M3)				Ahead			knee above ankle	dis-contin uous	shaped	shaped					hair was present on both sides but was sparsely distributed; Sighted with M1
Short Tusk (M4)	Present	Both	Parallel	Downward	1-2	Normal	Below ankle	Outsid e	Right/left -L shaped	Right/le ft-L shaped	No	No	15	Less sharp tusk tips	Seen with M1(2012-Cottebetta; Pollibetta); M7 (2011 - Yemmigundi); hair is mostly distributed outside and at the tip of the tail, very sparsely present inside
No Tail (M5)	Present	Both	Parallel	Downward	2-3	Normal	Absent	NA	Left-V shaped Right-V-shaped	Left-U shaped (inward s) Right-NA	No	UK	>15		Sighted only once; but mentioned about the elephant during the same month, March, in 2010 and 2011, by the same estate guard at the same location. Pollibetta estate
Ganesh (M6)	Present	Right	NA	Downward	2-3	Normal	Below Knee above ankle	Outsid e	Both-V shaped	Both-U shaped (outwar ds)	No	No	>15	Sharp Tusk tip	Spotted only twice; one in CT picturess at Yemmigundi and then at Gatatdhulla direct sighting crossing to Heroor estate with a family herd.
(M7)	Present	Both	Parallel	Downward	<1	Thick	Below knee above ankle	Both discon tinuou s	Both-L shaped	Both-U shaped	No	No	>15	Round tusk tips; with bumpy head	
Sans Right Ear (M8)	Present	Both	Parallel	Downward	<1	Normal	Below ankle	Both-contin uous	Right ear completel y missing	Right-Ear Missing	Right NA	Righ t NA	10-15		With a group of 6 elephants and was sighted in Yemmigundi and Woshully

M9	Present	Both	Parallel	Downward	1-2	Normal	Below ankle	Inside only	Left-V shaped	Left-U shaped	Left-No	UK	>15	Curved tusk – pointing downward with tips curing upwards, Sharp; tail – outside very sparse hair at the tip	With M10 at Pollibetta estate
M10	Present	Both	Splayed	Downward	>1	Normal	Below ankle	Both-discontinuous	Left-V shaped	Left-No	Left-Yes	UK	>15	Sharp tusk tip; Bump on the head; looks similar to M2; but with tail brush which is sparse outside and inside and concentrated at the tip	With M9 at Pollibetta estate
Swing (F1)	NA	NA	NA	NA	NA	NA	Below knee above ankle	Both-continuous	Left-V shaped	Absent	No	Left ear		Warts at the either side of the neck (so the name Swing); warts on upper back	<1 month old calf; Female 3-5Juvenile
F2 (with swing)	NA	NA	NA	NA	NA	NA	Below Knee above ankles	Both-continuous	Both-V shaped	Absent	No	No	>15		With 3-5 year Juvenile
F3 (with swing)	NA	NA	NA	NA	NA	NA	Below knew above ankle	Both-continuous	Right/Left –L shaped	Right and left-U shaped	Right-Yes	No	>15	Ear tear at the centre	<1 year calf
M11 (with Swing)	Present	Both	Parallel	Downward	<1	Thick	Below knee above	Both-continuous	Right-V shaped Left – V-	Right/Left-U shaped	Yes both	No	>15	Small Warts on legs; right ear cut at the lobe v shape, and c shape cut at the centre in the	Was sighted associated with the Swing group from December to March in Gattadhulla, Yemmigundi, Pollibetta,

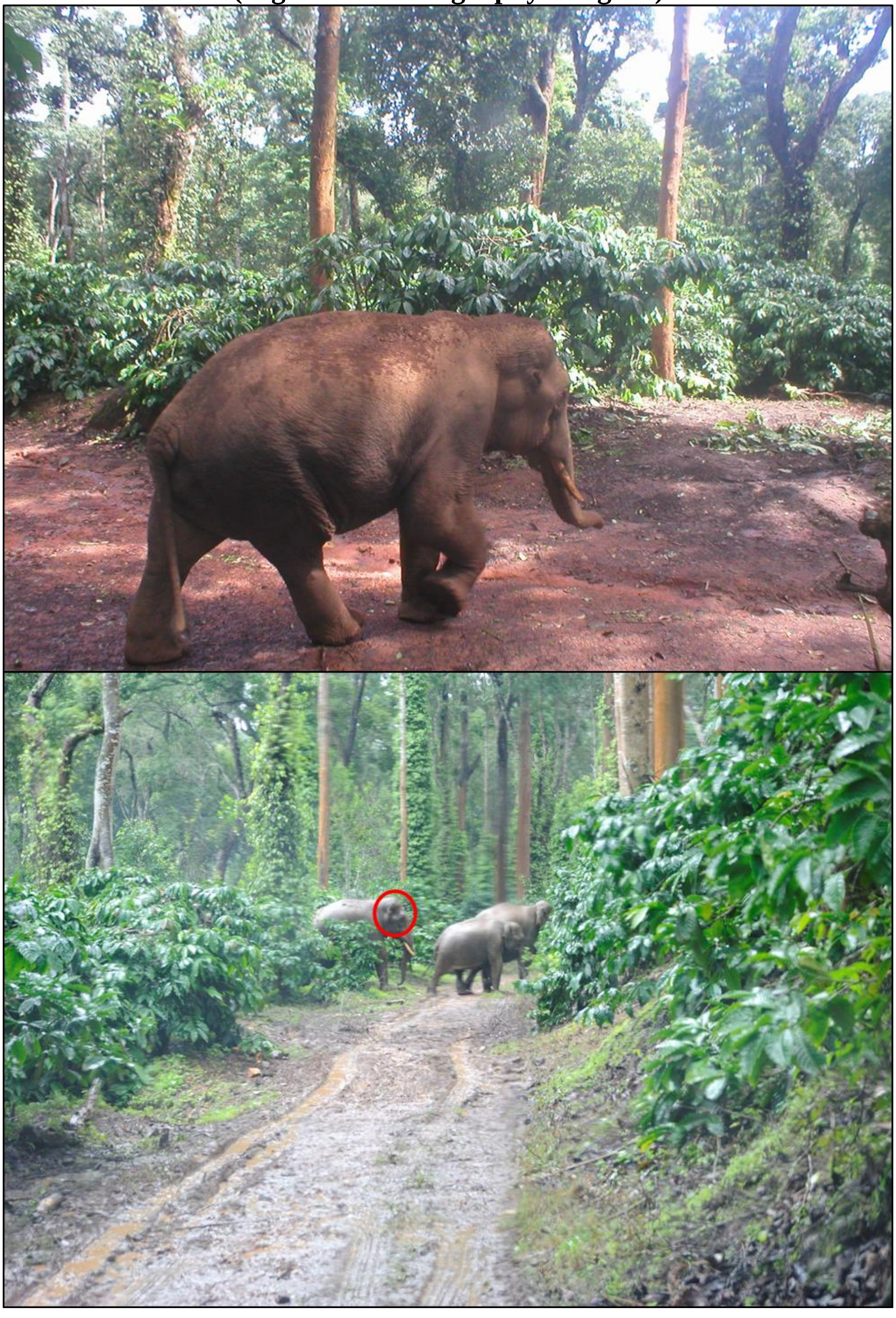
							ankle		shaped					margin; Left ear, Wide cut in the shape of ‘V’ at the lower bottom; Hefty build	BBTC
M12 (with swing)	Present	Both	Parallel	Downward	<1	Slender	Below ankle	Both-contin uous	Right/Lef t-V shaped	Right/L eft L Shaped	No	No	10-15	Sharp very small tusks	
M13 (with swing)	Present	Both	Parallel	Downward	1-2	Normal	Below ankle	Both-contin uous	Right/Lef t-L shaped	Right/L eft-L shaped	Left ear at the top corner	No	10-15		
M14 (with Swing)	Present	Both	Parallel	Downward	<1	Slender	Below ankle	Both – contin uous	Right/Lef t-L Shaped	Right /Left-U shaped	No	No	<10	Very Small tusks; Male 5-6 years	

See below examples of elephant ID pictures that were taken at different times through Camera traps and handheld Nikon Camera.

ID Name: Oldie

He was killed by electrocution in April 2011.

ID Name: M8
(Right Ear missing – physiological)



These are the only photographs of M8, but I have video documentation which confirms his identity.

ID Name: M 6
Ganesh – Single Tusk (right)

He was reported and seen twice during the entire field season.

ID Name: Group 1 (Swing)
Video 6

ID Name: F1
Swing (Warts both sides of the cheeks)

ID Name: M11
(sighted with Group 1)

ID Name: M12
(sighted with Group 1)

ID Name: M14
(sighted with Group 1)

ID Name: M13
(sighted with swing group)

ID Name: M10

ID Name: M2
(Splayed Brushless)

ID Name: M1
Makhna

APPENDIX 10: Fruits commonly found in coffee estates

Species name	**Scientific name**
Jackfruits	*Artocarpus heterophyllus*
Orange	*Cirrus reticulate*
Wild mangoes	*Mangifera indica*
Guava	*Psidium gujava*
Orange	*Cirrus reticulate*
Banana	*Musa paradisiac*
Arecanut	*Areaca catechu*
Coconut	*Cocos nucifer*

APPENDIX 11: Questionnaire (Narayana, 2009)

Questionnaire No:

Human – Elephant Conflict Survey form

Date:	**Time:**
Interviewer:	
Village name:	
Language Spoken:	

Initial Information

1. Respondent:

2. Owner (if different from the respondent):

3. Estate Name:

4. Gender: Male / Female

5. Age:

6. Born here:

   Moved here:

When	
As what	

7. Type of Farmer:

Large Farmer	Medium Farmer	Small Farmer

8. Owner lives on site: Yes / No

9. How many people in the family?

10. Level of education?

    a. Illiterate b. Primary education c. Secondary education

    d. Degree d. University

11. Do your children go to school/college/university?

12. What is your main source of income?

	Primary	Secondary
Crop Production		
Home stays		
Family Business		
Other working family member		
Any other		

Information on Land holdings and farming

1. Land Ownership

Ownership Type	
Private owned	
Government owned	
Lease/Tenant	
Other	

2. Land tenure system:

3. How many years have you been managing the estate / farm?

4. Total holdings of the land (acres):

5. Of which how many are under (acres)

Coffee	Area
Robusta	
Arabica	

Wetland	Cultivated (Acres)	Uncultivated
Paddy		
Areca Nut		
Palm		
Barren		
Any other		

Crop	Area (acres)
Pepper	
Cardamom	
Ginger	

6. How many trees do you have

	None	Less than 5	5 to 10	More than 10
Coconut				
Jackfruit				
Banana				
Orange				
Mango				
Papaya				
Guava				
Corn				
Other				

7. Do you sell any crops?

Locally	Nationally	Internationally

8. Do you have permanent workers (Nos)?

10. Do workers live on site? Yes / No

11. Do you use irrigation? Yes / No

Type	
Major	
Minor	
Rainfed	
Other	

12. How many times per year?

13. How many water storage systems do you have?

	1	2	3	4	5
Size (approximate)					

14. Do you use pesticides/fertilizers?

15. How many times have you taken support to cultivate your lands?

Government	
Bank Loans	
Private Loans	

16. Is there a forest

	Distance (mts/kms)	*Devarakadu*	*Baane*	*Urudve*	*Paisari*	Reserve forest	Wildlife Sanctuary	National Park
Within								
Nearby								

17. Is there a river within or nearby your estate? (mts/kms)

Initial Information on livestock and other secondary farming

1. Do you have any livestock? (1= Yes; 2= No)
    a. Cattle
    b. Pigs
    c. Chicken
    d. Other….

2. Where do you graze your animals?

Forest	
Open land	
Any other	

3. Do you do beekeeping? (1= Yes; 2= No)

4. How many boxes do you have?

5. Do you sell them (Income)?

Initial Information on wildlife

1. Do you visit the forests? (**If No, go to Question No. 4)**

For	
Timber	
Fuel/firewood	
Food/other	
Medicinal plants	
Other NTF products for construction	
Others (e.g access routes to estate)	

2. How frequently do you visit the forests?

Frequency	Daily	Weekly	Monthly	Other

Frequency	Seasonally	Rarely	Never

3. Do any wild animals visit your estate? (1=Yes;2=No)

4. Can you rank them in terms of which animal visits most often

Animals	Rank
Wild pigs	
Elephants	
Gaur	
Panther	
Monkeys	
Deer	
Any other	

5. Have you ever encountered any of the wild animals?

6. Which do you fear the most? And why?

7. Has anyone else encountered/got hurt by any wild animals in and around your estate?

8. When was the last visit of the elephants to the estate?

This week	Last week	Last month (April '09)	Last Year ('08- '09)	

9. Was it a direct sighting or a report? If report, by whom?

10. Can you specify (visit)
    a. Tick the months of the visit

Jan	Feb	Mar	Apr	May	Jun
Jul	Aug	Sep	Oct	Nov	Dec

    b. Time of the day

Morning	Afternoon	Evening	Night

    c. Frequency (per month)

Once	Twice	Thrice	Four	More than four

11. Do wild animals eat your crops? Which ones and rank them in order of the most damaged cost? (Coffee berries?)

Animals	**Rank**
Wild pig	
Elephants	
Monkeys	
Gaur	
Deer	
Any other	

12. Do the animals come alone or in groups?

13. How much did the damage to the crops cost you?

14. What do you do when you see them eating your crops?

15. Have anyone been hurt while trying to take actions against the elephants?

16. Was there a forest fire in the nearby forest recently?

17. How many times have you applied for compensation through the Forest Department?

18. Any private measures taken to prevent the elephants from coming into your farm?
NB: If No go to Question No. 20

Method	
Fire Crackers	
Shouting	
Fire	
Gun shots	
Repellant plants	
Repellant Chemicals	
Chillie Powder	
Electric Fencing	
Trenches	
Other	

19. How much did it cost you? Did the measures have any effect?

20. Is there a local community or organization which is working to take measures on mitigation (measures in preventing animals to enter the estate)?

Yes No

NB: If No go to Question No. 24

21. Are you involved?

22. Who are the other people involved?

23. Any effective measures taken by the local community?

24. Have there been any measures taken by the Forest department? Have they been effective?

25. What is your opinion on the overall present mitigation activities?

26. National Parks or Sanctuaries are deemed valuable by conservationists, media and the wild life department. What is your opinion on this?

27. Elephants are considered as valuable. Should they be protected?

28. Do you think people liked or disliked animals in the past? How is it presently?

29. Are you aware of any conservation activities (Government / NGOs)?

APPENDIX 12: Video lists

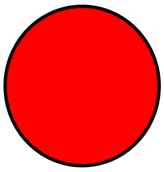
Video 1: This is the video of elephants crossing the main road breaking the fence with a tree.

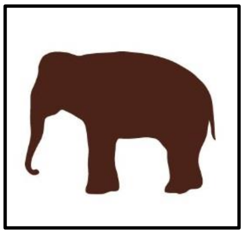
Video 2, 3 and 4: These videos are examples to show the visibility of elephants in coffee states. When they move within the coffee planted area, the visibility is poor and behavioural data is difficult to record. Video 4 and 5, is an example of the effort to ID elephants with limited visibility situations and time period.

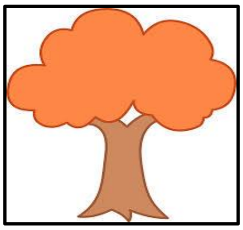
Video 5: is an example of all male group.

Video 6: Family group at the abandoned tank.

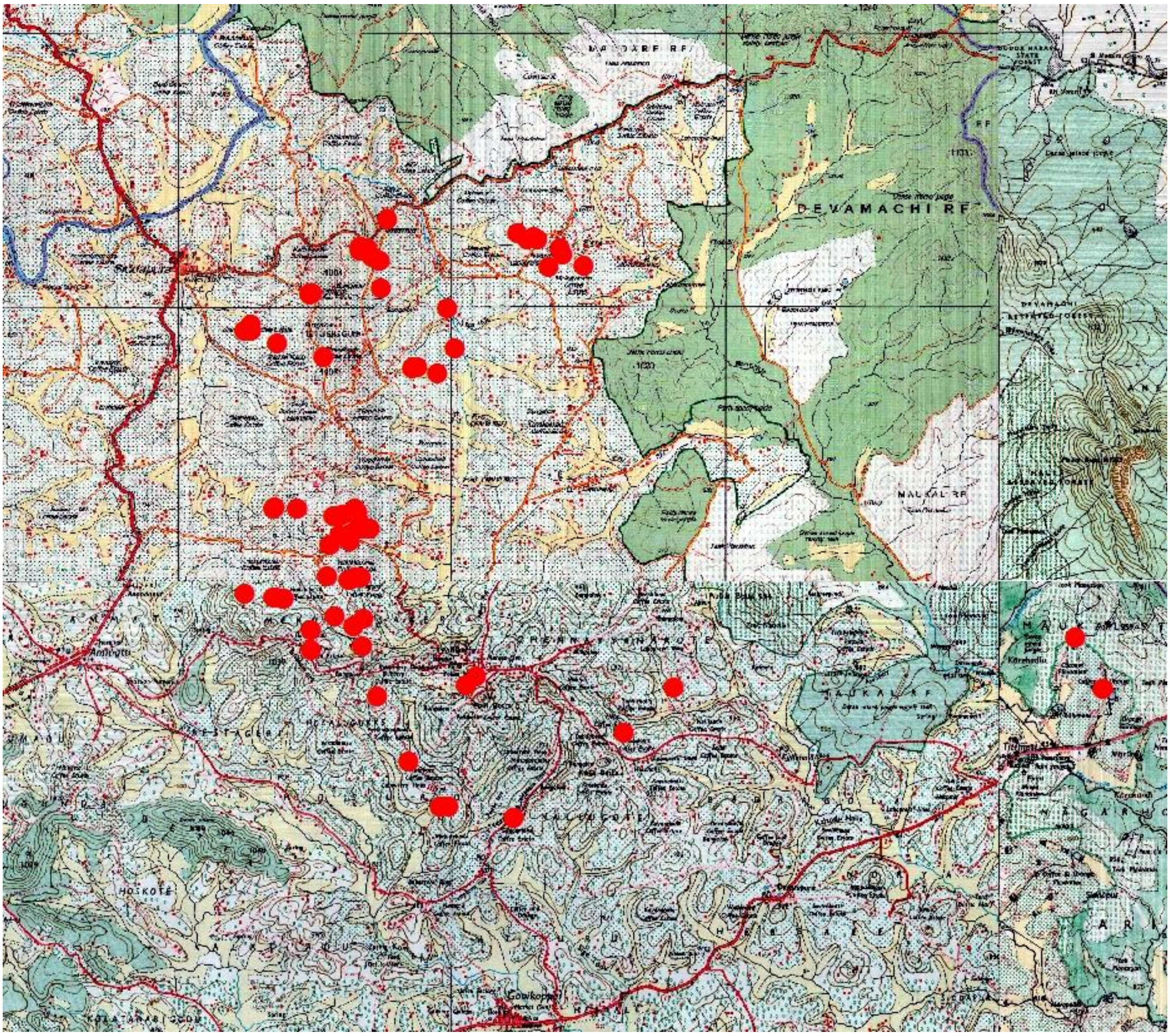
APPENDIX 13: GPS locations of the sightings, refuge areas and the dung sampling

Dung sampling 

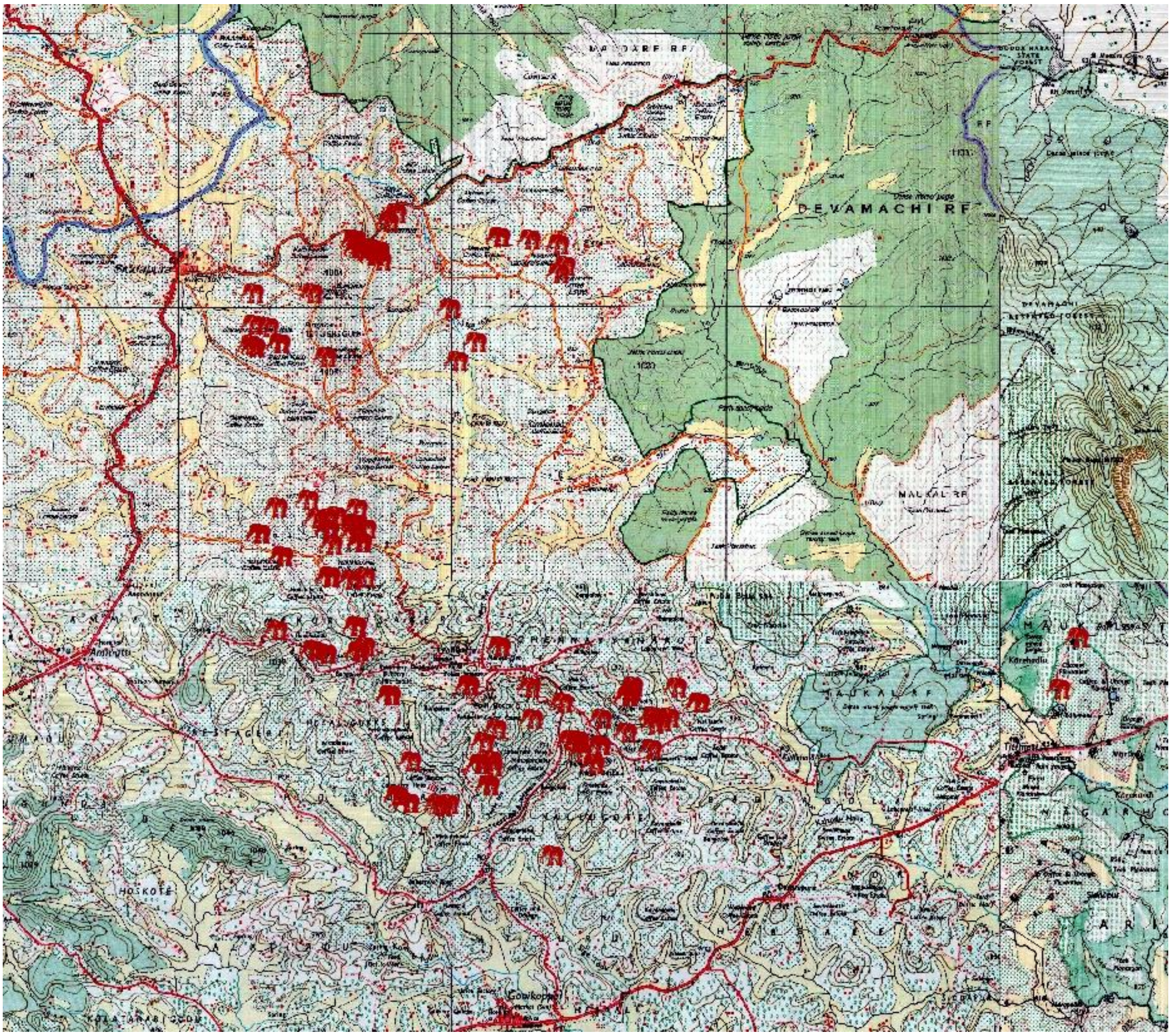
Elephant sighting events 

Refuge areas 

Map 1: GPS locations of the dung sample (across the study sites) mapped on scanned and digitized topographical maps using ESRI ArcGIS software.



Map 2: GPS locations of elephant sightings (across the study sites) mapped on scanned and digitized topographical maps using ESRI ArcGIS software.



Map 3: GPS locations of refuge areas along with elephant sightings (across the study sites) mapped on scanned and digitized topographical maps using ESRI ArcGIS software.