# ASSESSMENT OF HUMAN-WILDLIFE CONFLICT AND MITIGATION MEASURES IN MALAPPURAM DISTRICT, KERALA, INDIA

Thesis submitted to the University of Calicut in partial fulfillment of the requirements for the Degree of DOCTOR OF PHILOSOPHY

In Zoology

**BY**


**Riju P.**

(Reg. No. U.O.No. 7458/2015/Admn dated 13.07.2015)


Under the Supervision and Guidance of
Dr. E.A. Jayson


DEPARTMENT OF WILDLIFE BIOLOGY
FOREST ECOLOGY & BIODIVERSITY CONSERVATION DIVISION
KERALA FOREST RESEARCH INSTITUTE, PEECHI
THRISSUR DISTRICT, KERALA STATE, INDIA
680 653


September 2020

Dr. E.A.JAYSON D.W.L.M., Ph.D.
Former Research Coordinator &
Head, Dept. of Wildlife Biology
Kerala Forest Research Institute
Peechi-680 653, Kerala, India

Mobile: +91 9496216496
Email-jayson.58@gmail.com
jayson@kfri.org

# CERTIFICATE

This is to certify that the thesis entitled "**Assessment of human-wildlife conflict and mitigation measures in Malappuram District, Kerala, India**" is an authentic record of research work carried out by **Mr. Riju, P.** under my supervision and guidance in the Wildlife Biology Department of KSCSTE- Kerala Forest Research Institute, in partial-fulfilment of the requirements for the degree of Doctor of Philosophy of the University of Calicut. This has not been previously submitted for the award of any degree, diploma, associateship or other similar titles to any candidate of any university.

**Dr. E.A. Jayson**
Supervising guide
Senior Principal Scientist (Retd.)
Former Research Coordinator,
Programme coordinator, FEBC Division &
Head, Wildlife Biology Department,
KSCSTE-Kerala Forest Research Institute

Place: Peechi
Date:29-09-2020

## DECLARATION

I hereby declare that the thesis entitled **"Assessment of human-wildlife conflict and mitigation measures in Malappuram District, Kerala, India"** submitted to the University of Calicut for the award of the degree of Doctor of Philosophy is a record of independent research work carried out by me, under the supervision and guidance of Dr. E.A. Jayson Senior Principal Scientist (Retd.), Kerala Forest Research Institute, Peechi, Kerala. This thesis has not been previously submitted for the award of any degree, diploma, associateship or other similar title.

Riju, P.

Place: Peechi
Date: 29-09-2020

# Acknowledgement

I would like to express my sincere gratitude to my supervisor **Dr. E.A. Jayson** for the freedom and the time that he gave me to share the thoughts and also for being a constant source of encouragement and guidance during study.

I am grateful to **Dr. P.G. Latha** (former Director), **Dr. P.S. Easa** (former Director) **Mr. B.S. Corrie IFS** (former Director) and **Dr. Syam Viswanath** (Director), Kerala Forest Research Institute, for constant encouragement and support during the study tenure. I am also thankful to my RAC members - **Dr. M.V. Joseph, Dr. M. Nasser, Dr. Sebastian, Dr. Y. Shibu Varhan, Dr. P. Raveendran** and **Dr. P. Sunoj Kumar** from the University of Calicut during different periods and **Dr. K. Mohandas** expert member from KFRI for their valuable comments and suggestions.

I record my heartfelt thanks to **Dr. T.K. Dhamodaran, Dr. M.P. Sujatha** and **Dr. V. Anitha**, Ph.D. Nodal officers, KFRI, during the period for the facilitation and advice given for the betterment of my Ph.D.

I am indebted to **Dr. Suresh K. Govind** for being my mentor who set the path for me and also standing beside me throughout the journey. Many thanks to **Greeshma, P., Shonith, E.G. and Shine Raj** my lab mates for sharing beautiful moments and encouragement. I record my deep gratitude to my fellow students **Sandeep Das, Rajkumar, K. P. and Dhaneesh Bhaskar** whose challenges and productive criticism helped me to spark new ideas.

I would like to extend my thanks to the scientists of KFRI - **Dr. T.V Sajeev, Dr. K.F. George, Dr. V.B. Sreekumar, Dr. S. Sandeep, Dr. R. Jayaraj** and **Dr. Peroth Balakrishnan** for their continuous support and valuable suggestions rendered to organize my thesis.

I would also wish to express my gratitude to **Dr. Lucy King**, Head of the Human Co-Existence Program for Save the Elephants & Elephants and Bees Project Founder for her timely replies to the queries and opening the interaction which made my efforts meaningful.

*I most ardently express my thanks to my beloved friends **Dr. Sugantha Sakthivel, Dr. Dantus, Mr. Roy, Mr. Subin Sukumaran, Mr. Sabik, Mr. Alex C.J, Mr. Royal Tata, Mr. Anand Sebastian, Mr. Gnanakumar, Mr. Bharath Nair, Mr. Sanal viswam, Mr. Sanil M.S., Ms. Ragi Gopi, Mrs. Aswathy, Mrs. Shiya, Mr. Emmanual, Mr. Sanal (LAN), Mrs. Renuka, Mrs. Rugmini, Mrs. Sisitha of KFRI, Mr. Hareesh, Mr. Santhosh, Mr. Renjith** and **Mr. Rajesh** of University of Calicut, **Dr. Rajeev** of Banarus Hindu Universiy and **Dr. Vipin** (NIO, Goa).*

*I acknowledge the staff of KFRI library and LAN for their commendable service during the reference collection.*

*I wish to thank my field assistants and all the staff of Kerala Forest and Wildlife Department for their valuable company and unwavering support during the field days. My thanks are also to **Mr. Prashanth** for being my partner during the days of the questionnaire survey and the motor-bike (**KL-08-AQ, 7773**) allotted in the research project for carrying me safe for three years.*

*No words could express my immense gratitude to **Mr Predeep**- A beekeeping farmer from Pookkottumpadam who stood beside me and gave all his time and effort without expecting much back for my experimental days with beehive fence. I place on record my gratitude to **Haris, Jishnu, Kittu** and the farmers of Malappuram District in the forest fringes.*

*I express my thanks to KFRI drivers **Mr. Vasan, Mr. Sunny, Mr. Wilson, Mr. Rjendran, Mr. Mathai, Mr. Preman, Mr. Antony, Mr. Prijo, Mr. Roopesh** and **Mr. Shiju** for the safe journey during fieldwork.*

*Above all I would like to acknowledge the tremendous sacrifices taken by my **wife**, my **daughter** and **parents** for the successful completion of my thesis work. I am greatly obliged to my **brothers** and relatives for their love and care. For this and much more, I am forever in their debt.*

*RIJU P*

*Dedicated to my family*

## CONTENTS

# *Abstract*

# ABSTRACT


Human-wildlife conflict is a primary concern all over the world due to its increased pace in response to the growing population. The bigger need for space and resources for both the humans and wildlife become the major hindrance for the concept of coexistence. As a result, the magnitude of crop damage, livestock lifting and human casualties by wild animals become elevated and thus the retaliatory response of people towards the wild animals develop into an impediment for conservation efforts. In Kerala, all the three facets of human-wildlife interactions were reported. A landscape level approach is needed to ameliorate the issue, and in this context the study was carried out in the Malappuram District of Kerala State, India with the following objectives 1. To assess and estimate the extent of crop damage by wild animals in the Nilambur North and Nilambur South Forest Divisions, 2. To find out the reasons for cattle lifting incidences and human casualties due to wild animals in Malappuram District, 3. To model and predict the potential areas of crop damage in the study area using GIS and 4. To suggest the suitable mitigation measures to ameliorate the problem.

Malappuram District (10°45' to 11°25' N and 75°55' to 76°24' E) spanning an area of 3550 km$^2$ is covered with 1034.2 km$^2$ of forest of all the seven forest types of southern India. The field data was collected from June 2013 to September 2016. Quadrats of 10 m x 10 m were laid randomly in the mixed croplands of the fringe areas of all the five Forest Ranges to estimate the extent of crop damage by wild animals.

Incidences of crop damage were recorded from the selected quadrate in each month (n=36). The economic loss was assessed by multiplying the quantity of crops damaged in the selected plots with the average market value of the crops collected from the Farm Information Bureau, Kerala. Running quadrates were used to assess the crop loss to Asian elephant (*Elephas maximus*). Case studies were conducted to collect the information on the cattle lifting incidences and human casualties. Availability of natural food in the periphery of the Reserve Forest in all the five Forest Ranges close to the sample plots was estimated by employing Point Centered Quarter method (PCQ). A structured questionnaire survey was used to record the conservation attitude of the people towards the wildlife and the data were used to model and predict the potential areas of crop damage by wild animals. Arc Map v.10 GIS Software package was used to prepare the prediction map. Efficacy of the control measures like Beehive fence (proved successful as deterrent against the African elephants), yellow coloured cloth and bio repellant "Trump guard" were evaluated in the field.

The wild animals frequently came into conflict with the people in the forest fringes of Malappuram District were Asian elephant (*Elephas maximus*), wild pig (*Sus scrofa*), bonnet macaque (*Macaca radiata*), Indian crested porcupine (*Hystrix indica*) and black-footed gray langur (*Semnopithecus hypoleucos*). The crop species damaged by the elephant were plantain (*Musa paradisiaca*), coconut (*Cocos nucifer*a), arecanut (*Areca catechu*), rubber (*Hevea brasiliensis*), teak (*Tectona grandis*), jackfruit (Artocarpus heterophyllus), mango tree (Mangifera indica and nutmeg (*Myristica fragrans*). Elephants fed mostly on plantain, arecanut, coconut and rubber. Teak and paddy (*Oryza sativa*) were also damaged in negligible quantity. Karulai Forest Range, followed by Kalikavu and Vazhikadavu were facing severe crop damage and highest crop damage was reported during July and August. Forty-two cases of elephant encounters in the crop lands were reported during the period which covered a total of 2.90 hectare area. The crop raiders intruded into the farms up to 6 km from the Reserve Forest. The highest damaged crops by Asian elephants were plantains (60.93%) followed by rubber (27.08%), arecanut (7.90%), coconut (32.97%), teak (0.93%), jackfruit (0.122%) and mango tree (0.04%). Elephants damaged crops worth Rs. 22,62,822/- (US$ 32051) per annum in the District other than rubber and damaged rubber trees worth of Rs. 28,59464.83 per annum (US$ 39938).

Wild pig was distributed in all the five Forest Ranges of the District irrespective of the availability of forest. Highest damage was recorded from Nilambur followed by Edavanna, Vazhikadavu, Kalikavu and Karulai. Plantain and fallen coconuts were the most severely targeted crop species. Wild pig consumed 0.20±0.09 coconut/tree/month (n=215) by removing the mesocarp and endocarp and feeding on the endosperm. Debarking of the rubber trees was recorded from both Edavanna and Kalikavu Forest Range (n=47 trees). Wild pig caused huge loss to the plantain and coconut farmers in the District with 88.83 per cent of loss to plantain (Nendra- 73.04 per cent and Palayamthodan

15.79 per cent) and 11.16 per cent to coconut. Mean economic loss was estimated as Rs. 34,460.34/- per ha per annum.

The presence of Indian crested porcupine was recorded from all the Forest Ranges except Nilambur Range. Severe damage was recorded in the coconut plantations both by consuming the fallen coconuts and by debarking the basal portion of coconut palms (n=31). Indian crested porcupine destroyed 0.12±0.09 coconut/tree/month (n=91). The debarking behavior of porcupine on the rubber plants (n=27) and the feeding of newly formed bamboo culms (n=42) were also recorded from the Edavanna Forest Range. The mean economic loss by Indian crested porcupine was Rs. 1322.35/- per ha/annum and the highest damage was recorded from Edavanna Forest Range followed by Karulai, Vazhikadavu and Kalikavu. The crop raiding by bonnet macaque occurred throughout the day but mostly in the morning and evening hours (n=27). They were feeding on the tender coconuts by plucking it from the coconut palm and most of the time by sitting on the top of the palm itself. The highest loss of coconuts (Eight nuts/tree) due to bonnet macaque was recorded from the Kalikavu Forest Range followed by Edavanna. An economic loss of Rs. 11914.61/- per ha/annum was estimated from Kalikavu Forest Range followed by Rs. 877.06/- per ha/annum from Edavanna Forest Range. The coconut palms close to the forest boundary were targeted by Black-footed gray langurs and they were very shy and scary to the presence of human beings or any kind of disturbance when they approached the coconut palms. They caused an economic loss of Rs. 4412.32 per annum in the Kalikavu Forest Range.

Asian elephant, wild pig, leopard, bonnet macaque and gaur caused injury to the human beings. Eight cases of human casualties due to Asian elephant were recorded in the District and in five of them human lives were lost. A total of 19 human-wild pig encounters were recorded from the study area and 8 of them were the collision with vehicles (2 autos and 6 motor bikes). The number of victims was twenty six including three women. The highest number of human fatalities by wild pig was recorded in the age group of 50- 55 years and none of them was vehicle collision. Most of the incidents were occurred in Kalikavu Forest Range (63.15 %) followed by Nilambur (15.78 %), Karulai (10.52 %), Vazhikadavu (5.26 %), and Edavanna (5.26 %). The highest number (75 %) of wild pig-vehicle collisions were happened on the road, near the rubber plantation (n=8). The aggressive behaviour of a rabid wild pig was recorded from Pathippara ($11^{0}$18’08.9”N and $076^{0}$15’44.2”E).

Three school students were injured severely by the attack of bonnet macaque while they were on their way to school in the morning in Vazhikadavu town ($11^{0}$22’54.4”N and $076^{0}$20’30.9”E). Eight cases of death of monkeys due to infection with Kyasanur Forest Disease (KFD) virus was recorded from Karulai Forest Range and two cases from Kalikavu Forest Range. Four cases of positive KFD were identified from tribals under Karulai Forest Range and all victims were above 15 years of age, no human death was reported during the period by KFD. A solitary gaur (*Bos gaurus*) spotted in a rubber plantation close to

Reserve Forest at Mullapally in the Karulai Forest Range ($11^{0}16'20.7"N$ and $76^{0}18'16.7"E$) caused severe injuries to three people and later it was killed.

A total of six cattle-lifting incidences were recorded and five of them were by leopard (*Panthera pardus*) and one was by wild dog (*Cuon alpines*) and the prey species involved were ten goats and three cows (one calf and two adult). Sixty-six per cent of the attack on cattle occurred during the evening hours from the grazing field close to forest. Only in one incident the cattle was lifted from an open cattle pen.

Three hundred households were surveyed from twenty five Panchayaths in the District. The maximum households were surveyed from Kalikavu Forest Range (53.33%) followed by Nilambur Range (16.66%). A total of 8 crops were cultivated in the Malappuram District namely coconut (*Cocos nucifera*), Arecanut (*Areca catechu*), rubber (*Hevea brasiliensis*), turmeric (*Curcuma longa*), ginger (*Zingiber officinale*), plantain (*Musa paradisiaca*), cassava (*Manihot esculenta*) and vegetables. Eighty two per cent of the respondents reported wild pig as the major crop damaging wild animal followed by Bonnet macaque (11.16%), Asian elephant (6.05%) and Indian crested porcupine (0.47%) (n=215). Twenty priori models were prepared by using seven explanatory variables which are supposed to have an influence on the prediction of potential areas of crop loss in the District. Out of these, four factors were identified to have an influence on the prediction of crop damage by wild animals namely elevation, residing duration, number of crop damaging animal species and number of cultivated crops. Elevation ($\beta$= 0.017) and Residing duration ($\beta$= -0.031) has a little effect on the prediction as its value of beta coefficient is comparatively low. The prediction map showed that all the Forest Ranges except Edavanna Range has the places with high value of crop loss. The major places identified to have a high value for crop loss to animals are Manimooly from Vazhikadavu Range, Veralimunda from Karulai Range and Munadi from Kalikave Range.

Thirteen indigenous preventive measures were identified. Beehive fence was a good short term control measure against crop raiding Asian elephants. A total of 13 Asian elephant encounters were recorded in the area, of which five times through the fenced area, two times by breaking the fence and in three occasions failed to cross the honey bee fence. Approximately 15 kg of honey was extracted from eighteen beehives in the experimental site which generated an income of Rs. 3000/- (US$ 46) at a time. Yellow colored cloth and the bio repellent “Trump guard” were proved as successful deterrent against wild pig. The particular smell of the repellent kept the wild pigs away from the crop field and it was noticed that the proper application of the repellent in the field twice in a week was essential to keep it active against the crop raiders.

Peaceful co-existence with minimum damage on both sides was the achievable target to reduce the human-wildlife conflict. Community participation is the primary requirement for the success of mitigation strategies. People were well aware of the wildlife laws and equally reprisal against the animals. When it becomes the livelihood issue for humans, the attitude will be more harmful and the conservation will remain only in papers. Proper awareness campaigns from the authorities, which gave a feeling of belongingness, will help to create positive attitudes by the affected people.

# Chapter one
# ***Introduction***

# 1. INTRODUCTION

Human-wildlife conflict (HWC) has a long history of years. In the present world, the human population with its control on other species, the perception and interpretation of the HWC has changed and it is producing more hue and cry. At the same time, the conservation and protection of wildlife is also strengthened. Human-wildlife conflict occurs everywhere, where the needs of human beings and wildlife meet at a common point, like in the case of space, crops, and other natural resources. The increased demand for the expanded human population and the resulted land use pattern, which is incompatible with wildlife in the forest fringe has also contributed to this scenario to a large extent. As the wild animals get habituated to the newly introduced mitigation measures, the situation becomes worst and which in turn forces the scientific community to spend more energy in this field to provide a peaceful co-existence. In many areas, the human population expansion with uncontrolled encroachment into the wildlife habitat, construction works, and developmental activities near the marginal areas are recognized as the fundamental cause for conflicts (Romanach *et al.*, 2007; Sharma *et al.*, 2011).

The HWC has several dimensions and primarily come under two heads, namely wildlife dimension and human dimension. The issues like crop damage, cattle-lifting, human casualties, household damage and zoonoses are the wildlife dimensions of HWC. The attack of wild animals on human beings can be of three different ways, they are (i)

Territorial attack- many animals keep their distance from others by creating their territory and people unknowingly intrude to their space will provoke the animal to attack, (ii) defensive attack- the wild animal attack humans defensively for their survival, (iii) Predatory attack- it occurs when the animal views the person as prey (Conover, 2002). Zoonoses are human diseases for which vertebrates serve as reservoirs or hosts for the disease organism. The cropping pattern and intensity, cultivation upto boundary of forests, linear intrusions like road, railway lines and canals in wildlife habitats, presence of animals in human-dominated landscapes, infrastructure development, a retaliatory response from people, unscientific mitigation measures, inadequacy of frontline staff and lack of awareness are the major human dimensions (Sekar, 2013). The factors like social, economic, political and poaching are also included in the human dimensions in a global perspective. In addition to these, the hidden aspects of HWC include the diminished psycho-social wellbeing, disruption of the lively hood and food security along with the considerable opportunistic cost through crop and livestock guarding (Barua *et al.*, 2013). It is evident that an investigation on the connection between morals regarding conservation can help to increase understanding about, why humans support to oppose a policy, mainly related to HWC. However, the moral dimension of human-wildlife conflict has most of the time remain unconsidered and unmeasured (Lute *et al.*, 2016). We have to consider all these factors while thinking for an effective mitigation strategy to reduce the human-wildlife conflict. Mitigation measures developed in other countries, need to be evaluated in the local condition and the new methods which will be appropriate for the local environmental and social conditions should be developed to reduce the problem.

The problem of human-wildlife conflict has a long-term environmental impact. The wild animal species exposed to conflict with people are more prone to extinction (Ogada *et al.*, 2003). The fatal results caused due to the crop-raiding, wild animal-vehicle collision on the roads, train accidents, unexpected fall into the abandoned wells in the farmland, local poaching due to high exposure in the human-dominated area, the intentional and unintentional retaliatory shooting and poisoning are causing the loss of population viability of endangered species and it is the major threat for the ecosystem equilibrium and biodiversity conservation.

A well-compacted participatory approach from local governmental bodies and local communities is essential for the development of long-term, cost-effective solutions. Incorporating local stakeholders as partners in planning and implementation can help to win space for wildlife beyond protected area boundaries (Treves *et al.*, 2006). Peoples' attitude towards wildlife is complex according to different religious affiliation, ethnicity and cultural beliefs. It also determines the intensity of the conflict and human-wildlife conflicts are often the manifestation of underlying human-human conflicts, such as between people of different cultural background or between authorities and local people (Dickman, 2010). Human-wildlife conflict varies according to geography, land use pattern, attitudes and behaviour of the local people and the habitat and behaviour of the wildlife species involved. The behavioural changes that happened to the wildlife in the recent past due to the continuous encounter of human beings in their habitat without any harm due to Wildlife Protection Act made them fearless in the presence of human beings. It became one of the primary reasons for the increased conflict with wildlife, in the urban or semi-urban areas, which in turn is the result of increased tourism activities in the protected areas. Site-specific studies are essential to come up with suitable solutions to solve these problems.

## 1.1. Human-wildlife conflict in Kerala

Human-wildlife conflict in the Western Ghats of Kerala exists as intense as in many other parts of India as well as in other countries. It has attained more considerable attention in recent years due to the straying of wild animals into the farmlands and human settlements from which it not reported earlier and the resultant human casualties by carnivores. Among these, crop damage by wild animals is one of the major problems faced by the marginal farmers of Kerala. The studies on human-wildlife conflict of Kerala have been carried out by the scientists of Kerala Forest Research Institute, Peechi, India from 1992 onwards.

The forest land of Kerala has lost its natural connections due to the increased settlements and corresponding agriculture expansion which ultimately led to the crop damage by wild animals in the agricultural fields close to the fringe of the forest. Asian elephant, wild pig, Indian crested porcupine and bonnet macaque were the dominant crop-raiding species recorded from the croplands and plantations. Wildlife census reports revealed that the population of most of the wildlife species in Kerala are stable or growing (Easa *et al.*, 2002; Sivaram *et al.*, 2005; Sivaram *et al.*, 2007; Sivaram *et al.*, 2010; Sivaram *et al.*, 2013) which reflects the effect of strict implementation of stringent wildlife laws and its awareness among the people.

Wild animals in Kerala destroyed forty-five species of crops and most important among them were paddy (*Oryza sativa*), coconut palm (*Cocos nucifera*), plantains (Musa sp.), cassava (*Manihot esculenta*), arecanut (*Areca catechu*), coffee (*Coffea arabica*), oil palm (*Elaeis guineensis*), pepper (*Piper nigrum*), jack tree (*Artocarpus heterophyllus*), mulberry (*Morus alba*) and mango (*Mangifera indica*) (Jayson, 1999). Asian elephant (*Elephas maximus*), gaur (*Bos gaurus*), sambar (*Rusa unicolor*), wild pig (*Sus scrofa*), bonnet macaque (*Macaca radiata*), common langur (*Presbytis entellus*), black-naped hare (*Lepus nigricollis*) and Indian peafowl (*Pavo cristatus*) were the dominant animal species involved in crop damage. Asian elephant and wild pig were the two species responsible for highest damage. The Kerala Forest and Wildlife Department sanctioned only 8.2% of compensation in the total claim of the farmers (Jayson, 1999).

Several studies about human-wildlife interactions were carried out in the Kerala State. Human-wildlife interaction in the Wayanad Wildlife Sanctuary (Easa and Sankar, 2001), human-crocodile conflict in Neyyar Wildlife Sanctuary (Jayson and Padmanabhan, 2002), Peppara Wildlife Sanctuary (Jayson and Christopher, 2008) and Idukki District (Veeramani *et al.*, 2004) were the few earlier studies.

For tackling the issue effectively, we have to approach it at a landscape level and for that, it is essential to have scientific data from all the affected areas. The increasing of conflict with wildlife creates a negative attitude towards them and it is a major threat and hindrance for the conservation of wild animals and biodiversity. Earlier studies from Kerala indicated that crop damage due to wild animals was a serious issue affecting the farmers of forest fringes (Veeramani *et al.*, 2004). The questionnaire survey conducted in the fringe villages of Nilambur Forest Divisions reported that majority of the respondents were ready to conserve wildlife without bearing any associated cost (Rohini *et al.*, 2017). So far, only one study was in Kerala regarding the quantification of crop loss in a large area (Govind and Jayson, 2014). No such studies carried in the Malappuram District.

## 1.2. Crop-raiding by wild animals

Managing HWC without harming wildlife or human welfare requires a delicate balance of agricultural extension and wildlife conservation (Treves *et al.*, 2006). The frequency and occurrence of crop-raiding by the wild animals depend on a multitude of conditions such as availability, variability, and type of food source in the area, the extent of human activity in the farmland and the type and the maturation time of crops as compared to natural food sources. Every season, on an average of 4-7 per cent of crops was lost by the farmers residing within 500 m of the protected areas, to the rampage caused by the wild animals (Parisara Envis Newsletter, 2015). The increased damage of crop by wildlife causes loss of support for conservation by local communities and harm both wildlife and communities. Guarding the crop field during harvesting period is the most effective method of preventing crop damage. Even though many farmers suffer crop-raiding by wildlife, most of the affected communities were not reporting the same to the concerned bodies, due to the lack of communication (Tesfay, 2016). The strategies employed by farmers to control the crop-raiding species are leading to disruption of the ecosystem service (Tesfay, 2016). Most of the wildlife damage effect to the farmers living near the forest edge and the risk perception among these farmers has been escalated by legal prohibitions on the killing of wild animals. So that increasing local tolerance for wildlife will require different approaches, including economic benefits to the locals and disbursing compensation in limited cases (Naughton-Treves, 1998). Most of the local farmers in Luangwa Valley of eastern Zambia expanded their crop fields mainly to compensate for crop damage and their needs and aspirations expressed through expansion and segregation of fields were antagonistic to wildlife conservation (Nyirenda, 2013). For a productive discussion regarding the relative agricultural damage by different wild animals requires a systematic data along with an accurate description of the extent of the study area and its proximity to natural habitat or reservoir of raiding animals. Interpreting the pattern of damage by wild animals of different sizes and behaviour requires careful attention to scale, both spatial and temporal aspects of damage (Naughton-Treves, 1998).

Another critical problem is that the farmers view the wild animals as government property and draw the perception that the government being a bad neighbour, allowing its animal to damage crops but not offering compensation (Hill, 2004). This kind of attitude among the farmers can change only through giving awareness programmes about the need for cooperation between the local farmers and the different Government Departments for the successful mitigation of wild animals from the croplands. In some cases, the repeated encounters of the elephant in the farmland can cause entire farms to be abandoned, which inject a negative attitude in the affected people towards the wild animals (Naughton-Treves, 1998).

## 1.3. Need of the study

Quantification of the crop loss due to wild animals is essential to know the impact of conflict and subsequent economic loss to the farmers. There is a lack of studies dealing with the monetary cost associated with HWC and no realistic estimates are available for involved species. Majority of the studies are from protected areas and less consideration was given for the unprotected forest and it is essential to make action plans, which target offsetting economic loss of locals and enhanced public participation at a landscape level where human and wildlife can coexist (Manral *et al.*, 2016).

The best way to conserve the wild animals in the present scenario with high human population is to change the attitude of people in favour of wild animals. For this, we have to address the problem of crop damage, which is the major facet of HWC in terms of cost involved in front of the authorities who can implement mitigation strategies. This study was an attempt to reduce the gap between affected people and those who have the power to act. The support from the authorities will help to develop positive conservation attitudes among the marginal farmers. The present study is a new attempt in this philosophy from the Malappuram District.

## 1.4. Objectives of the study

Main objective of the study was to assess the human-wildlife conflict in Malappuram District of Kerala, India. Specific objectives were given below.

1. To assess and estimate the extent of crop damage by wild animals in the Nilambur North and Nilambur South Forest Divisions.
2. To find out the reasons for cattle lifting incidences and human casualties due to wild animals in Malappuram District.
3. To model and predict the potential areas of crop damage in the study area using GIS.
4. To suggest suitable mitigation measures to ameliorate the problem.

Chapter two

# *Review of literature*

# 2. REVIEW OF LITERATURE

## 2.1. Human-wildlife conflict

### 2.1.1. Studies in other countries

The human-wildlife conflict was studied extensively all over the world. Various studies have highlighted the importance of public awareness and understanding of wildlife due to inadequate availability of factual knowledge on wildlife and highly emotional approach to wildlife issues (Dahlgren *et al.*, 1977). In the current scenario, the landscapes appear as small patches of degraded forests which are interspersed with small-scale gardens and plantations are believed to facilitate the occurrence of human-wildlife conflict (Hoare, 1999; Sitati *et al.*, 2005; Rood, 2006; Rood *et al.*, 2008). Duffus and Dearden (1990) suggested that no consumptive wildlife-oriented recreation is essential to develop the idea of conservation from the long-term effect of changing attitudes towards wild animals and natural habitats.

There are several opportunistic costs to the victim of human-wildlife conflict which includes competition for water resources, loss of sleep, reduced school attendance, fear of travel, reduced employment opportunities, increased exposure to malaria and physiological stress (Naughton-Treves, 1998; Sukumar, 1990; Hoare, 2000). Sotolu *et al.* (2017) examined the impact of human-wildlife conflict on socio-economy of communities in the Cross River National Park, Nigeria and crop loss was ranked as the highest effect of human-wildlife conflict in the community. They argued that the custodian of the biodiversity, before its protection, was the sole beneficiary of the resource, so that their lives and livelihood should be secured after its protection to ensure a conservation attitude and sustainable development among the local community. Protected areas urgently require priority actions for assessment of grazing capacities, allocation and enforcement of grazing quota and also the better coordination between Government conservation agencies and natural resource management organizations to avoid further exhaustion of the large mammal community due to the high grazing intensity (Soofi *et al.*, 2018).

Human-elephant conflict (HEC) is a part of a complicated relationship that arises where the elephants and people exist in the same area; however, the pattern of this relationship varies significantly according to the sites. The fundamental reasons were typically spatial and temporal more than the numerical or density-dependent (Barnes, 1996; Hoare, 1999; Hoare and Du Toit, 1999; Smith and Kasiki, 1999).

As one of the primary needs to sustain the life, the elephants will always be attracted towards artificial water resources during the drought season (Thouless, 1994; Sutton, 1998) and also the presence of water has a major role in the distribution of elephants (Western, 1975; Williamson, 1975; Viljoen, 1989). If the movement of elephants through their traditional migration routes restricted due to any of the human intrusions like canals, power installation and cattle fences they will become aggressive in their behaviour and that will increase conflicts (Kangwana, 1995). The farmers were extending their agricultural land by encroaching into migration routes of elephants (Smith and Kasiki, 1999).

Wild pig found in the urban area will have smaller home ranges due to restricted space compared with the forest so that they will show longer daily movement due to patchy resources. They will exhibit increased nocturnal activity and ranging behaviour in an attempt to avoid human interference. It was observed that in the urban area, the wild pig was almost exclusively nocturnal whereas, in the primeval forest, wild pig activity was evenly distributed throughout the day (Podgorski *et al.*, 2013). The authors opined that wild pig could adjust their spatio-temporal behaviour to local conditions which could be one factor explaining rapid demographic expansion.

Dela (2011) studied the monkey-human relationships and habitat change on *Semnopethecus vetulus nestor* in human-modified habitats of Sri Lanka and reported that the loss of canopy cover due to habitat destruction was the most significant threat to Western purple-faced langur in human-modified environments, followed by hunting. The loss of canopy cover was much higher than expected as all home gardens had undergone low-level arboreal pathways, engage more frequently in ground travel to cross the roads or use power lines to cross the gap in the canopy. These changes make langurs more vulnerable to low food availability, predation by dogs, human harassment, hunting and injury or death due to electrocution. Property damage and economic loss by macaques were reported in northern Japan (Enari and Suzuki, 2010). McLennan *et al.* (2017) reviewed the primate behaviour in anthropogenic habitats and found that their interactions with people increased markedly since the 2000's.

The survey of Romanach *et al.* (2007) in Central Kenya revealed that all commercial ranchers felt that, coexistence between people and predators was possible. The most common response given (by 22% of ranchers) about ways to promote coexistence was to begin trophy hunting followed by any income from wildlife (17%) and improved livestock husbandry techniques (17%). The human-carnivore conflict directly causes the death of humans, livestock which in turn result in a negative local attitude and revenge killings which curtail the future of many endangered carnivores (Barlow *et al.*, 2010).

The people are ready to tolerate the conflicting wildlife species if the species are perceived as beneficial to the personal, spiritual, cultural, economic, social, or political well being of the society (Madden, 2004). Treves *et al.* (2009) argued that the systematic and participatory monitoring of the relative merits of the alternative interventions is essential for the effectiveness of conservation action.

### 2.1.2. Indian context

Anand and Radhakrishna (2017) reviewed the trends of human-wildlife conflict since 1990 in India. They reported that there was a consistent increase in the number of publications regarding human-wildlife conflict and about 90 per cent of the country is presently exasperated by this problem. A total of 80 species belonging to 9 taxonomic groups are responsible in the conflict however the researches are limited to selected species and geographical locations. The main species involved in conflict during 1976-1995 were Asian elephant, blackbuck (*Antilope cervicapra*) and Indian gerbil (*Tatera indica*) and this has been changed into the Asian elephant, Indian tiger and common leopard during 1996-2015. The study of Deb *et al.* (2018) on the anthropogenic impact on forest land use and land cover changes in the Himalayan Terai revealed that there is a continuous decrease in the dense forest from 1978 to 2016 and the modelling predicted that the trend would continue up to 2050. Cultivated land increased from 1978 to 2016. Increasing population pressure, agricultural production demands, and high human intervention in forests were identified as the possible causes of temporal forest degradation, which in turn leads to the conflict between humans and wild animals. Ogra and Badola (2008) examined the processes of applying for compensation for the damages from wild animals and reported that along with the factors like inadequate remuneration, processing delays and corruption, the factors including wealth, gender, social network, and pre-existing expectations are hindering them from applying for compensation.

Kumar *et al.* (2010) studied the habitat use of Asian elephants in fragmented rainforest and plantations in the Anamalai hills and suggested that protection of rainforest fragments, secondary vegetation along the river, and regulated and sequential felling of Eucalyptus along elephant movement routes will help to retain forage cover and passage routes of elephant herds which will reduce the direct human-elephant encounters in fragmented landscapes. Ramkumar (2013) surveyed on people's perception on conflict and elephant conservation in Coimbatore Forest Division and revealed that most of the respondents (87%) supported in favour of elephant conservation besides that 80% of the respondents believed that elephants have the right to live. According to Roy and Sukumar (2015), the main challenges for the preservation of elephant corridors in Northern West Bengal were the presence of tea gardens, army establishment and villages within them. Roy and Sukumar (2017) attributed the increased frequency of elephant movement across the railway tracks in India to the season of crop cultivation.

The monkey troops invading into the human settlements and damage to human properties in Haryana was reported by Imam *et al.* (2001). Sharma *et al.* (2011) elaborated on the human-monkey conflict and its management in Jodhpur and observed that the hanuman langurs have gradually learned that proximity to human beings can be advantageous since they can receive food, or increase their chance of stealing.

## 2.2. Crop damage

### 2.2.1. Studies in other countries

Retamosa *et al.* (2008) stated that the rate of crop damage is negatively related to the area of the field and the distance to the nearest forest patch from the edge of the field. Which is positively related to the factors like the perimeter of the field adjacent to wooded areas, the distance to the water body, the amount of wooded areas, the amount of developed areas, the amount of forest edge, and the mean forest patch size in an area of 530 ha centred on crop field. The extent of farmer's tolerance towards the crop loss to wild animals is influenced by factors like their dependence on agriculture as their primary source of income, the extent of agriculture land and also the residing duration in the area (Nyerges, 1992; Naughton-Treves, 1999; Hill, 2004).

Farmer's perception of the crop damage by wild animals depends on the factors like economic value of the crop, opportunity cost to guard the farm, frequency, extent of crop-raiding, and maturity of crop damaged (Linkie *et al.*, 2007). Gross *et al.* (2018) found that crop availability, seasonality, type and phenological stage of the crop have an inevitable role in the crop-damaging behaviour of herbivores in Africa and Asia, the elephants and wild pig show preferences for harvested and/or maturing crops. Highly nutritional staple crops will always bear a high attractiveness to wildlife species so that, as long as the attractiveness of the crop is not reduced, crop protection will continue to cost high labour and finance.

Changes in land tenure with a trend towards privatization caused the decreased traditional farming strategies based on joint properties which in turn increase the impact of crop loss on individual rather than communities. Similarly, farmers have abandoned guarding, communal hunting and planting activities that once reduced crop loss in many sites (Lahm, 1996; Nelson *et al.*, 2003). The study of Linkie *et al.* (2007) revealed that temporal crop-raiding peaks were positively correlated with periods of the high rainfall for all species. The occurrence of crop raid was nearest to the forest edge for most of the time and the guarding strategies locally used were inefficient. They suggested that the most effective mitigation strategies should be identified by checking the alternate mitigation strategies both in dry and rainy seasons. The guarding efforts should be increased during the rainy seasons by focusing on specific crop-raiding species based on their unique spatial patterns.

According to Hoare (1999), the association of crop-raiding by an elephant with the rainfall was statistically weak. In contrast, the most incidents occurred in the year with moderate rainfall but the fewest in the drought year when many crops failed to mature and also reported that more than sixty per cent of the crop-raiding incidences happened to the matured crops. The local extinction of food trees is generally attributed to the elephant’s excessive feeding on particular species (Ramakrishnan *et al.* 1997). The number of crop-raiding incidents by elephants in the dry season rapidly decreased with increasing distance from the rivers (Parker and Osborn, 2001). According to the study of Parker and Osborn (2001), majority of the elephant crop-raiding incidents occurred during the wet season which occurred primarily in farmland along the edge of a protected wildlife area whereas the dry season crop damage occurred along the major rivers of the Muzarabani District in Zimbabwe and they also opined that despite the lower number, dry season incidents were more severe than wet season incidents. Crop damage in the dry season by elephants may affect farmer’s livelihoods to a greater degree than wet season damage because dry season crop supplement the farmer's diet at a time of year when food scarce. The study of Ben-Shahar and Macdonald (2002) in Northern Botswana described that elephants appear not to differentiate between areas concerning the protein contents of mopane leaves. So that they were not concentrate feeding in a particular (high protein) area until they exhaust the available resources and destroy the vegetation in the process.

Elephants were observed feeding on growing shoots, leaves and fruits during the wet season while taking barks and whatever available during the dry season (Biru and Bekele, 2012). According to the study of Pozo *et al.* (2017), the decrease in the number of reported crop-raiding incidences by elephants in the Eastern Panhandle since 2008 is, despite the human and elephant population size, connected to the curtailment in agricultural land distributed to people in recent years. Neupane *et al.* (2017) reported that the practices such as the cultivation of crops like maize, rice and plantain and brewing of alcohol at home attract the elephant and the intensity of elephant attack is very high during the winter months when paddy is harvested. Berliani *et al.* (2016) reported that areca, banana, oil palm, paddy and rubber are the high-risk plants and cacao, coffee, chilli, candlenut, patchouli are low-risk plants damaged by Sumatran elephants and they also suggested that, these low-risk plants species can be used as elephant-friendly crops adjacent to elephant habitat to reduce the human-elephant conflict.

The study of Rode *et al.* (2006) on the nutritional ecology of elephants in Kibale National Park, Uganda and its relationship with crop-raiding behaviour argued that the low mineral concentration of leaves, fruits, barks, and stems in their range is an essential factor driving elephant behaviour and patterns of habitat use. Investigation on the effect of high-risk foraging behaviour (crop-raiding) and genetic heterozygosity on male body size in a well-studied population of African elephants revealed that crop-raiding predicted male size in adulthood with raiders larger than non-raiders. However, this difference is not there in the young age, strong sexual selection for large size and condition-dependent mating success in males were the motive to take this additional risk in foraging (Chiyo *et al.*, 2011). Karimi (2009) assessed the impact of crop-raiding by African elephants (*Loxodonta africana*) in a Tanzanian village and found that even though the damage from elephants were infrequent, the villagers perceive the effect as the major one than the damage from other factors due to its nature of maximal damage by a single event. It was also observed that traditional deterrent methods had not been effective and innovative techniques are difficult to institute on a wide scale.

The topographical factors like the elevation and distance from the road are positively related to the crop damage and also the factors like small field size, low over ground openness, proximity to a river and proximity to a forest are negatively related to crop damage from wild pig (Honda and Sugita, 2007). Nijman and Nekaris (2010) tested a model for predicting primate crop-raiding using crop and farm-specific risk values (RV) in the 273 farms in southwestern Sri Lanka and revealed that RVs are working well for predicting crop-raiding behaviour in langurs as the RVs of crop-raided farms have a significantly higher value than the others. It was less effective for macaques due to their range over larger areas and also the opportunistic crop-raiding behaviour. Regmi *et al.* (2013) studied the predictions, patterns and perceptions towards the crop-raiding macaques from Langtang National Park, Nepal by calculating the incidence rate ("IR is the proportion of farms where a particular crop is raided by macaques associated with the total number of farms where this crop is grown and available to macaques")-IRs were highest for potato (0.783) and maize (0.697) and lower for cereals. The IRs of macaque species from Sri Lanka and Indonesia compared and showed that IRs are not related to nutritional content or caloric value of crops or to the number of plants grown and also observed that there is a decrease in crop-raiding with increasing distance between the farm and the nearest forest. Lim (2016) reported porcupine as a minor pest of oil palms, rubber and pineapple plantations and also the crops like tapioca, melon, sweet potatoes and vegetables. Indian crested porcupine (*Hystrix indica*) in Faisalabad, Pakistan was examined by Hafeez *et al.* (2011) by analyzing the stomach content and faecal pellets and it revealed that twenty-seven species of plants including the tubers, leaves, stem, and spike of crops like *Triticum aestivum*, *Zea mays*, *Saccharum officinarum*, *Hordeum vulgare*, *Brassica oleracea*, *Brassica campestris*, *Allium cepa* were consumed extensively.

The modelling by Retamosa *et al.* (2008) suggested that the slope of the regression line for deer was steeper than the slope of the other species, indicating that the magnitude of crop damage by deer increased more rapidly than the magnitude of damage by other species for similar changes in the amount of wooded area.

### 2.2.2. Indian context

Many studies are reported on crop damage by wild animals in India (Sukumar, 1991; Veeramani and Jayson, 1995; Sekhar, 1998; Gubbi *et al.*, 2014). The dominant crop-damaging species in India were Asian elephant, Wild pig, Indian crested porcupine, Bonnet macaque, Rhesus macaque, Nilgai (*Boselaphus tragocamelus*), Blackbuck (*Antilope cervicapra*) and Gaur (Chauhan and Sawarkar, 1989; Sukumar, 1991; Rajpurohit, and Mohnot, 1988; Prashanth *et al.,* 2013; Saraswat *et al.*, 2015; Anand *et al.*, 2018; Govind and Jayson, 2018). Crop guarding has decreased with men moving to cities to seek employment, while children are increasingly involved in education (Lahm, 1996). Reduced biomass of palatable forage could lower carrying capacity of the area for elephants and wild ungulate prey of large felines which in turn provoking intensified crop-raiding by elephants and killing of livestock by big cats (Madhusudan and Mishra, 2003; Madhusudan, 2003). Bayani *et al.* (2016) assessed the crop damage by mammalian wild herbivores on the western boundary of Tadoba-Andhari Tiger Reserve (TATR), Maharashtra Central India and reported that the crop damage estimated was high in the fields near to the forest and the intensity is gradually reducing with increasing distance. They also revealed that the visual method currently used for the damage assessment by the Government for paying the compensation to farmers was uncorrelated to and grossly underestimated the actual damage.

Sukumar (1991) states that adult male elephants are far more prone than the member of a female-led family herd to crop-raiding and also kill people. Joshi and Singh (2008) examined the feeding behaviour of wild Asian elephants in the Rajaji National Park and reported that alternation between a predominantly browsers diet all over the year and a grass diet during the early dry season depending on the seasonally changing mineral content of grasses. Consumption of tree species (74%) was highest compared to grasses (14%) and shrubs (8%), but their diet was mainly dependent on the availability of seasonal food around the year and on their migration. The eastern population of elephants was subjected to feed mainly on Tectona grandis and *Holophramitis* spp. whereas south-western populations of elephants were not utilizing these species as their food. Crop-raiding was sporadic during the wet season which gradually increased with more area being cultivated with the onset of monsoon (Joshi and Sigh, 2008).

Bapureddy *et al.* (2015) estimated the densities of lion-tailed macaque, bonnet macaque and southern plains grey langur in Karnataka and revealed that gradual increase in agriculture in the landscape probably resulted in the relatively high density of bonnet macaques in the Aghana shini Lion-tailed macaque conservation reserve than in other two parks where there are no such palatable crops available.

The consumption of fallen coconut, arecanut and debarking of coconut palm by Indian crested porcupine was reported by Thyagaraj *et al.* (2006). Prashanth *et al.* (2013) studied the crop-raiding behaviour of *Bos gaurus* in Mookambika Wildlife Sanctuary, India and found that maximum crop-raiding cases (56.84%) were reported in summer season

(March-May), minimum cases (9.79) during monsoon season (June-August), the maximum damage was caused by the medium seized herd (9-12 individuals) and highest damages was caused to paddy.

## 2.3. Cattle-lifting and human casualties

### 2.3.1. Studies in other countries

Patterson *et al.* (2004) studied the livestock predation on ranches neighbouring Tsavo National Park, Kenya by lions (*Panthera leo*) and other carnivores and reported that there was no temporal autocorrelation of daily losses thereby the attacks are independent events. The number of carnivore attacks and the number of livestock killed was significantly different and there was a positive correlation between their monthly totals and precipitation. Intensified predation in the wet season differs from patterns of lion predation elsewhere but reinforces the trend that large carnivores take more livestock when native prey is most challenging to find and kill. Wang and Macdonald (2006) found that about sixty per cent of the households did not have proper stables for corralling their livestock at night around the Wangchuck National Park, Bhutan and a significant correlation was there between the number of livestock lost and the distance between the household and the grazing pasture. Tiger and leopard attacked cattle, mostly in areas with less human activity. The authors also observed that a combination of lax herding, poor guarding practices, lack of favourable cover, poor habitat condition and high predator densities combine to create conditions where depredation rates are high.

Improved attitudes and increased tolerance may be best achieved through conservation education, developing means to reduce livestock losses and generation of financial incentives for predator conservation that reach individuals (Romanach *et al.*, 2007).

The study of Tamang and Baral (2008) about the livestock depredation by large cats in Bardia National Park, Nepal revealed that the highest livestock loss occurred during the hot, dry season, just before the rainy monsoon. They identified the use of the park for livestock grazing and lack of robust corrals as the two main reasons for increased livestock predation. Sangay and Vernes (2008) examined the pattern of livestock predation by large mammalian carnivores in the Kingdom of Bhutan and they revealed that life stock predation is higher in summer and autumn which is in correlation with the peak in agriculture cropping because livestock is moved to forest and pasture during the cropping season and are less protected than other times. The rate of livestock predation was not related to forest cover or human population density. Dar *et al.* (2009) reported the human-carnivore conflict in and around the Machiara, National Park (MNP), Pakistan and revealed that leopard kills inside the villages were significantly higher in the areas without electricity, whereas outside communities it was higher for pastoralists that were further from MNP and also with the larger herd. Temporal leopard attacks were significantly and positively related to temperature.

Cahill *et al.* (2012) reported that the abundance of anthropogenic food sources attracts the wild pig into the urban areas especially during the warmer summer season when foraging conditions are more unsatisfactory in their natural woodland habitat. Thereby the number of the capture of habituated wild boar in peri-urban areas is significantly correlated with mean monthly temperature. Zarco-Gonzalez *et al.* (2013) suggested a spatial model of livestock predation by jaguar and puma in Mexico in which the variables most positively related with predation risk by jaguar were the vegetative cover percentage, the percentage of free-grazing animals and altitude, whereas arid vegetation has a negative influence on predation risk. In the case of puma, the variables with the highest contribution were livestock density, which negatively influences the predation risk, in addition to forest and altitude, both with a positive relation. The study of Kgathi *et al.* (2012) on livestock predation, household adaptation and compensation policy in a village of Northern Botswana recommended a review of the compensation rate to make it closer to the market value and further argued that ensuring of the same along with strict animal husbandry practices will increase the willingness of households to co-exist with the predators.

Local people generally had positive attitudes towards tiger conservation and were willing to tolerate some loss of livestock but no human casualties (Bhattarai and Fischer, 2014). Widman and Elofsson (2017) analyzed the cost of livestock depredation by large carnivores in Sweden and revealed that 1% increase in the density of carnivores leads to a 0.3-0.4% increase in compensation costs. According to Lamichhane *et al.* (2017), the transient tigers without a territory or physically impaired animals are likely to involve in conflict with people in Nepal. Acharya *et al.* (2017) studied the effect of forest fragmentation on human-wildlife conflict and reported that attacks of tigers were significantly and positively associated with forest fragmentation, attacks by common leopards were positively correlated with landscape heterogeneity and negatively related to the proportion of bush and grassland, and elephant encounters were strongly and positively associated with the forest fragmentation. The study of Kabir (2017) about the livestock depredation by a leopard in Pir lasoora National Park in Pakistan revealed that among the domestic animals, goats were killed in higher numbers, young and female stocks were more vulnerable to leopard attack which predominantly occurred at night and both attack and killing in June showed a significant difference from other months of the year.

### 2.3.2. Indian context

Overgrazing by domestic livestock, collection of water plants from the marshy areas of the forest as fodder and the associated entry and exit of people in the villages decreased the quality of the forest and the number of animal population within the forest in the Keoladeo Ghana Sanctuary, Rajasthan (Spillett *et al.*, 1966). Kumar and Rahmani (2000) studied the livestock predation by wolves in the Indian bustard sanctuary, Nannaj (Maharashtra) and reported that multiple attacks were made by wolves on livestock herd to divert the attention of guard dogs and the predation was higher during the pup-rearing period. The maximum number of kills (52%) made during day time was found up to 0.2 km from the sanctuary. The authors observed that all the kills by Indian wolf occurred in the grazing lands outside the Great Indian Bustard Sanctuary and the kills were carried out into the core areas for feeding.

Kala and Kothari (2013) reported that 0.33% density of the leopard in the Binsar Wildlife Sanctuary was responsible for the 1763 domestic animals kill which involved 90% of cattle in 14 year period on an average of 126 livestock per year, one human death and injury to nine persons during the 8 year period. Most of the people were attacked while they were alone in the field. Joshi *et al.* (2013) examined the connectivity of tiger (*Panthera tigris*) populations in the human-influenced forest mosaic of Central India and revealed that the tiger connectivity was affected by landscape elements such as human settlements, road density and host tiger population density, but not by the distance between populations. Odden *et al.* (2014) studied the GPS collared leopards in human-dominated landscapes in India and revealed that the translocated leopards moved through the human-dominated landscapes in their release wanderings and they stated that leopards are highly adaptable species with an excellent ability to utilise whatever resources are available in the human-dominated environment.

Sidhu *et al.* (2017) studied the human-leopard interaction in a plantation landscape in Anamalai hills and reported that the livestock depredation has a positive correlation with the number of livestock and negative correlation with the distance from the protected area and the number of residents.

## 2.4. Control measures

### 2.4.1. Studies in other countries

Ngama *et al.* (2016) experimentally examined whether the presence of *Apis melifera adansonii*, the African honey bee species present in central Africa, deters forest elephant (*Loxodonta Africana cyclotis*) from feeding on fruit trees and the result showed that empty boxes and the colonies with low bee activity were not deterring the elephant for all the time whereas the beehives with high bee activity deter the elephants. It is essential to have an optimum activity of 40 to 60 bee movements per minute in the colonies to achieve the best result on deterring elephants and producing honey. Thus, beehives colonised by *Apis melifera adansonii* bees can be effective elephant deterrents only if people actively manage hives to maintain optimum activity level. Paudel (2016) assessed the crop protection strategies in Kali Gandaki river basin, West Nepal and reported that the most commonly used crop protection strategy in guarding their field against *Macaca assamensis* was by constant vigilance followed by the use of scarecrows, guarding dogs and tin- box catapult.

Wiafe and Sam (2014) proved that a well constructed and regularly maintained pepper grease fence is effective in warding off elephants from entering farmlands in Ghana. Gandiwa *et al.* (2012) observed that burning chilli pepper mixed with elephant dung scaring animals by beating drums, shooting in the air, linearisation of the hut, setting fire around fields at night and herding and kraaling livestock were the conventional methods employed to reduce human-wildlife conflict in

Zimbabwe and also suggested that the combination of control strategies and establishing a temporary barrier would also be effective. Technical factors that affect the effectiveness of the electric fence were identified as the inability of Government bodies to maintain the rules and regulations, incomplete coverage by the fence, ignorance of geographical and other variations in the establishment, ignorance of water and feed availability to the elephants, flows in strength and other designing aspects. The socio-economic factors were inadequate community support to maintain the fence, financial limitations to meet the maintenance costs, inaccessibility to the forest, lack of knowledge on fencing equipment, a dispute between settlers and non-settlers (Gunaratne and Premarathne, 2006).

Osborn and Parker (2003) suggested that the success of the deterrent methods were directly proportional to the responsibility of farmers. The role of external agencies and wildlife managers is to work with farmers to develop a range of management solutions for repelling elephants. The primary input needed to make electric fences more effective were related to improving cooperation and coordination within communities and developing the capacity to effectively maintain and guard the fence (Daniel *et al.*, 2008). It is very important to include the affected people in the solution for human-wildlife conflict which can be best achieved by transferring the ownership of the management strategies to the local communities that are affected, especially where they are "high-tech" and prone to maintenance need and skill acquisition (Nelson *et al.*, 2003).

Graham and Ochieng (2008) tested the performance of farm-based measures to reduce the elephant conflict in Kenya and the factors like availability of household labour, local politics and insecurity were identified as the important barriers to uptake of some of the deterrent introduced and the respondents from trial farms were willing to contribute financially towards the cost of materials to sustain the deterrent introduced. The distance of the farmland to the area of high elephant density, elephant corridors and the vegetation cover has been important factors which determine the success of elephant barriers (Seidensticker, 1984; Sukumar, 1986; Hoare, 2001, Kioko *et al.*, 2008).

King *et al.* (2017) evaluated the efficacy of beehive fence against crop-raiding African elephant (*Loxodonta africana*) in a 100.4 ha farmland near to Tsavo East National Park the result showed that eighty per cent of the elephants that approached the trail farms were prevented from beehive fence protected areas and fences were broke by the herd which is smaller than the average herd size, the method also provided 228 kg of elephant-friendly honey.

King *et al.* (2018) field-tested the efficacy of sound from disturbed Asian honey bees as a deterrent against crop-raiding Asian elephants in Sri Lanka by playing the recorded sound of a disturbed honey bees *Apis cerana indica* against 120 wild elephants in 28 different groups resting under trees in Uda Walawe National Park in Sri Lanka. Elephants responded by moving significantly further away from their resting site in bee playback trails compared to controls. Parker and Osborn (2006) tested the potential for chilli *Capsicum* spp to reduce human-wildlife conflict in Zimbabwe and indicated that chilli is less attractive to wildlife than other crops and is also economically viable. Massei and Cowan (2014) reviewed the practice of fertility control to mitigate human-wildlife conflict and revealed that population-level studies of fertility control increase survival and affect social and spatial behaviour of treated animals. However, the effects are species and context-specific. A substantial initial effort is generally required to reduce population growth; however, the fertility control, particularly of isolated populations, can be successfully used to limit population growth and reduce human-wildlife conflict.

Wild boar is one of the major species which can cause significant damage to crops (Genov, 1981; Feichtner, 1998; Bieber and Ruf, 2005; Schley *et al.*, 2008). Thurfjell *et al.* (2013) studied the effect of hunting on the behaviour of wild boar and found that the type of hunting is strongly affected the type of avoidance behaviour displayed by wild boar, with implication for their movement and space use and they suggested that adjusting hunting method to the season could be an essential management tool for minimising crop losses.

Immediate increase in compensation claims results in either corruption through inflated claims or a decrease in crop guarding, or both (Nelson *et al.*, 2003). Bulte and Rondeau (2007) reported that compensation could lower the wildlife stock and may result in a net welfare loss for local people. Nyhus *et al.* (2003) suggested a comprehensive approach for the compensation that includes options for control of offending animals, proactive mitigation measures and in some cases, broader economic incentives for changes in land-use practices. According to him, the most effective compensation program is fair, transparent and most importantly, fast. The community-based conservation effort played an important role in efforts to solve the human-elephant conflict (Zhang and Wang, 2003) and the mitigation of human-wildlife conflict required practical approaches based on the establishment of transparent, impartial co-management partnerships between local people in rural settlements and higher-level wildlife management authorities (Gillingham and Lee, 2003).

### 2.4.2. Indian context

Sukumar (2003) observed that many of the traditional techniques are merely effective to drive away inexperienced crops raiders whereas the notorious habituated raiders, usually adult bulls or even some family groups are difficult to be fooled. Chakravarthy *et al.* (2006) revealed that Indian crested porcupine became a pest on crops due to degradation and fragmentation of forest habitat. Mode of its attack on different crop species was studied, and they introduced a method to mitigate the crop damage by encasing the seedlings of coconut and arecanut with porcelain pipes. Smearing the seedlings as well as adult palms with coal tar was also examined for preventing the debarking by a porcupine. Athreya *et al.* (2011) reported that the use of translocation as mitigation tool would increase the human-leopard conflict due to the factors like increased aggression by induced stress of translocation process, movement through unfamiliar human-dominated landscapes following the release and loss of fear of humans due to familiarity with humans acquired during captivity. For conserving leopards in human-dominated landscapes, it is imperative to evaluate and use effective conflict mitigation measures in order to maintain or increase tolerance and limit negative impacts on local people (Odden *et al.*, 2014).

The fencing of the line of control (LOC) has fragmented natural habitat resulting in the hindrance of wild animal's movements across the line. Consequently, they are heading towards human settlements adjoining forests which in turn result in killing and injuring people and often get killed (Habib *et al.,* 2015). Mary and Karthikeyan (2016) proposed a design of a wireless sensor network system for warning elephant intrusion. Static and mobile sensors are used for the detection of elephant intrusion and a sink node acting as a base station which collected the information from different sensors. The information collected by the sink node is based on the priority considering different places of sensor deployment. The message collected is automatically transmitted to the forest officials to prevent the intrusion of the elephants.

The simple act of filing compensation becomes a difficult task due to the unavailability of the concerned staff and also the difficulty to access to forest officers (Madhusudan, 2003). Milind *et al.* (2016) proposed a theoretical model community-operated compensation scheme for crop damage by wild herbivores and they suggested that the compensation should be paid in proportion to individual farm's products based on the average loss. The authors also argued that according to the analysis based on the principles of behavioural economics the compensation scheme would expedite good inputs in agricultural and integrity in reporting the produce which in turn isolate wildlife damage from other forms of agricultural loss. Karanth and Kudalkar (2017) reported the low awareness of governmental compensation schemes made the households of Rajasthan especially vulnerable to wildlife impact on their livelihood and they suggested the need of improved access to compensation and promoting the nonlethal mitigation measures to reduce the conflict.

# *Chapter three*

# ***Study area***

# 3. STUDY AREA

Kerala is a State in south India laying along the southwestern shoreline of the Indian subcontinent, sharing its boundary with Karnataka to the north and northeast, Tamil Nadu to the east and south and Arabian Sea to the west. The Kerala State is situated between 80 18' and 120 48', N latitude and 740 52' and 770 22' E longitude. The climate of the State is an equatorial tropical climate, changing between the three distinct regions, namely eastern highland, central midland and low western land (Fig. 01).

The State is known for the backwaters, mountains, coconuts and spices and it is also the home for highly diverse organisms concentrated and protected in the Western Ghats. The major forest type consists of tropical wet evergreen and semi-evergreen forest, tropical moist and deciduous forest and montane subtropical and temperate forest. Altogether 24% of Kerala is forest. Among the 14 Districts of Kerala, Malappuram District lies in the northern part of Kerala starting from the core of the Nilgiri and traverse through the high land, midland and low land areas up to the seacoast (Sreedharan, 2004). Forest Divisions of Nilambur in the Malappuram District, support plethora of wild animals which include the species like wild pig (*Sus scrofa*), Asian elephant (*Elephas maximus*), Bonnet macaque (*Macaca radiata*), and Indian crested porcupine (*Hystrix indica*). Most of the forest fringe of the District is cultivated with palatable crop species. Previous reports from the District revealed the frequent rampage of the wild animals in the human settlements, farmlands. On an average of 80 news items regarding the

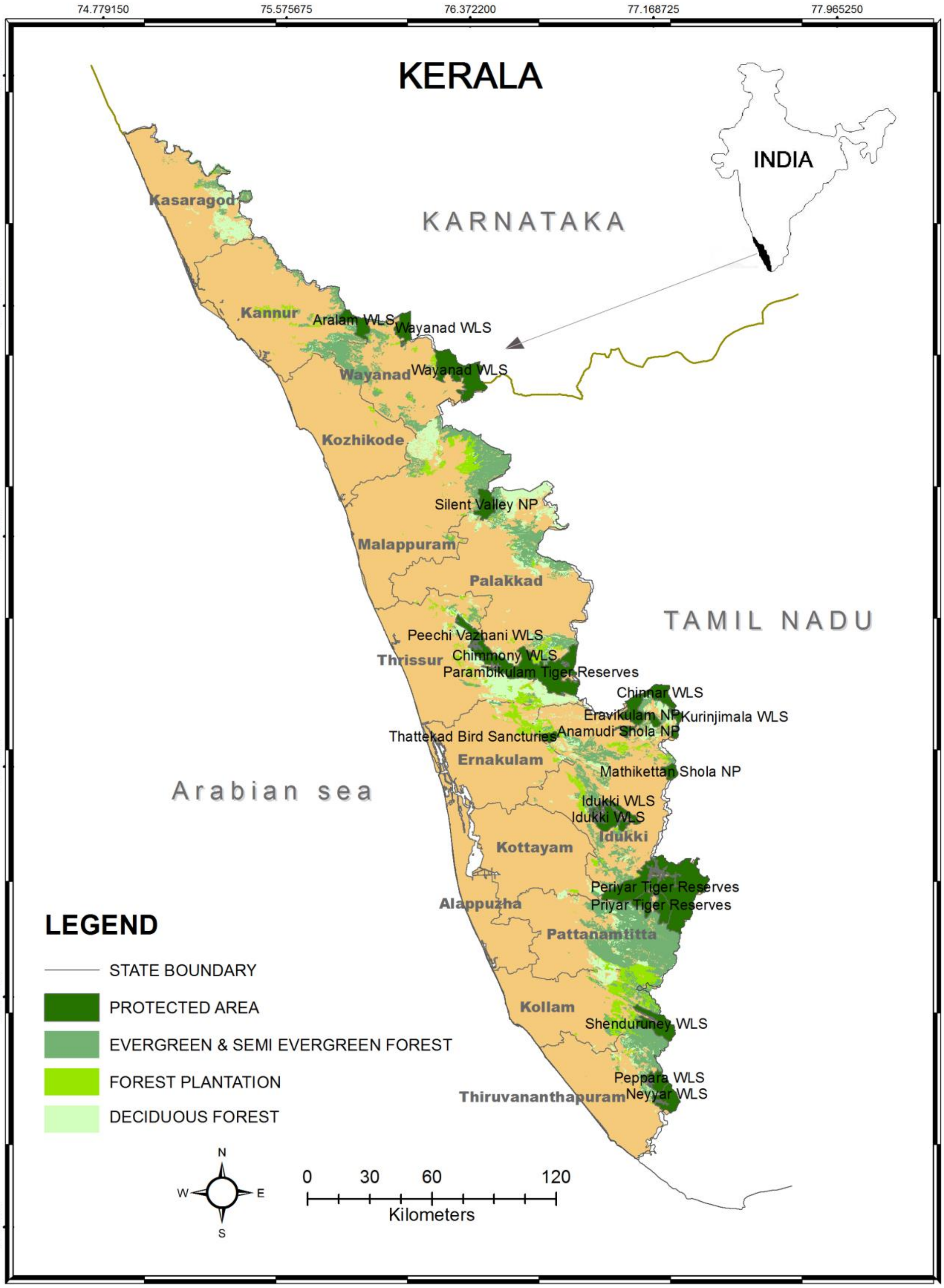



Fig.01. Districts of Kerala State

human-wildlife conflict in an year in the local daily has elicited the need for a detailed study on human-wildlife conflict in the District and thus Malappuram District was selected as an intensive study area.

## 3.1. Location

Malappuram District (10°45’ to 11°25’ N and 75°55’ to 76°24’ E) spanning an area of 3550 $km^2$ is situated 50 km south-east of Kozhikode, bounded by the Nilgiri Hills in the east, the Arabian Sea in the west, Thrissur and Palakkad Districts in the South (Fig. 02). The innumerable streams that meander these hills reach the coconut fringed and charming seacoast, and in many places, these streams are linked with backwaters which facilitate a network of inland waterways. The main crop species include paddy (*Oryza sativa*), arecanut (*Areca catechu*), cashew nut (*Anacardium occidentale*), pepper (*Piper nigrum*), ginger (*Zingiber officinale*), pulses, coconut (*Cocos nucifera*), plantain (*Musa paradisiaca*), tapioca (*Manihot esculenta*) and rubber (*Hevea brasiliensis*). It comprises three Forest Ranges namely Edavanna, Nilambur and Vazhikadavu of Nilambur North Forest Division and two Forest Ranges namely Kalikavu and Karulai of Nilambur South Forest Division. The District is covered with 1034.2 $km^2$ of forest lands of all, the seven forest type of southern India, tropical moist deciduous, tropical semi-evergreen, subtropical hills forest, sub-tropical savannahs and montane wet temperate grasslands with a vast collection of wildlife apart from teak plantations. The District is mainly drained by Kadalundi, Chaliyar and Barathapuzha Rivers. It was observed that during the last thirty years, large tracts of forest land were converted

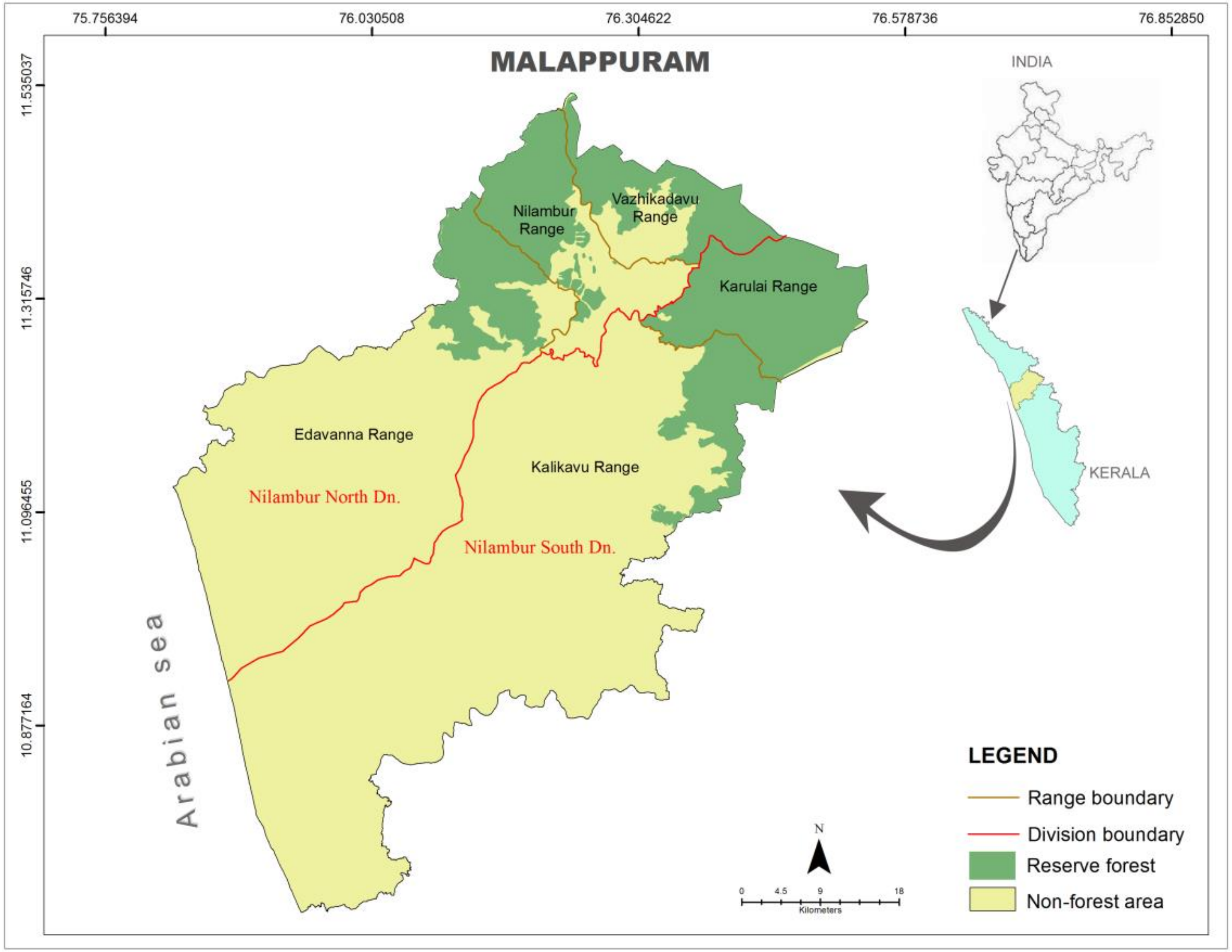



Fig. 02. Map showing the study area

into teak and rubber plantations and this resulted in the upsetting of the ecological equilibrium. The plain land is covered with cash crops like rubber, paddy, arecanut, coconut, banana and pepper plantations. Rubber has become the major plantation crop of the area. Jack-fruit tree, arecanut and coconut trees are the major cash crops in the homestead plots (Kakkoth, 2001).

New Amarambalam Reserve is spanning an area of 26,572 hectares and it shows very high altitudinal gradation from 40 m to 2554 m which in turn results in its high rainfall and thick forest cover. New Amarambalam lies in a stretch continuous with Silent Valley National Park. Indian Bird Conservation Network has identified 121 species of birds from Nilambur and New Amarambalam. Sixteen restricted-range species have been identified from New Amarambalam Reserve and is classified as an important bird area of the Western Ghats.

The important ecotourism areas of the District are Canolly's plot, Kozhippara waterfalls and Adyanpara waterfalls in Nilambur North Division, Nedungayam and Kalkundu under Nilambur South Divison.

## 3.2. Climate

The climate of the Malappuram District is similar as elsewhere in Kerala is with a dry season (December-February) followed by a short spell of hot season (March-May) and then the beginning of the rainy season with South-West monsoon (SW) from June to September and North-East monsoon (NE) from October to December. The District receives a normal of 2793.3 mm rainfall out of which the major contribution (73.5%) is from South-West monsoon in which heavy rainfall will occur. North-East monsoon contributes 16.4 per cent, the summer rain from March to May contribute 9.9 per cent and the balance 0.2 is accounted for January to February (Sreenath, 2013) (Fig. 03). The general nature of temperature is hot and humid, the hottest period is during March and April and the coldest months are December to February (Fig. 04 & Fig. 05). The maximum temperature ranges from 28.9 to 36.20 ºC and minimum temperature ranges from 17.0 to 23.40 ºC. The relative humidity ranges from 84- 94% during morning hours and is more during the peak monsoon months from June to September. The wind is mainly from East as well as West during morning and evening hours. The December and February months usually have the more speedy wind with a range from 2.9 to 7.2 km per hour.

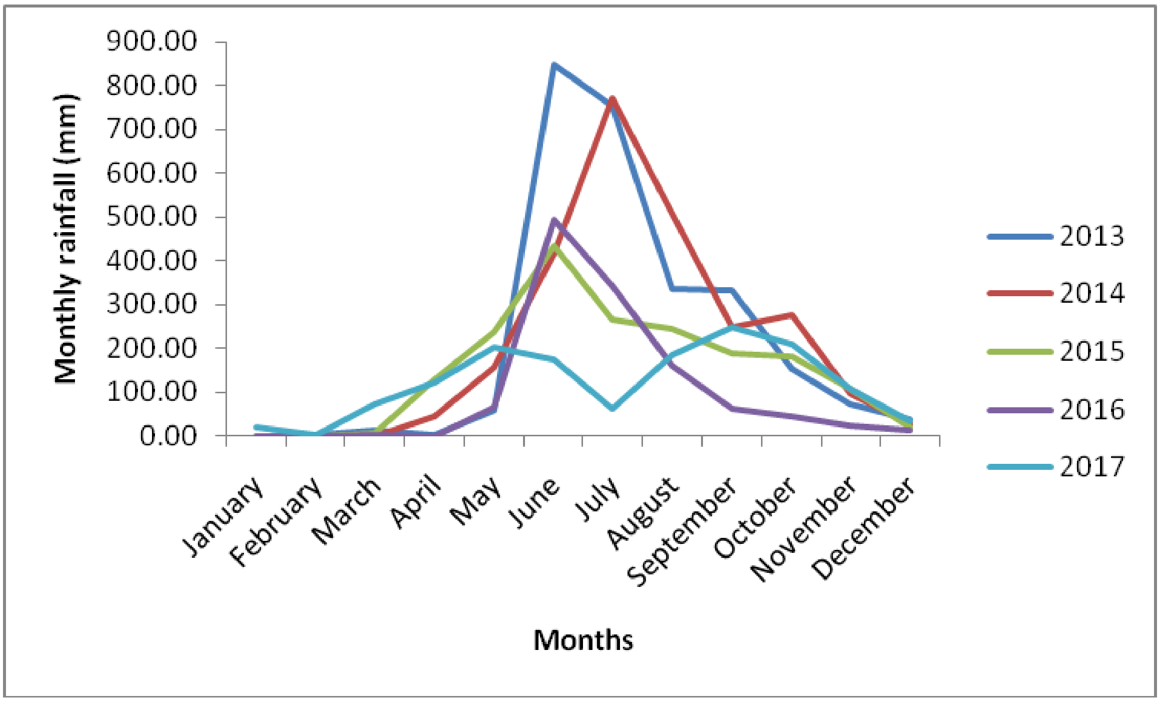



Fig. 03. Mean monthly rainfall over the years (Agricultural Research Station, Anakkayam)

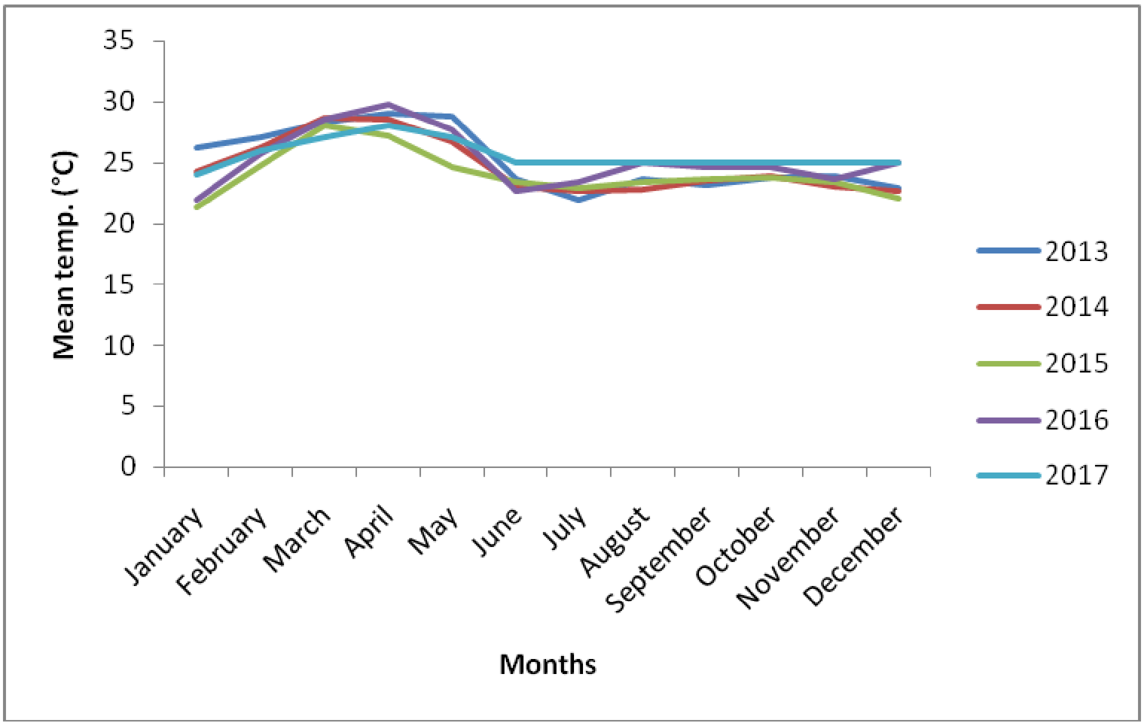



Fig. 04. Mean monthly temperature over the years (Agricultural Research Station, Anakkayam)

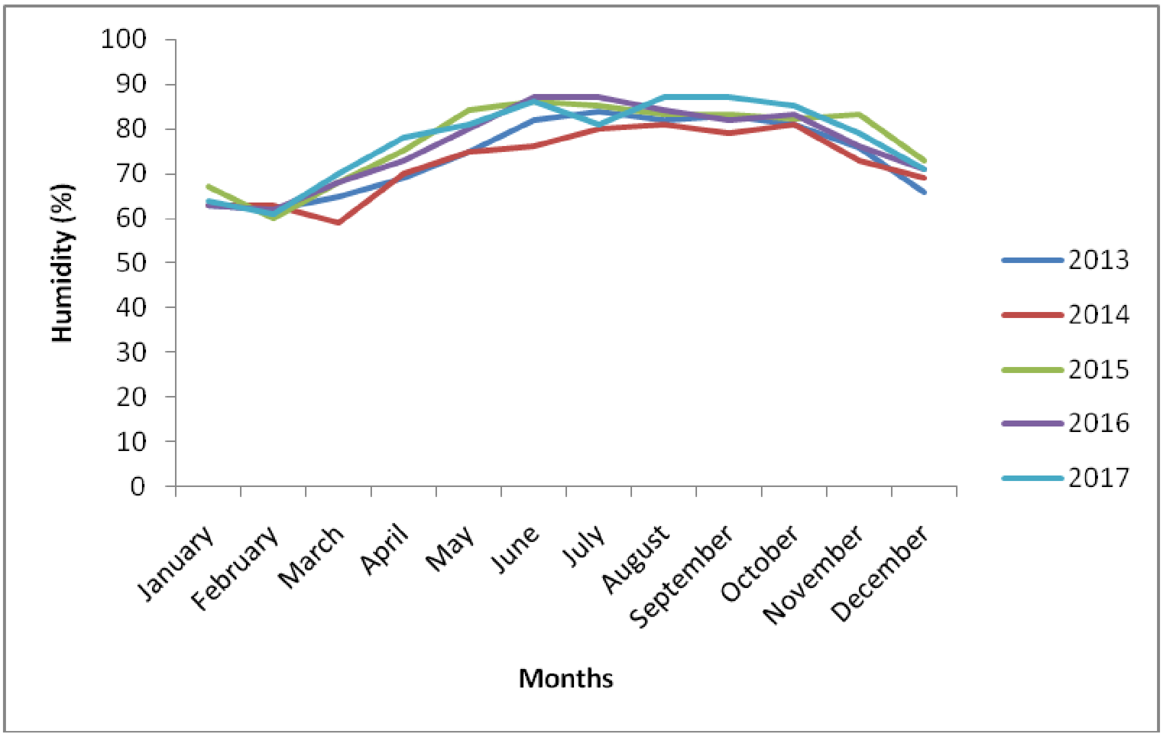



Fig. 05. Humidity over the years (Source: World Whether, Online Website)

## 3.3. Geology and soil

Presence of laterite stones in the District resulted in the existence of hundreds of quarries for its extraction. Archean gneiss is the prevalent geological formation in the District. Quartz gneisses are found in Nilambur, Edavanna and Pandikad areas. The soil in the District can be typed as laterite, alluvium and forest loam. Nilambur forested hills dominate with charnockite bed along with a major portion of cordierite gneiss, hornblende gneiss. A patch of laterite and forest loam is also present there. The undulating upper land region has a lateritic bed with charnockite and basic dykes as its geological beds (Vahab, 2018).

## 3.4. Human settlements in the forest

### 3.4.1. Paniyan

The word “Paniya” is derived from the Malayalam word “Pani” which means work. ‘Paniya’ community was the largest tribal community in Kerala. They were treated as the bonded labourers of the landlords. The females and children of the Paniya family generally involve in the digging for roots or herbs in the forests. The history says that the King of Malabar introduced Paniya tribes to Wayanad, centuries ago as slaves for agriculture labour. This tribal community was mainly inhabited in the northern part of Western Ghats, Wayanad District, the eastern part of Kozhikode (Calicut), Malappuram and Kannur Districts. In Malappuram District, they reside in colonies in the houses constructed by Government at Nedungayam. They use Paniya dialect and Malayalam language for communication.

### 3.4.2. Cholanaikans

Cholanaikans are only seen in the Chungathara and Karulai Forest of Nilambur in Malappuram District. They are one of the oldest and the most primitive vanishing native communities of tribes in Kerala. Their shelters were usually the rock caves or crude huts beside the brook. Cholanaikans were considered as one of the last existing hunter-gather tribes of South India. Though they predominantly communicate in Cholanaikan language, approximately, half of this community is also capable of interacting in Malayalam. The community named themselves as 'Malanaikan' or 'Sholanaikan'. The word 'Shola' or 'Chola' means deep thicket in the forest and naikan means king. Generally, they are well-built, strong bodied people with short stature, fair complexion, curly hair and round or oval face. They collect Non-Timber Forest Products (NTFP) like honey, black dammer, mosses, nutmeg, shikaki from the forest and sell them to Nilambur co-operative society and take back rice, tobacco, salt, oil and other necessities from the society for their livelihood and they prefer to live in semi-evergreen and moist deciduous forests. They are very much attached to their habitat and never likes to come out of the forest. They live under the leadership of Mooppan (Elder).

### 3.4.3. Kattunaicken

The name Kattunaicken was derived from the Malayalam words "Kadu" and "Nayakan" which means forest and leader respectively so that they are regarded as the leaders of the forest. They have a nuclear family system and follows patriarchy. They primarily depended on the hunting and gathering, especially honey for livelihood. On an average of 5 to 8 houses are there in their settlement. Occasionally just 1-2 families can also be found living together. Though not in large quantities, collection of NTFP is the main income during the season. The main item among them is honey and the other items include cinnamon, forest pepper and nutmeg. They live in Pattakarimbu, Chenappady, Uchakulam, Mannarmala, Mundakkadavu and Cheengakallu areas of Nilambur South Forest Division (Plate 01a).

### 3.4.4. Aranadan / Eranadan

Aranadan tribes are nomadic hill tribe and they are engaged in hunting. Most of their settlements were located in Eranadu Taluk of Malappuram District and also the places like Kavalamukkatta, Chokkad, Edakkara, Vazhikadavu, Aranadankara, Telppara and Pattakkarimpu (Plate 01b). Some of the families are settled in the Government constructed tribal colonies including one near to Chokkad. They are also distributed in Karulai Range and Kalikavu range of the Nilambur south forest division and Vazhikadavu Range of the Nilambur north forest division.

### 3.4.5. Muthuvan

It is the tribal group who are still abstained from the mainstream population of the outside world. They are totally independent and do not await people of the civilized society for anything. They have

a. Kattunaicken at Pattakarimbu under Karulai Forest Range

b. Aranadan at Kavalamukkatta under Kalikavu Forest Range

c. Muthuvan at Veetikunnu colony under Edavanna Forest Range

**PLATE 01: Tribal hamlet**

restrained from the process of education and academics. So, most of their members are very reluctant to establish a connection with other tribes. The female members of the Muthuvan have to follow the strict social rules that not to maintain any relationship with the people outside their tribal community, including all the males. They are seen in Karimba, Veettikunnu, Kanjirapuzha, Kalluvari and Palakkayam of Nilambur North Forest Division and Chokkad 40 cent colony of Nilambur South Forest Division of Malappuram District (Plate 01c).

## 3.5. Vegetation types

The District mainly consists of Tropical evergreen forest, Tropical semi-evergreen forest, Tropical deciduous forest, Tropical shoal forest and Forest plantation (Fig. 06).

### 3.5.1 Flora

The common tree species of the District are Neeratti (*Hydnocarpus pentandra*), Irumbakam (*Hopea ponga*), Venmaruthu (*Terminalia paniculata*), Poopathiri (*Stereospermum colais*), Thavalamaram (*Trewia nudiflora*), Kulamavu (*Persea macrantha*), Kariveeti (*Dalbergia latifolia*), Poovarasu (*Thespesia populnea*), Cheru (*Holigarna arnottiana*), Punna (*Calophyllum calaba*), Karimaruthu (*Terminalia elliptica*), Teak (*Tectona grandis*), Venthekku (*Lagerstroemia microcarpa*), Plasu (*Butea monosperma*), Kumizhu (*Gmelina arborea*), Pulamaram (*Bombax ceiba*), Irul (*Xylia xylocarpa*), Pala (*Alstonia scholaris*), Chadachi (*Grewia tiliifolia*), Kalkanjiram (*Anogeissus latifolia*), Kattuveppu (*Melia

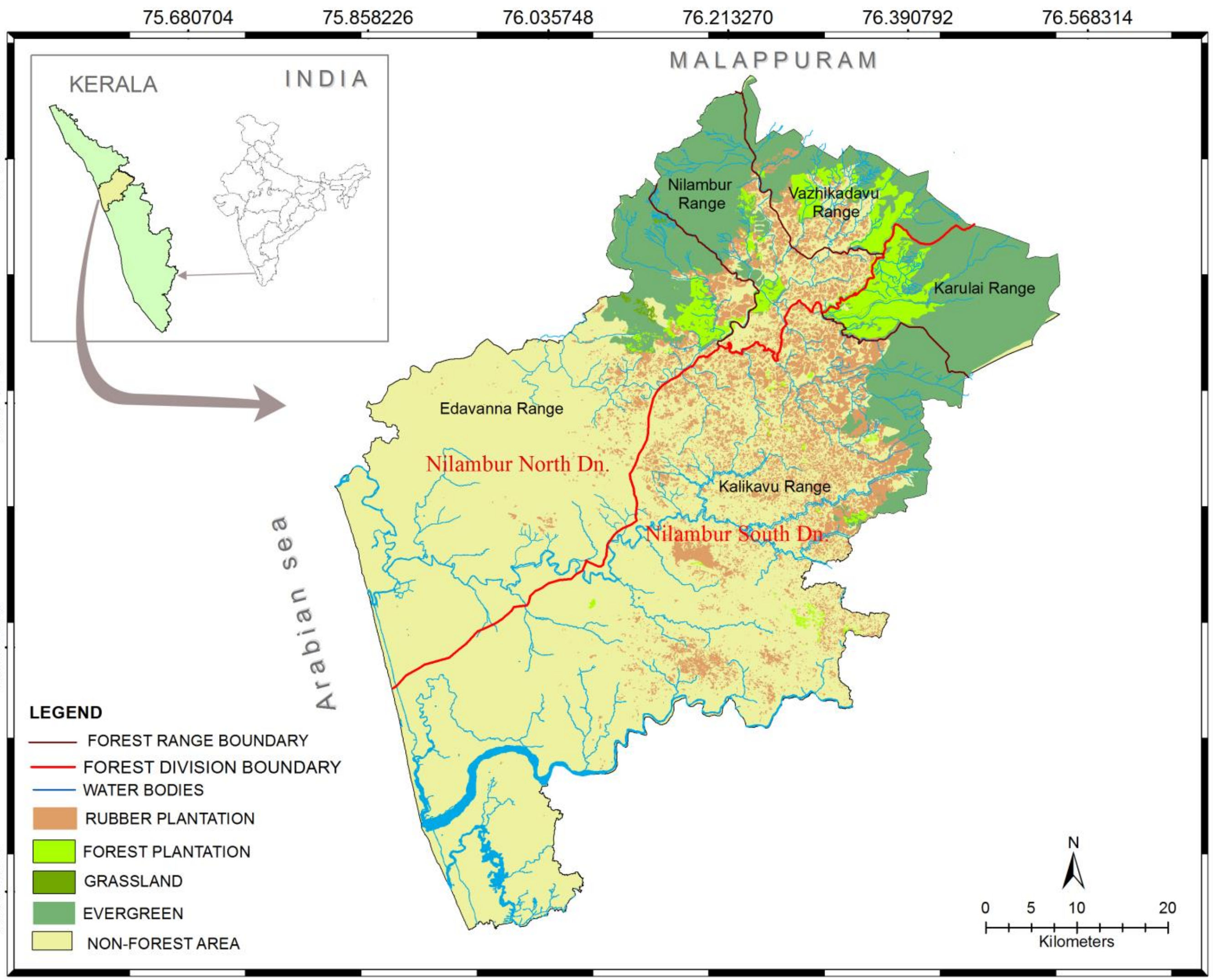



Fig. 06. Vegetation map

*azedarach*), Mullankkayini (*Briedelia retusa*), Anjili (*Artocarpus hirsutus*), *Bamboo* (*Bambusa bambos*), Kanjiram (*Strychnos nux-vomica*), Kambippala (*Wrightia tinctoria*), Kattampazham (*Spondias pinnata*), Matti (*Ailanthus triphysa*), Kanakaitha (*Miliusa tomentosa*), Thanni (*Terminalia bellirica*), Kanikonna (*Cassia fistula*), Kadambu (*Mitragyna parvifolia*), Anakkaram (*Lannea coromandelica*), Atthi (*Ficus racemosa*), Chandanam (*Santalum album*), Urunjikai (*Sapindus trifoliatus*), Karivetti (*Olea dioica*), Sindooram (*Mallotus philippensis*), Karivaka (*Albizia lebbeck*), Thodali (*Ziziphus rugosa*), Vatta (*Macaranga peltata*), Cheeni (*Tetrameles nudiflora*), Venga (*Pterocarpus marsupium*), Aavannakku (*Ricinus communis*), Arampuli (*Bauhinia malabarica*), Karimpongu (*Hopea glabra*), Kambagam (*Hopea parviflora*), and Niralam (*Hydnocarpus laurifolia*) are some of the plant species found in the area.

### 3.5.2. Fauna

The forest and adjacent areas of Malappuram District consists of wide variety of faunal compositions including mammals, birds, reptiles, amphibians, butterflies and other insects.

Mammals:- Nilgiri Langur (*Semnopithecus johnii*), Bonnet Macaque (*Macaca radiata*), Lion-tailed Macaque (*Macaca silenus*), Black-footed Gray Langur (*Semnopithecus hypoleucos*) Indian Giant Squirrel (*Ratufa indica*), Common Palm squirrel (*Funambulus palmarum*), Flying squirrel (*Petaurista petaurista*), Sambar (*Rusa unicolar*), Chital (*Axis axis*), Barking Deer (*Muntiacus muntjak*), Asian Elephant (*Elephas maximus*), Indian Hare (*Lepus nigricollis*), Gaur (*Bos gaurus*), Indian Crested

Porcupine (*Hystrix indica*), Mouse Deer (*Moschiola indica*), Nilgiri Marten (*Martes gwatkinsi*), Leopard (*Panthera pardus*), Leopard Cat (*Prionailurus bengalensis*), Jungle Cat (*Felis chaus*), Golden Jackal (*Canis aureus*), Wild Dog (*Cuon alpinus*), Asian Small-clawed Otter (*Amblonyx cinereus*), Indian Grey Mangoose (*Herpestes edwardsii*), Eurasian Otter (*Lutra lutra*), Indian Pangolin (*Manis crassicaudata*), Sloth bear (*Melursus ursinus*), and Wild pig (*Sus scrofa*) are the larger mammals.

Avian diversity:- Nilgiri Wood pigeon (*Columba elphinstonii*), Malabar Parakeet (*Psittacula columboides*), Malabar grey hornbill (*Ocyceros griseus*), White-bellied Treepie (*Dendrocitta leucogastra*), Crimson-backed Sunbird (*Leptocoma minima*), Grey-headed Bulbul (*Pycnonotus priocephalus*), Flame-throated Bulbul (*Rubigula gularis*) Nilgiri Flycatcher (*Eumyias albicaudata*), Wayanad Laughingthrush (*Pterorhinus delesserti*), Rufous Babbler (*Argya subrufa*), Malabar Trogon (*Harpactes fasciatus*), Malabar Whistling-thrush (*Myophonus horsfieldii*), White-bellied Blue-flycatcher (*Cyornis pallidipes*), Malabar Starling (*Sturnia blythii*), Red Spurfowl (*Galloperdix spadicea*), Grey Junglefowl (*Gallus sonneratii*), Asian Emerald Dove (*Chalcophaps indica*), Indian Nightjar (*Caprimulgus asiaticus*), Jungle Nightjar (*Caprimulgus indicus*), Banded Bay Cuckoo (*Cacomantis sonneratii*), Indian Cuckoo (*Cuculus micropterus*), Indian Roller (*Coracias benghalensis*), White-throated Kingfisher (*Halcyon smyrnensis*), Stork-billed Kingfisher (*Pelargopsis capensis*), Black-hooded Oriole (*Oriolus xanthornus*), Ashy Drongo (*Dicrurus leucophaeus*), Crested Serpent-eagle (*Spilornis cheela*), and Brahminy Kite (*Haliastur indus*) are some of the common birds (Joju, 2015; Abideen, 2015).

## 3.6. Agricultural profile of the District

People in the Malappuram District cultivate different crops. The main plantation crops include Coconut (*Cocos nucifera*) Arecanut (*Areca catechu*) and Rubber (*Hevea brasiliensis*). Coconut is a perennial crop, grown all over the State. Production of coconut is intense in Malappuram District which holds the second position in the State with 13 per cent of the total area. Paddy (*Oryza sativa*) is the principal crop extensively cultivated in all the Districts of the State having a seasonal pattern in the production with three seasons as follows; July to October, November to February and March to June. In the summer season, the productivity is found to be highest in Malappuram District. The areas of major plantation crops cultivation in the District are as follows. Coconut palm (1,033,91 ha), Arecanut Palm (17,8,94.54 ha), and Rubber (42,7,50 ha). The block-wise analysis showed that Kuttippuram, Perinthalmanna, Tirurangadi, Tanur and Vengara produced coconut more than the District average whereas Nilambur, Kalikavu, Areacod and Perinthalmanna produced the arecanut more than the district average. Rubber is an important cash crop in the District which contributes an average area of 42,750 ha with the annual production of 32450 tonnes in the agricultural sector of the District. Malappuram is in the second position of the cultivation of fresh fruits with 10% of the total area of the State during the year of 2025-16. The major fruit crops in the districts are jack tree (*Artocarpus heterophyllus*) (8,698 ha), plantain (*Musa paradisiaca*) (4,294 ha) and pineapple (*Ananas comosus*) (133 ha). Tapioca (*Manihot esculenta*) (5,117 ha), colocasia (*Colocasia esculenta*) (659 ha) and elephant foot yam (*Amorphophallus paeoniifolius*)

(492 ha) were the main tuber crops cultivation in the District (Source – Agriculture statistics 2015 – 2016, Government of Kerala).

## 3.7. Linear intrusions

Linear intrusions have a significant impact on wildlife and wildlife habitats when it becomes disproportionate to the entire landscape. Wildlife forced to face the indirect effects like reduced access to habitat along with habitat destruction and in the long run, they become the victim of human exploitation. Restriction of wildlife movement, fragmentation of wildlife populations, disruption of gene flow and metapopulation dynamics are other facets of linear intrusions. When we are approaching the scenario of human-wildlife interactions at the landscape level, transportation infrastructures also have a significant role in it.

The main road ways passing through the Malappuram District is given in the Table 01.

Table 01. Details of Major roads in the Malappuram District

| Type of Road | National Highway (NH) | State highway | PWD roads | Other District road | Panchayath roads |
|---|---|---|---|---|---|
| Length of road | 123.28 km | 285.8 km | 1870.73 | 1144.755 km | 17404.79 km |

Source: Industrial Potential Survey- 2018, Malappuram District (Vahab, 2018)

**Railway:-**

Total length of railway line in the district is 142 km which include two important connections

a) Manglore-Chennai line

b) Nilambur-Shornur line

# Chapter four

# Methods

# 4. METHODS

The intensive study area was surveyed on foot and vehicle. Field visit and direct observational methods were used for the study. Field data were collected from June 2013 to September 2016. A pair of binocular (Carl Zeiss Terra Ed 10 x 45) was used for detailed observations. Garmin GPS 60CSx was used to record the latitude and longitude and Canon EOS 20D SLR Camera with a Canon EF 300 mm lens used for photographing the important events. The specific methods employed for achieving each objective is explained in this chapter.

## 4.1. Vegetation sampling

Availability of natural food in the periphery of the Reserve Forest in all the five forest ranges close to the sample plots was estimated by employing Point Centered Quarter (PCQ) method (Cottam and Curtis, 1956) which is the most commonly used sampling method for the estimation of tree density. Four transects of 100 m length were laid in four directions (900) (Fig. 07). In each transect, a minimum of five sampling points was taken at 20 m interval and within each sampling point, four quarters were marked.

In each quarter, nearest tree with more than 10 cm DBH was selected and the distance from the centre to the tree was measured, DBH of those particular trees were also measured using tape (Plate 02a & b). The trees were identified with the help of the software “Flowering plants of Kerala” and also with the help of scientists in the Department of Botany, Kerala Forest Research Institute, Peechi.

a. Vegetation sampling at Edavanna Forest Range

b. Vegetation sampling at Vazhikadavu Forest Range

**PLATE 02: Point centered quarter sampling**

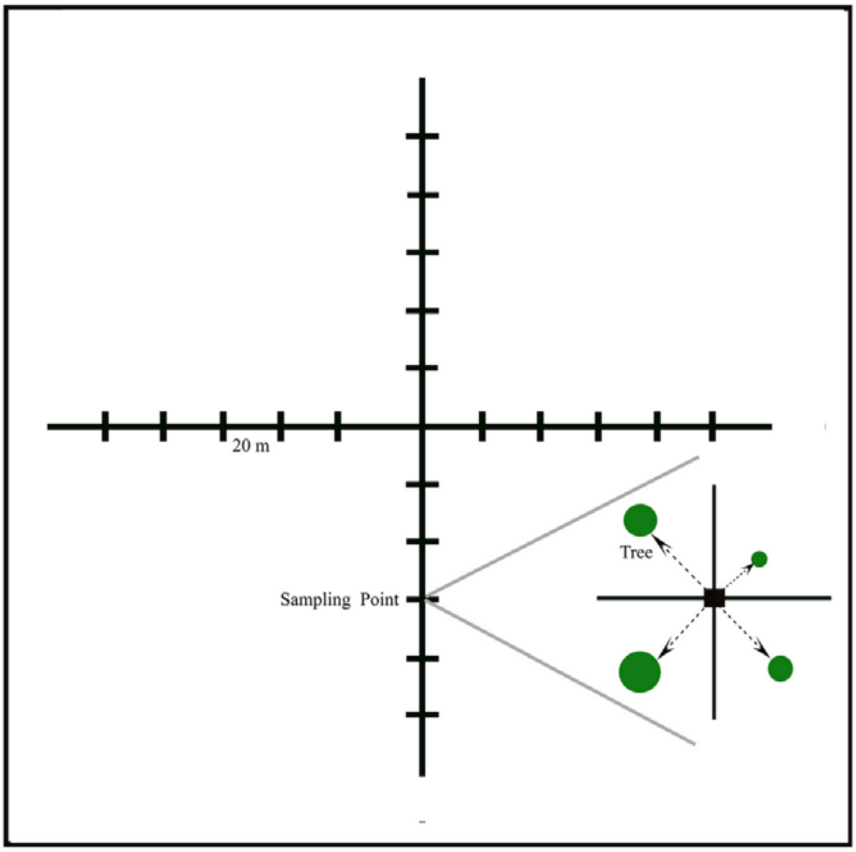



Fig. 07. Pictorial representation of Point centered quarter method

## 4.2. Crop damage

Crop damage by wild animals in the District were assessed by the following methods

### 4.2.1. Reconnaissance survey

An announcement was made in the visual media and the newspapers about the planned study and information on human-wildlife conflict was invited from affected people (Plate 03). Many responses were obtained from different parts of the District. All the areas were visited in a four-wheeler for reconnaissance survey and to identify the places for establishing survey plots according to the intensity of the human-wildlife conflict. Detailed field data were collected from such locations later.

# വന്യമൃഗശല്യം: പഠനം നടത്താൻ വിദഗ്ധ സംഘം തയാറെടുക്കുന്നു

മലപ്പുറം: മലയോര മേഖലകളിലെ കൃഷിയിടങ്ങളിലെ വന്യമൃഗശല്യം തടയുന്നതിനെ കുറിച്ച് പഠിക്കാൻ വിദ്ഗ്ധ സംഘം എത്തുന്നു. തൃശൂർ പീച്ചി കേന്ദ്രമായി പ്രവർത്തിക്കുന്ന കേരളാ വന ഗവേഷണ സ്ഥാപനത്തിലെ വന്യജീവി വിഭാഗം നേതൃത്വത്തിലുള്ള സംഘമാണ് മലപ്പുറം, പാലക്കാട് ജില്ലകളിലെ കിഴക്കൻ മേഖലകളിൽ എത്തുക. കർഷകരിൽനിന്ന് വിവരങ്ങൾ ശേഖരിക്കും. മൂന്ന് വർഷത്തെ പഠനമാണ് സംഘം നടത്തുക. ആന, പന്നി, മുള്ളൻപന്നി തുടങ്ങിയവയുടെ ശല്യമുള്ള കർഷകർ 9747141235 നമ്പറിൽ ബന്ധപ്പെടണമെന്ന് വന്യജീവി വിഭാഗം മേധാവി ഡോ. ഇ.എ. ജെയ്സൺ അറിയിച്ചു.

വന്യ മൃഗശല്യം തടയാൻ പ്രദേശമനുസരിച്ചുള്ള മാർഗങ്ങളാണ് തയാറാക്കേണ്ടത്. മുളകുപൊടിയും കരിഓയിലും ചേർത്ത മിശ്രിതം കയറുകളിൽ പുരട്ടിയുണ്ടാക്കുന്ന മുളകു വേലി പ്രയോഗം ആന ശല്യം കുറക്കാൻ സഹായിക്കുമെന്ന് ഡോ. ജെയ്സൺ പറഞ്ഞു.

ജില്ലയിലെ കാളികാവ്, കരുവാരകുണ്ട്, മരുത, പോത്തുകൽ, മുണ്ടേരി മേഖലകളിലുള്ളവർ വന്യമൃഗ ശല്യം മൂലം പലരും കൃഷി അവസാനിപ്പിച്ചിരുന്നു.

## മലപ്പുറത്തും പാലക്കാട്ടും ആറു വർഷത്തിനിടെ 67 മരണം

# വന്യജീവി- മനുഷ്യ സംഘർഷം: കെ.എഫ്.ആർ.ഐ പഠനം തുടങ്ങി

■ **അനീഷ് ചാലിയാർ**
മലപ്പുറം

ആറു വർഷത്തിനിടെ മലപ്പുറത്തും പാലക്കാട്ടും നടന്ന വന്യജീവികളുടെ ആക്രമണത്തിൽ 67 മരണം നടന്ന സാഹചര്യത്തിൽ ഇതേകുറിച്ച് കേരള വനഗവേഷണ കേന്ദ്രം(കെ.എഫ്.ആർ.ഐ) പഠനം ആരംഭിച്ചു. വന്യജീവികളും മനുഷ്യനും തമ്മിലുള്ള സംഘർഷാവസ്ഥ കൂടിവരുന്ന സാഹചര്യത്തിൽ വനംവകുപ്പ് നിർദേശത്തെ തുടർന്നാണ് പഠനം നടത്തുന്നത്. മൂന്നു വർഷം കൊണ്ട് സംഘർഷം സംബന്ധിച്ച് കൃത്യമായി വിലയിരുത്തുകയും ഓരോ പ്രദേശങ്ങൾക്കും അനുയോജ്യമായ പ്രതിരോധ മാർഗ്ഗങ്ങൾ നിർദേശിക്കുകയുമാണ് ലക്ഷ്യമെന്നും പഠനത്തിന് നേതൃത്വം നൽകുന്ന ശാസ്ത്രജ്ഞൻ ഡോ.ഇ.എ ജെയ്സൺ പറഞ്ഞു.

വന്യമൃഗങ്ങൾ കൂടുതൽ ആക്രമണോത്സുകത കാണിക്കുന്ന മേഖലകളിൽ തേനീച്ചകളെ ഉപയോഗിച്ച് പ്രതിരോധം സൃഷ്ടിക്കാനാവുമോയെന്ന് പഠിക്കുമെന്നും ആഫ്രിക്കയിൽ ഇത് വിജയകരമാണെന്നും അദ്ദേഹം പറഞ്ഞു.

ഒലവക്കോട് സർക്കിൾ പരിധിയിലെ പാലക്കാട്, നെന്മാറ, മണ്ണാർക്കാട്, നിലമ്പൂർ നോർത്ത്, സൗത്ത് ഡിവിഷനുകളിൽ ആറു വർഷത്തിനിടെ 2007(07), 2008(04), 2009(05), 2010(18), 2011–2012(33) 67 പേരാണ് വന്യജീവികളുടെ ആക്രമണത്തിൽ കൊല്ലപ്പെട്ടത്. നിരവധി പേർക്ക് ഗുരുതരമായി പരിക്കേൽക്കുകയും, കോടികളുടെ കൃഷി നാശവും സംഭവിച്ചിട്ടുണ്ട്.

മലപ്പുറം ജില്ലയിൽ മലയോര മേഖലയിലെ പതിനൊന്ന് പഞ്ചായത്തുകൾ ആന, പുലി, കാട്ടുപന്നി എന്നിവയുടെ ആക്രമണ ഭീതിയിലാണ്. കടുത്ത വേനലായതോടെ വന്യമൃഗങ്ങൾ ജനവാസ കേന്ദ്രങ്ങളിലിറങ്ങുന്നത് പതിവാണ്. കഴിഞ്ഞ മാസം ആറുപേർക്കാണ് മൂത്തേടത്ത് പുലിയുടെ ആക്രണത്തിൽ പരിക്കേറ്റത്. പുലി നിരവധി വളർത്തു മൃഗങ്ങളെ കൊന്നൊടുക്കുകയും ചെയ്തു.

പാലക്കാട് ജില്ലയിലെ കരിമ്പ, വടക്കേഞ്ചേരി, മംഗലം ഡാം പരിസരം, അലനല്ലൂരിലെ അമ്പലപ്പാറ, ഉപ്പുകുളം, അട്ടപ്പാടി തുടങ്ങിയ പ്രദേശങ്ങളിൽ കഴിഞ്ഞ വർഷങ്ങളിൽ വന്യജീവികളുടെ ആക്രമണം വർധിച്ചിട്ടുണ്ട്. കഴിഞ്ഞ പത്തുവർഷത്തെ നാശനഷ്ടങ്ങളുടെ കണക്കുകൾ കെ.എഫ്.ആർ.ഐ പരിശോധിക്കും. പഠനകാലയളവിൽ സംഘർഷാവസ്ഥ നിലനിൽക്കുന്ന പ്രദേശങ്ങളിൽ നേരിട്ടെത്തി വിവരങ്ങൾ ശേഖരിക്കുകയും ചെയ്യും. ഇതിനായി വനത്തോട് ചേർന്ന പ്രദേശങ്ങളെ വ്യത്യസ്ത പ്ലോട്ടുകളാക്കി തിരിക്കും. ഓരോ പ്രദേശങ്ങളിലും വ്യത്യസ്ത കാരണങ്ങളാണ് വന്യജീവികളുടെ ആക്രമണത്തിനിടയാക്കുന്നത് എന്നതിനാലാണിത്.

വനങ്ങൾ ജനവാസകേന്ദ്രങ്ങളാൽ ചുറ്റപ്പെട്ട ദ്വീപുകളായി മാറുന്നതും, ഉൾവനങ്ങളിലെ മനുഷ്യന്റെ ഇടപെടലുകളും സംഘർഷാവസ്ഥക്ക് ആക്കം കൂട്ടുന്നുണ്ട്.

നിലമ്പൂർ വനമേഖലയിൽ നക്സലൈറ്റ് സാന്നിധ്യമുണ്ടെന്ന സംശയം നിലനിൽക്കുന്നുണ്ട്. ഉൾവനങ്ങളിലെ മനുഷ്യ സാന്നിധ്യമായിരിക്കാം ഈ മേഖലയിൽ വന്യജീവികളുടെ ആക്രമണം വർധിക്കുന്നതിനുള്ള പ്രധാന കാരണമെന്ന് വിലയിരുത്തപ്പെടുന്നുണ്ട്. വന്യമൃഗങ്ങളും മനുഷ്യനും സംഘർഷം സംബന്ധിച്ച് 1993 മുതൽ വിവിധ ഘട്ടങ്ങളിലായി പേപ്പാറ, മൂന്നാർ, വയനാട്, മറയൂർ എന്നിവിടങ്ങളിൽ പഠനം നടത്തിയിട്ടുണ്ട്.

2009 മുതൽ 2011 വരെ തൃശൂർ ജില്ലയിലും പഠനം കെ.എഫ്.ആർ.ഐ പഠനം നടത്തിയിട്ടുണ്ട്. തൃശൂരിൽ നടത്തിയ പഠനത്തിൽ മുളക് വേലി ഉപയോഗിച്ച് ഫലപ്രദമായി ആനകളെ പ്രതിരോധിക്കാനാവുമെന്ന് കണ്ടെത്തിയിരുന്നു. വാഹനങ്ങളിലെ ഉപയോഗ ശൂന്യമായ എഞ്ചിൻ ഓയിലും മുളകും ചേർത്തുണ്ടാക്കുന്ന മിശ്രിതം ചേർത്ത് ചകിരിക്കയറിൽ പുരട്ടിയാണ് ഈ വേലി നിർമിക്കുന്നത്.

**PLATE 03: News item announced about the study in local language (Malayalam)**

### 4.2.2. Quadrat method

Based on the detailed survey conducted in the District, two locations in the fringe areas of the forest were selected randomly in each of the five Forest Ranges and the quadrats were laid in the farmlands (Plate 04a & b). The quadrats of the size of 10 m x 10 m (Jayson, 1999) were selected as follows. These areas constituted the intensive study area (Fig. 08).

1) Five sample plots (quadrats) in the mixed crop farm land (Fig. 09).
2) Two control plots which are blocked or fenced to prevent the entry of wild animals in the cultivated land near the sample plots.
3) One control plot 30 m inside the Reserve Forest near the sample plot.

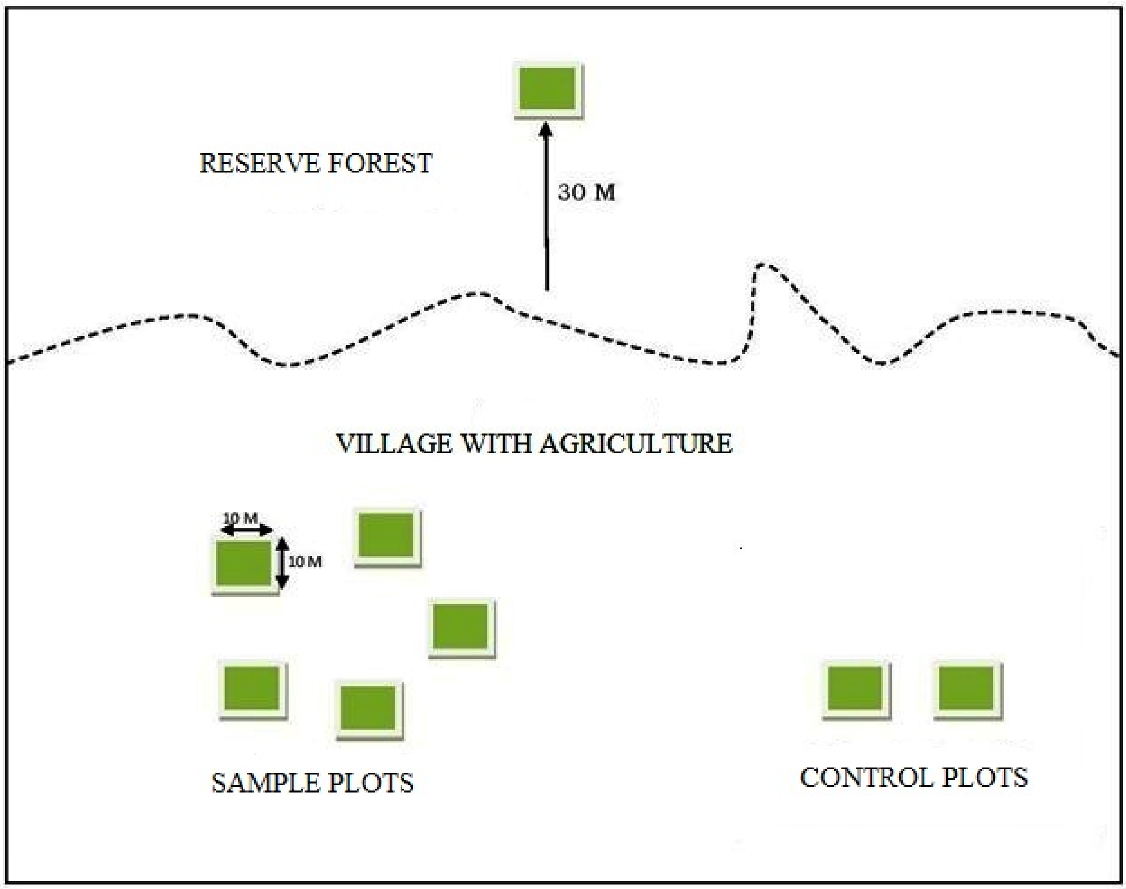



Fig. 09. Pictorial representation of selected plots

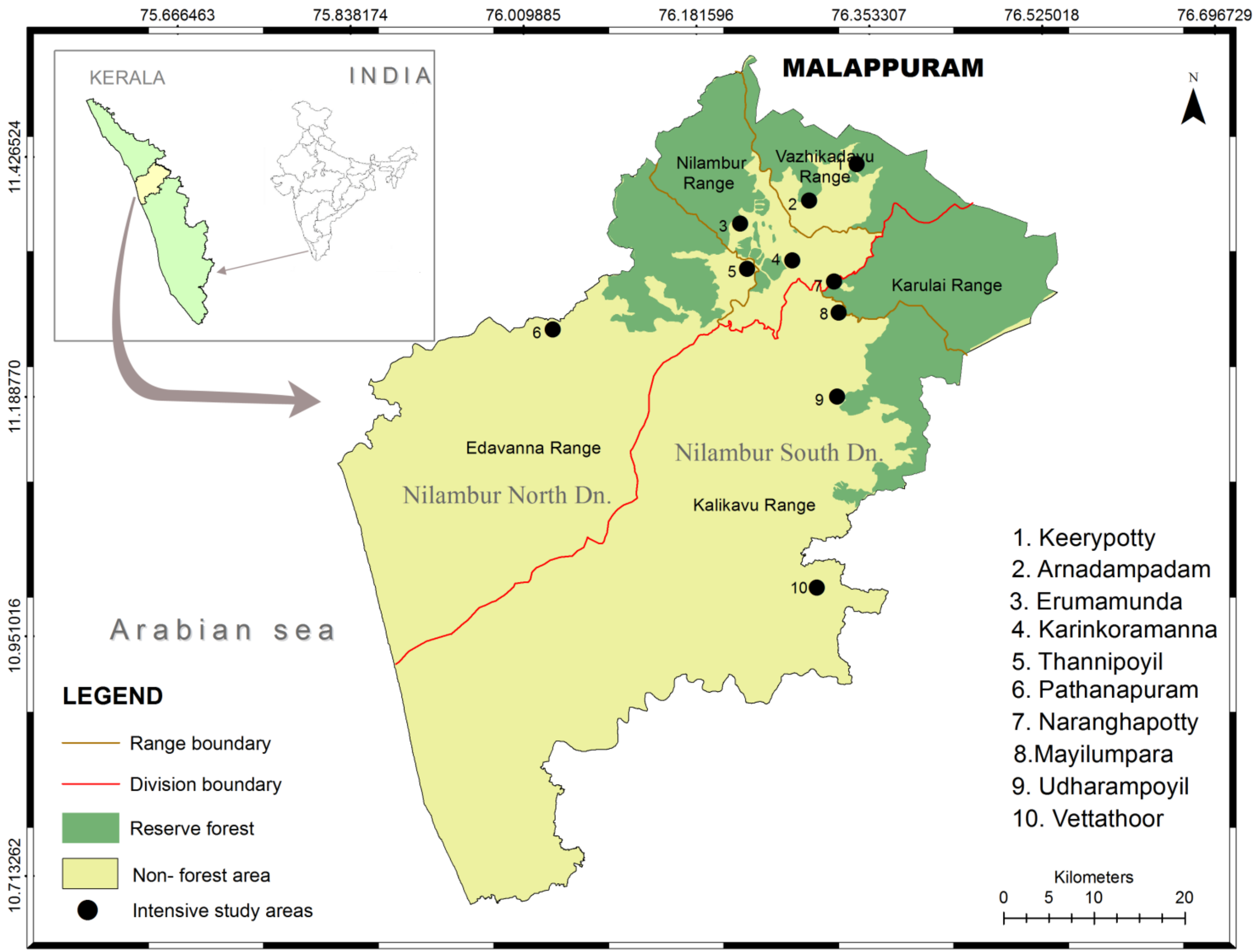



Fig.08. Map showing the intensive study area

a. Mixed cropland in Kalikavu Forest Range

b. Mixed cropland adjacent to forest in Karulai Forest Range

**PLATE 04: Mixed cropland**

Crop damage by the wild animals was recorded from the sample plots. The control plot within the forest was used to detect the presence of animals in the fringe of the forest and the other two control plots were used to quantify the yield of major crops damaged. Each plot was demarcated and marked by colored ribbon (Plate 05). The crop-damaging incidences were recorded in each month (n=36) from the quadrats and the damaged crop species were identified and quantified. In order to quantify the consumption of tubers, estimation was made after discussing with the farmers of the respective lands. Following details were collected from each quadrat.

a) Number of trees or plants damaged and undamaged.

b) Number of coconuts damaged in each plot.

c) Number of indirect evidence of wild animals in each month.

d) Damage in the nearby areas to the quadrats.

Details of the crop species, age of the crop plant, vegetation type, animal causing the damage, nature of the damage and the cost and efficacy of the protective methods employed at the time of visit also recorded. The species involved in the raids, the frequency of raiding, date and the time of the raids were confirmed with the help of farmers. From each permanent quadrat, the indirect evidence such as scats, droppings, diggings, feeding signs and scratching mark were also identified and recorded. A total of 80 permanent quadrats (50 sample plots, 20 control plots in cultivated land and 10 control plots in Reserve Forest) were observed for the study from the five Forest Ranges namely Kalikavu, Karulai, Edavanna, Nilambur and Vazhikadavu (Table 02).

**PLATE 05: Demarcation of permanent quadrat using coloured ribbon**

Percentage of occurrence of a wild animal in the crop field was calculated by dividing the number of occurrences of these species in the quadrats in each month by total months of observation (n=36) and multiplying this by 100.

Table 02. Details of the sample plots established in the Forest Ranges of Malappuram District

| Forest Division | Forest Range | Location | Latitude & Longitude | Number of sample plots |
|---|---|---|---|---|
| Nilambur South | Kalikavu | Udharampoyil | 11°11’19.6”N 76°19’17.9”E | 5 |
| | | Vettathoor | 11°59’57.3”N 76°18’06.1”E | 5 |
| | Karulai | Mayilumpara | 11°16’19.6”N 76°19’24.4”E | 5 |
| | | Naranghapotty | 11°18’10.6”N 76°19’07.1”E | 5 |
| Nilambur North | Edavanna | Thannipoyil | 11°18’56.6”N 76°13’56.4”E | 5 |
| | | Pathanapuram | 11°15’19.4”N 76°02’21.6”E | 5 |
| | Nilambur | Erumamunda | 11°21’37.9”N 76°13’32.0”E | 5 |
| | | Karinkoramanna | 11°19’25.9”N 76°16’37.7”E | 5 |
| | Vazhikadavu | Arnadampadam | 11°22’59.8”N 76°17’38.1”E | 5 |
| | | Keerypotty | 11°25’10.9”N 76°20’28.5”E | 5 |
| | | | **Total** | **50** |

### 4.2.3. Running quadrats

The quadrats that were established in the cropland only after the Asian elephant encounters occurred was termed as running quadrat. Unlike the permanent quadrat the number of running quadrats was directly proportional to the area of damage. To quantify the crop damage by Asian elephant in the crop field, the running quadrats of 10 m x 10 m were laid in the damaged cropland (Christopher, 1998). The damage by elephant was confirmed by examining the indirect signs (footprints and dung piles) and mode of consumption (uprooting, trampling, and debarking) in the farmland. The information regarding the place, number of damaged and undamaged plants, age of the crop, time of the attack, number of elephants and distance to the Reserve forest were collected by direct observation from the field as well as through the focus group discussion with at least ten people selected from the place of incident. A total of two hundred and ninety running quadrats were laid for the study (Tables 03 & 04). The seasonal encounter of Asian elephants in the crop field was calculated using the formula,

$$\text{Seasonal encounter index} = \frac{\text{Mean encounter in different seasons}}{\text{Overall mean}} \times 100$$

Pearson's correlation (r) was used to compare the climatic parameters (rainfall and temperature) and seasonal encounter index of elephants.

Table 03. Details of running quadrats established to assess the crop damage by Asian elephants

| Sl. No. | Places | Forest Range | No. of plots |
|---|---|---|---|
| 1 | Mayilumpara | Karulai | 14 |
| 2 | Panichola | Karulai | 67 |
| 3 | Mundakadavu | Karulai | 7 |
| 4 | Naranghamoola | Karulai | 13 |
| 5 | Naranghapotty | Karulai | 5 |
| 6 | Namboorypotty | Karulai | 16 |
| 7 | Palengara | Karulai | 4 |
| 8 | Kalkulam | Karulai | 3 |
| 9 | Thanipotty | Karulai | 3 |
| 10 | T.k colony (Poothottukadavu) | Kalikavu | 5 |
| 11 | Chenappady | Kalikavu | 6 |
| 12 | Kelunairpady | Kalikavu | 3 |
| 13 | Pullangodu rubber estate | Kalikavu | 14 |
| 14 | Chenkodu | Kalikavu | 8 |
| 15 | T.K Colony | Kalikavu | 7 |
| 16 | Munadi | Kalikavu | 10 |
| 17 | Parayanmedu | Kalikavu | 7 |
| 18 | Melekalikavu | Kalikavu | 4 |
| 19 | Udharampoyil | Kalikavu | 5 |
| 20 | Karuvarakundu (Puliyakkodu) | Kalikavu | 18 |
| 21 | Vattamala | Kalikavu | 11 |
| 21 | Chettiyarangadi | Vazhikadavu | 30 |
| 22 | Udhiramkulam | Vazhikadavu | 4 |
| 23 | Onichandam | Vazhikadavu | 5 |
| 24 | Anamari | Vazhikadavu | 17 |
| 25 | Thekkepalodu | Vazhikadavu | 2 |
| 26 | Veettikunnu | Edavanna | 2 |
| | | **Total** | **290** |

Table 04. Details of running quadrats with rubber tree damage

| Sl. No. | Name of place | Forest Range | No. of plots |
|---|---|---|---|
| 1 | Mayilumpara | Karulai | 6 |
| 2 | Panichola | Karulai | 51 |
| 3 | Naranghapotty | Karulai | 4 |
| 4 | Poothottukadavu | Kalikavu | 2 |
| 5 | Pullangodu | Kalikavu | 4 |
| 6 | Udhirampoyil | Kalikavu | 3 |
| 7 | Vattamala | Kalikavu | 8 |
| 8 | Moonadi | Kalikavu | 2 |
| | | **Total** | **80** |

#### 4.2.4. Estimation of economic loss

Estimation of economic loss was calculated based on the market price of the commodities collected from the website of Farm Information Bureau, Kerala, during the study period. In each month (n=36), the price of commodities in northern Kerala for 3 days were selected, with a gap of 10 days. The economic loss was calculated by multiplying the average market price of the commodities and the quantity of crops damaged. For estimating the potential loss of perennial crops, its economic life period was divided into an immature phase and productive phase. If a crop is damaged during the immature phase, the potential value was considered as the market price of a new plant or a seed. The potential value of the crops damaged during the productive phase was estimated by multiplying the average market price of the yield during the study period and overall yield per tree during its economic life period. The perennial crops in the forest fringes are prone to get damaged at any age due to wild animals. In order to quantify the loss, the productive phase was equally divided into two age classes, *i.e.* primary stage (the period from the initial stage of bearing to the middle age of its productive phase) and secondary stage (the period from the middle age of productive phase to the end of its economic life period). If the crops were damaged during the primary stage, the overall potential value of the perennial crop was considered and if the crops were damaged during the secondary stage, half portion of the overall potential value was accounted (Govind and Jayson, 2014).

Only the perennial crops seriously damaged by wild animals (partial damage was not considered) and the species of crops damaged more than 20 trees were accounted for the potential loss estimation. Average yield per annum of the perennial crops was collected from Rubber Board Kottayam, Kerala and Central Plantation Crops Research Institute Kasaragod, Kerala, India.

## 4.3. Factors affecting the human-elephant conflict

For determining the factors that affect the human-elephant conflict (HEC), environmental variables of the study area were compared with the occurrence of human-elephant conflict using binary logistic regression analysis. The entire study area was divided into the grids of 2 km x 2 km size to ensure the presence of different crop species in maximum grids and the cells with recorded human-elephant conflict were taken as conflict cells and the non-conflict cells were selected in the simple random method. In the selected non-conflict cells, four places from each cell were selected to extract the value of required parameters and its mean value was used for the analysis (Fig. 10). While selecting the non-conflict cells, the cells towards the western part of the District were not considered as it was far away from the Reserve Forest and the chance for the occurrence of human-elephant interaction was practically nil. For the data analysis, all the independent variables were superimposed on to the grid cells in a way to cover the elephant range. The entry and exit of environmental variables were determined by Wald Statistic with *P*-values of 0.05 and 0.1 respectively. Spearman's rank correlation (*rs*) was used to observe the relationship between predicted probabilities of the occurrence of crop damage from the logistic model and the number of crop-raiding incidents in the grid cells. The variables selected for the analysis are stated as follows.

1. Elevation (m) – Measured using GPS.
2. Slope (angle) – Recorded from Digital Elevation Model (DEM).
3. Aspect value – Recorded from DEM.
4. Canopy Density – Calculated by preparing Normalized Difference Vegetation Index (NDVI) Map of the study area from Land sat 7 Satellite images by using Arc GIS 10 software.
5. Distance from river (m) – Measured from toposheets.
6. Distance to the forest from the area of crop damaged (m) – measured using GPS.
7. Types of crops were recorded during the field visit.

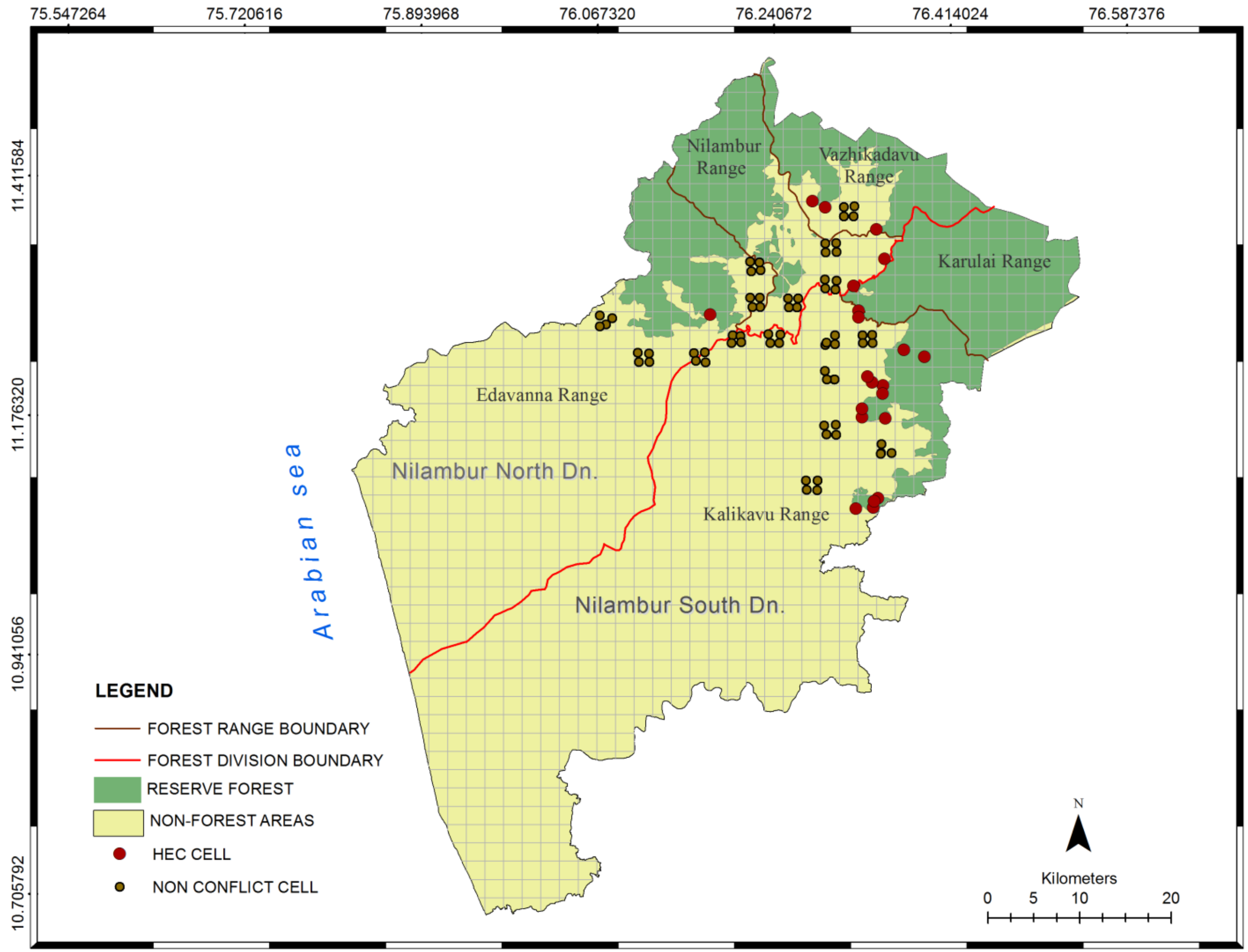



Fig. 10. Grid cells selected for logistic regression analysis

The site-specific environmental variables have a definite influence on the occurrence of human-elephant conflict of an area (Hoare, 1999, Sitati *et al.*, 2003) and that was worked out in Attappady region of Kerala and revealed the influence of each of the selected variables in predicting the HEC of (Prasad *et al.*, 2011).

### 4.4. Cattle lifting and human casualties

The data on cattle lifting incidences and human casualties were collected by conducting case studies in the District. The emphasis was given to collect information on the predator attacked and its mode of attack, prey involved, age and sex of the prey, time, and place of attack. Information on the history of the place concerning the presence of wildlife, distance from the place of incidence to Reserve Forest, awareness on wildlife laws and the source of income for the respondents was also documented during the group discussion. Case studies were conducted to document the incidences of human casualties by wild animals in the District. The details like the animal involved, the nature of the attack, age and sex of the victim, place and time of the attack, distance from the place to Reserve Forest were documented.

## 4.5. Control measures

### 4.5.1. Beehive fence

The natural fear of elephants keeps them away from the honey bees. Mayilumpara (11016’19.6”N and 076019’24.4”E), of Karulai Forest

Range, was selected for the experiment where the presence of elephants was rampant in the crop field. Previous observations (n=21) in this area revealed that elephants entered the crop field through 8 different paths and consumed the edible crops namely plantain, coconut (*Cocos nucifera*), arecanut (*Areca catechu*) and pineapple (*Ananas comosus*). Six paths were selected randomly and blocked with the beehive fences (Fig. 11). Two to six beehive boxes were hanged in iron wire, supported by wooden posts (having a width of 10 m) for blocking a single path (Plate 06a). The remaining two paths were left unblocked. *Apis cerana indica* was used for the experiment (Plate 06b). All the twenty boxes were protected from monsoon rains using plastic sheets. Whenever the elephants touched the iron wire which is installed across the path, the beehive boxes were disturbed and the guard bees attacked the elephants and deterred them. It was found useful during both day and night hours (King *et al.*, 2009). The guard bees attacked the elephants on its sensitive areas like the tip of the trunk and behind the ears and around the eyes (King, 2013). The efficacy of this method was evaluated by recording the encounter of elephants through either blocked or unblocked paths. Three visits in each month were made to collect the data. The expertise of a trained apiculturist Mr. Pradeep was obtained for maintaining the honey bees. Social aspects of maintaining the beehive fences were recorded and the beehive-fence were maintained from March to December months in the year 2014.

a. Beehive fence erected at Mayilumpara

b. *Apis cerana indica* in the beehives

**PLATE 06: Beehive fence experiment**

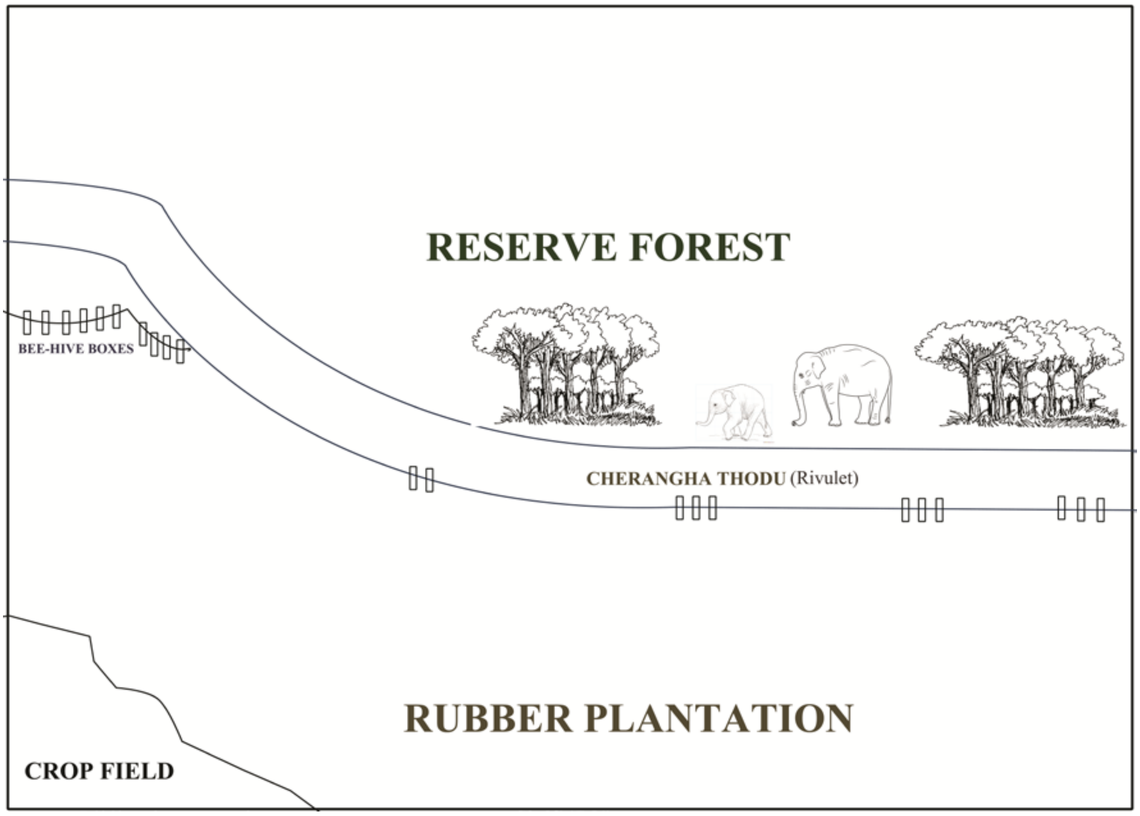



Fig. 11. Pictorial representation of beehive-fence experiment at Mayilumpara

### 4.5.2 Yellow-coloured cloth

The display of yellow coloured cloth as the fence was carried out in Kalikavu Forest Range in a private plantain plantation for deterring the wild pig. This innovative remedial measure was known to prevent the entry of wild animals to the crop field and its efficiency was evaluated in Udharampoyil ($11^0$11'19.6"N, $76^0$19'17.9"E) of Kalikavu Forest Range. Yellow cloth (120 cm height) was fixed in the boundary of this farm (Plate 07a). The cost of the yellow coloured cloth was Rs. 10.00 per meter and it was purchased from the textiles as damaged lining cloth of the blouse and this was invested by the farmers. A total 10 quadrats (10

a. Yellow coloured cloth in Kalikavu Forest Range


b. “Trump guard” against wild pig

**PLATE 07: Preventive measures to deter wild pig (*Sus scrofa*) from the cropland**

m x 10 m) were taken for evaluating the efficiency of this method. Five quadrats each were selected randomly from the area where this method was employed and an open private land having mixed cultivation (without any remedial measure) as control. All the quadrats were laid within one $km^2$ and observations were recorded in each month from the quadrats and the per cent of encounter was documented from April 2014 to March 2015 (n=12).

### 4.5.3. Bio-repellent (Trump guard)

"Trump guard" is a biological product for repelling wild pigs without killing them (Plate 07b). It is an eco-friendly liquid deterrent manufactured by Agrocare (India) Pvt. Ltd. Bangalore and is marketed by Farm Panacea Trade Links, Kerala. It is used by diluting 100 ml per 15 litres of water and sprayed in 152 cm to 183 cm broad border around the farm. Constituents of the formulation were established using Gas Chromatography-Mass Spectrometry (GCMS) method and it was supplied to ten farmers of all the five Forest Ranges near to the permanent quadrats for evaluating its efficacy (Appendix-1). Month-wise observations were recorded with the help of farmers from July 2015 to December 2015 (n=6).

## 4.6. Assessment of conservation attitude

Conservation attitudes of the people affected with human-wildlife conflict were recorded from the District through the focus group discussion using structured questionnaire survey.

### 4.6.1. Questionnaire survey

A structured questionnaire survey was carried out in the Forest Ranges of Malappuram District to find out the conservation attitude of local people (Christopher, 1998) (Appendix-II). The experts reviewed the questionnaire and it is validated by conducting a pilot study on a subset of participants and checking the internal consistency of the responses by using SPSS. The whole study area was divided into grids with a size of 2 km x 2 km. Non-forest areas towards the western side of the District were omitted from the grids, as the human-wildlife interaction in the non-forest areas were negligible. Alternate grids were selected for the survey (Fig. 12). The houses within the grids were selected non-randomly. Five houses were selected for the survey from each grid. Fifty questions were included in the questionnaire pro-forma, mainly focusing on background information, details of the farming, crop damage, lifting of livestock, human casualties and social dimension. Emphasis was given to record information pertaining to human-wildlife conflicts and the management of wildlife resources. Interviews were conducted primarily with the head of the household, of which most were male (Plate 08). The exception was where they were absent during the household visit. Interview with respondents made after visiting them in their homes and interacting with them roughly 15 to 20 minutes with the respondent. If a member of 18 years of age or older was absent during the survey, the house was skipped and the next house was surveyed.

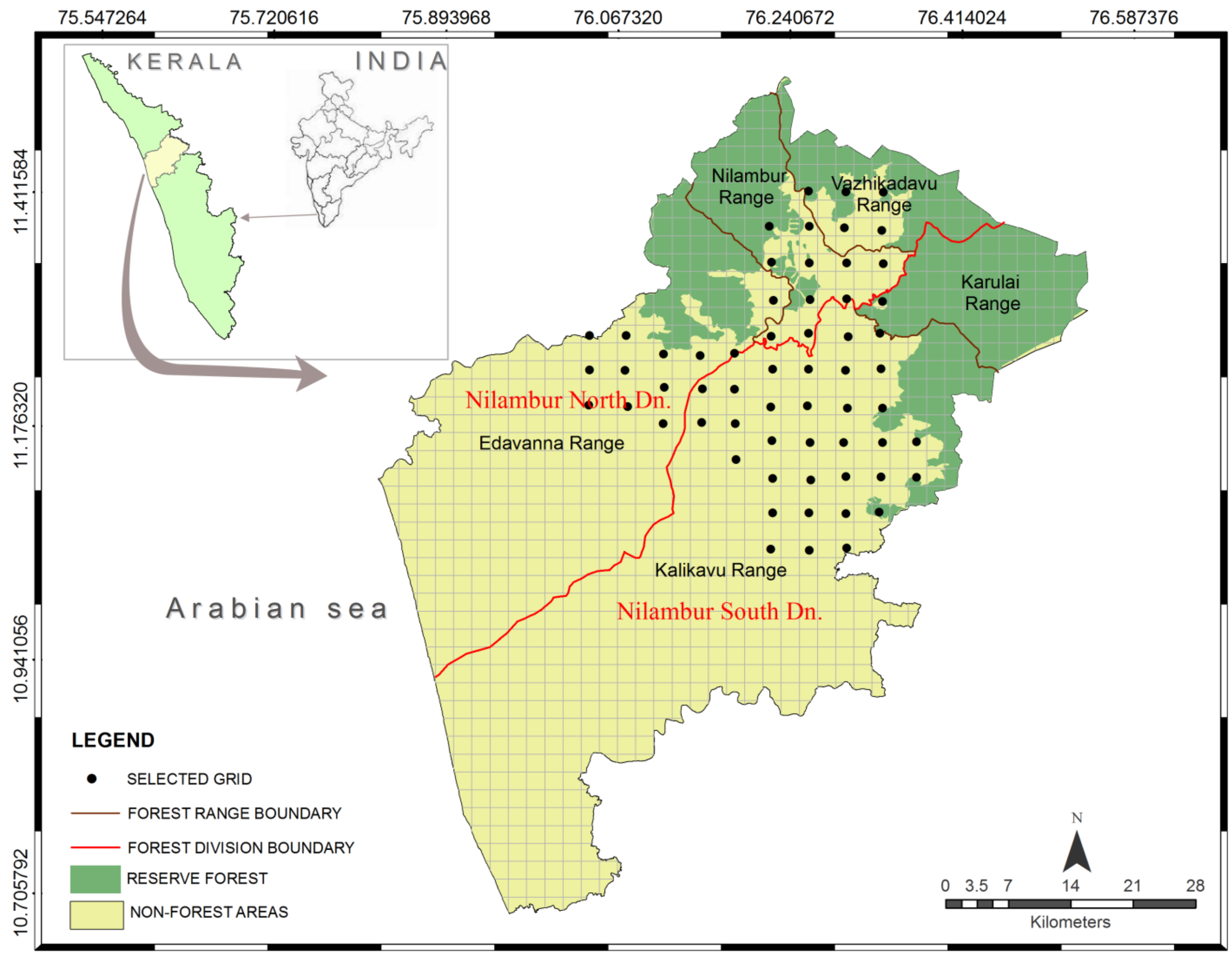



Fig. 12. Grids selected for questionnaire survey

**PLATE 08: Questionnaire survey**

Almost all questions were close-ended (close-ended questions have multiple options to direct the respondents to the interviewers own set response, whereas open-ended questions have no options and respondents are required to answer themselves) for simplicity in quantitative analysis.

Specifically, information was collected on the following.

a. Details of the area: Name of colony, panchayath, ward, nature of settlement.

b. Demographics: Name, age, occupation, education, native/migrated status, fuel wood and water source of the respondents.

c. Details about cultivation: Land holding, crops cultivated extent and perception of damage, ranking of crops prone to damage as well as ranking of raiding species, mode of attack, annual loss, compensation details and protective methods to mitigate the crop-raiding.

d. Livestock lifting: Incidences of livestock lifting, species involved, mode of attack, compensation status and maintenance of livestock.

e. Human casualty/injury: Details of victims, animals involved, location, mode of attack and compensation details.

f. Social dimension of crop-raiding: Land tenure system, degree of dependence on agriculture local beliefs and taboo systems regarding wildlife etc.

Table 05. Number and location of grids selected using systematic random method

| Sl. No. | Forest Ranges | No. of grids selected | Number of houses surveyed |
|---|---|---|---|
| 1 | Kalikavu | 32 | 160 |
| 2 | Edavanna | 12 | 60 |
| 3 | Nilambur | 10 | 50 |
| 4 | Vazhikadavu | 5 | 25 |
| 5 | Karulai | 1 | 5 |
| | | **Total** | **300** |

A total of 300 houses were surveyed from 5 Forest Ranges namely Kalikavu, Karulai, Edavanna, Nilambur and Vazhikadavu (Table 05).

### 4.6.2. Predicting the potential areas of crop loss

The candidate models were prepared by using variables collected by question survey and the factors associated in the prediction were selected from the top model to predict the potential areas of crop loss (Karanth *et al.*, 2012; Karanth *et al.*, 2013). The combinations of the variables in the models were tried in such a way to represent the various hypotheses about the characteristic of crop damage reported in the focus group discussion. Pearson's correlation coefficients were calculated to find the collinearity of the variables involved in each model. The Corrected Akaike's Information Criterion (AICc) was used for defining the models, evaluating the model fit and recognizing the variables of crop damage. The best models (cumulative weight > 0.95) were selected to estimate the probabilities of crop loss (Burnham and Anderson, 2002) and their weighted estimated probability at each sampled location was provided to produce the posterior probability map. Ordinary kriging (spherical model) in the spatial analyst tool of Arc Map v.10 GIS Software Package was used to fit the weighted estimated probability.

### 4.7. Media coverage of human-wildlife conflict

For assessing the coverage of print media newspapers in different perspectives about human-wildlife conflict issues, the news were collected from the local newspapers in the District which includes "Malayalamanorama", "Mathrubhumi", "Chandrika", "Madhyamam", and "Deepika". The collected data were entered in the Microsoft excel 2007 and the descriptive analysis was done using SPSS statistical software package.

All the data were processed and analysed using the Statistical Package for the Social Science (SPSS) version 17.0. Both the descriptive and analytical procedures were used in data analysis to determine the relationship between the variables and also for the statistical model preparation. It was used to prepare all the maps presented in the study

Chapter five

# Result and discussion

# 5. RESULT AND DISCUSSION

## 5.1. Status of natural vegetation

Vegetation in the periphery of the Reserve Forest in Edavanna, Nilambur, Vazhikadavu and Karulai Forest Ranges were estimated. Tree species, relative density and relative dominance are given in Table 06, 07, 08, 09 & 10.

Table 06. Density of trees in the periphery of the Reserve Forest in the Edavanna Range

| Sl. No. | Name of Species | Common name | Relative dominance | Relative density |
|---|---|---|---|---|
| 1 | *Artocarpus hirsutus* | Anjili | 2.71 | 8.55 |
| 2 | *Bauhinia racemosa* | Arampuli | 0.05 | 0.66 |
| 3 | *Bambusa bambos* | Bamboo | 0.67 | 1.32 |
| 4 | *Holigarna arnottiana* | Cheru | 5.30 | 1.97 |
| 5 | *Xylia xylocarpa* | Irul | **30.78** | **32.24** |
| 6 | *Hopea ponga* | Irumbakam | 6.71 | 4.61 |
| 7 | *Terminalia chebula* | Kadukka | 0.31 | 0.66 |
| 8 | *Sterculia guttata* | Kalanthatta | 1.45 | 1.97 |
| 9 | *Wrightia tinctoria* | Kambippala | 0.77 | 1.32 |
| 10 | *Sageraea laurina* | Kanakaitha | 4.46 | 5.92 |
| 11 | *Cassia fistula* | Kanikonna | 0.46 | 1.32 |
| 12 | *Strychnos nux-vomica* | Kanjiram | 4.16 | 1.32 |
| 13 | *Swietenia macrophylla* | Mahogani | 3.79 | 1.32 |
| 14 | *Terminalia paniculata* | Maruthu | 11.84 | 17.76 |
| 15 | *Scolopia crenata* | Mullukara | 2.35 | 1.32 |
| 16 | *Alstonia scholaris* | Pala | 0.02 | 0.66 |
| 17 | *Mallotus philippensis* | Sindooram | 2.53 | 3.29 |
| 18 | *Terminalia bellirica* | Thanni | **14.18** | **7.90** |
| 19 | *Dalbergia latifolia* | Kariveeti | 4.70 | 3.29 |
| 20 | *Terminalia cuneata* | Vellamaruthu | 0.84 | 1.32 |
| 21 | *Lagerstroemia microcarpa* | Venthekku | 1.92 | 1.32 |

Table 07. Density of trees in the periphery of the Reserve Forest in the Nilambur Range

| Sl. No. | Name of species | Common name | Relative dominance | Relative density |
|---|---|---|---|---|
| 1 | *Lannea coromandelica* | Anakkaram | 18.26 | 2.63 |
| 2 | *Xylia xylocarpa* | Irul | **24.85** | **40.79** |
| 3 | *Sterculia guttata* | Kalanthatta | 1.79 | 1.32 |
| 4 | *Sageraea laurina* | Kanakaitha | 4.12 | 11.84 |
| 5 | *Cassia fistula* | Kanikonna | 0.32 | 1.32 |
| 6 | *Strychnos nux-vomica* | Kanjiram | 7.57 | 5.26 |
| 7 | *Terminalia paniculata* | Maruthu | **37.50** | **27.63** |
| 8 | *Briedelia retusa* | Mullankkayini | 0.40 | 1.32 |
| 9 | *Alstonia scholaris* | Pala | 0.10 | 1.32 |
| 10 | *Calophyllum calaba* | Punna | 4.17 | 1.32 |
| 11 | *Terminalia bellirica* | Thanni | 0.61 | 2.63 |
| 12 | *Mitragyna parvifolia* | Veembu | 0.22 | 1.32 |
| 13 | *Dalbergia latifolia* | Kariveeti | 0.10 | 1.32 |

Table 08. Density of trees in the periphery of the Reserve Forest in Vazhikadavu Range

| Sl. No. | Name of species | Common name | Relative dominance | Relative density |
|---|---|---|---|---|
| 1 | *Spondias pinnata* | Ambazham | 4.10 | 0.66 |
| 2 | *Artocarpus hirsutus* | Anjili | 0.15 | 0.66 |
| 3 | *Ficus racemosa* | Athi | 6.63 | 1.97 |
| 4 | *Bambusa bambos* | Bamboo | 0.10 | 0.66 |
| 5 | *Grewia tillifolia* | Chadachi | **13.64** | **11.84** |
| 6 | *Santalum album* | Chandanam | 0.10 | 0.66 |

| | | | | |
|---|---|---|---|---|
| 7 | *Mallotus philippensis* | Sindooram | 0.35 | 1.32 |
| 8 | *Holigarna arnottiana* | Cheru | 0.96 | 0.66 |
| 9 | *Xylia xylocarpa* | Irul | **6.84** | **11.84** |
| 10 | *Wrightia tinctoria* | Kambippala | 0.39 | 1.97 |
| 11 | *Sageraea laurina* | Kanakaitha | 0.48 | 1.97 |
| 12 | *Cassia fistula* | Kanikonna | 0.47 | 1.32 |
| 13 | *Strychnos nux-vomica* | Kanjiram | 0.68 | 1.32 |
| 14 | *Elaeocarpus serratus var.serratus* | Kara | 2.95 | 0.66 |
| 15 | *Terminalia elliptica* | Karimaruthu | 2.18 | 2.63 |
| 16 | *Persea macrantha* | Kulirmavu | 2.95 | 0.66 |
| 17 | *Terminalia paniculata* | Maruthu | 24.65 | 31.58 |
| 18 | *Ailanthus triphysa* | Matti | 2.16 | 2.63 |
| 19 | *Briedelia retusa* | Mullankkayini | 0.38 | 0.66 |
| 20 | *Miliusa tomentosa* | Kanakaitha | 0.47 | 0.66 |
| 21 | *Hydnocarpus pentandra* | Neeratti | 1.87 | 2.63 |
| 22 | *Butea monosperma* | Plasu | 0.09 | 0.66 |
| 23 | *Macaranga peltatta* | Podini | 4.41 | 2.63 |
| 24 | *Stereospermum colais var.colais* | Poopathiri | 1.22 | 1.32 |
| 25 | *Schleichera oleosa* | Puvathi | 0.68 | 2.63 |
| 26 | *Calophyllum inophyllum* | Punna | 2.33 | 1.32 |
| 27 | *Tectona grandis* | Teak | 1.02 | 1.97 |
| 28 | *Terminalia bellirica* | Thanni | 1.99 | 1.97 |
| 29 | *Scolopia crenata* | Mullukara | 1.82 | 0.66 |
| 30 | *Sapindus trifoliatus* | Uruvangi | 0.12 | 0.66 |
| 31 | *Albizia lebbeck* | Vaka | 6.02 | 0.66 |
| 32 | *Dalbergia latifolia* | Kariveeti | 3.28 | 1.97 |
| 33 | *Terminalia cuneata* | Vellamaruthu | 2.49 | 3.29 |
| 34 | *Lagerstroemia microcarpa* | Venthekku | 2.05 | 1.32 |

Table 09. Density of trees in the periphery of the Reserve Forest in Karulai Range

| Sl. No. | Name of species | Common name | Relative dominance | Relative density |
|---|---|---|---|---|
| 1 | *Glochidion zelylanium var.zeylanicum* | | 0.10 | 3.29 |
| 2 | *Holigarna grahamii* | Cheru | 1.62 | 4.61 |
| 3 | *Ricinus communis* | Avanakka | 0.10 | 0.66 |
| 4 | *Tetrameles nudiflora* | Cheeni | 0.34 | 0.66 |
| 5 | *Xylia xylocarpa* | Irul | 3.07 | 3.95 |
| 6 | *Hopea ponga* | Irumbakam | 0.62 | 0.66 |
| 7 | *Sterculia guttata* | Kalanthatta | 0.22 | 0.66 |
| 8 | *Anogeissus latifolia* | Kalkanjiram | 0.03 | 1.32 |
| 9 | *Terminalia elliptica* | Karimaruthu | 2.36 | 1.32 |
| 10 | *Melia azedarach* | Kattuvappu | 0.01 | 0.66 |
| 11 | *Persea macrantha* | Kulamavu | **8.55** | **5.26** |
| 12 | *Gmelina arborea* | Kumbili | 0.03 | 0.66 |
| 13 | *Scolopia crenata* | Mullukara | 0.00 | 0.66 |
| 14 | *Terminalia paniculata* | Maruthu | 9.60 | 6.58 |
| 15 | *Zanthoxylum rhetsa* | Mullilam | 0.70 | 3.29 |
| 16 | *Bombax ceiba* | Poolamaram | 3.19 | 0.66 |
| 17 | *Hydnocarpus pentandra* | Neeratti | **11.80** | **21.71** |
| 18 | *Lophopetalum wightianum* | Vembala | 2.06 | 2.63 |
| 19 | *Alstonia scholaris* | Pala | 2.88 | 3.29 |
| 20 | *Butea monosperma* | Plasu | 0.04 | 0.66 |
| 21 | *Kydia calycina* | Vellachadachi | 5.59 | 0.66 |
| 22 | *Stereospermum colais* | Poopathiri | 8.67 | 6.58 |
| 23 | *Schleichera oleosa* | Puvthi | 7.50 | 6.58 |
| 24 | *Calophyllum inophyllum* | Punna | 9.19 | 5.26 |
| 25 | *Mallotus philippensis* | Sidooram | 0.03 | 0.66 |
| 26 | *Tectona grandis* | Teak | 4.85 | 3.95 |

| | | | | |
|---|---|---|---|---|
| 27 | *Grewia tiliifolia* | Chadachi | 2.02 | 1.97 |
| 28 | *Terminalia cuneata* | Vellamaruthu | 0.10 | 1.32 |
| 29 | *Trewia nudiflora* | Thavalamaram | 0.34 | 1.32 |
| 30 | *Dalbergia latifolia* | Kariveeti | 1.98 | 1.97 |
| 31 | *Syzygium salicifolium* | Vellamanchi | 2.92 | 3.29 |
| 32 | *Pterocarpus marsupium* | Venga | 1.59 | 0.66 |
| 33 | *Lagerstroemia microcarpa* | Venthekku | 8.28 | 2.63 |

Table 10. Density of trees in the periphery of the Reserve Forest in Kalikavu Range

| Sl. No. | Name of Species | Common name | Relative dominance | Relative density |
|---|---|---|---|---|
| 1 | *Grewia tiliifolia* | Chadachi | 2.86 | 1.33 |
| 2 | *Mallotus philippensis* | Sindooram | 0.81 | 4.00 |
| 3 | *Syzygium cumini var. cumini* | Chorakatta-pazham | 0.30 | 1.33 |
| 4 | *Xylia xylocarpa* | Irul | **23.21** | **29.33** |
| 5 | *Sterculia guttata* | Kalanthatta | 1.57 | 2.67 |
| 8 | *Anogeissus latifolia* | Kalkanjiram | 3.80 | 5.33 |
| 9 | *Wrightia tinctoria* | Kambippala | 0.57 | 2.67 |
| 10 | *Cassia fistula* | Kanikonna | 0.38 | 1.33 |
| 11 | *Terminalia elliptica* | Karimaruthu | 7.52 | 4.00 |
| 12 | *Albizia lebbeck* | Karivaka | 5.67 | 1.33 |
| 13 | *Terminalia paniculata* | Maruthu | **19.59** | **12.00** |
| 14 | *Zanthoxylum rhetsa* | Mullilam | 0.18 | 1.33 |
| 15 | *Phyllanthus emblica* | Nelli | 0.53 | 1.33 |
| 16 | *Rubia cordifolia* | Poovathi | 0.07 | 1.33 |
| 17 | *Bombax ceiba* | Poola | 1.21 | 1.33 |
| 18 | *Calophyllum calaba* | Punna | 7.19 | 8.00 |
| 19 | *Terminalia bellirica* | Thanni | 9.90 | 4.00 |
| 20 | *Dalbergia latifolia* | Veeti | 5.34 | 8.00 |
| 21 | *Terminalia cuneata* | Vellamaruthu | 2.51 | 2.67 |
| 22 | *Lagerstroemia microcarpa* | Venthekku | 6.83 | 6.67 |

The vegetation analysis showed that the study area exhibits high diversity of the species. The trees like *Xylia xylocarpa, Terminalia bellirica, Terminalia paniculata, Grewia tilIifolia, Hydnocarpus pentandra, Persea macrantha, Kydia calycina* were observed as the dominant species in the forest. The bark, branches and leaves of the species like *Terminalis* spp, *Grewia Tilifolia*, *Kydia Calycinia* are the preferred food items of the Asian elephant. In addition to this, a variety of herbs, shrubs and grassland patches were also observed within the forest during the survey. The abundance, density and diversity of the tree species within the forest indicate the standing health of the natural forest in the District which can support a variety of wild animals.

## 5.2. Crop damage by wild animals

The animals frequently came into conflict with the people in the forest fringes of Malappuram District were Asian elephant (*Elephas maximus*), wild pig (*Sus scrofa*), bonnet macaque (*Macaca radiata*), Indian crested porcupine (*Hystrix indica*) and black-footed gray langur (*Semnopithecus hypoleucos*). Twenty-one farmers responded to the request for information in the print media (Table 11).

The crops damaged by wild animals were coconut (*Cocos nucifera*), arecanut (*Areca catechu*), plantain (*Musa paradisiaca*), paddy (*Oryza sativa*), pineapple (*Ananas comosus*), jack tree (*Artocarpus heterophyllus*), rubber (*Hevea brasiliensis*), Teak (*Tectona grandis*), Mango tree (*Mangifera indica*), Tapioca (*Manihot esculenta*), Colocasia (*Colocasia esculenta*) and Elephant foot yam (*Amorphophallus paeoniifolius*) (Table 12). Highest crop damage recorded during July and lowest in March.

Table 11. Details of the farmers who responded towards the newspaper announcement

| Sl. No. | Name of person | Place name | Forest Range | Animals involved |
|---|---|---|---|---|
| 1 | Haridasan | Chaliyar | Nilambur | Monkey, Wild pig |
| 2 | Veerankutty | Pulikkal | Edavanna | Monkey, Wild pig |
| 3 | Mohanan | Thiruvali | Edavanna | Monkey, Wild pig Pea fowl |
| 4 | Asraf | Pathanapuram | Edavanna | Wild pig |
| 5 | Mathai | Chunghathara | Nilambur | Wild pig |
| 6 | Jony | Karuvarakundu | Kalikavu | Elephant |
| 7 | Kunjiraman | Manjeri | Edavanna | Wild pig |
| 8 | Jeorge | Karuvarakundu | Kalikavu | Elephant, Wild pig |
| 9 | Shoukathali | Karuvarakundu | Kalikavu | Elephant, Wild pig |
| 10 | Kunjuttan | Mampattumoola | Kalikavu | Wild pig |
| 11 | Asraf | Pathanapuram | Edavanna | Wild pig |
| 12 | Muhammadhali | Karuvarakundu | Kalikavu | Wild pig, Sambar deer |
| 13 | Renjith | Akampadam | Nilambur | Wild pig |
| 14 | Venugopal | Chembankolli | Vazhikadavu | Wild pig, Indian crested porcupine |
| 15 | Muhammad | Vettathoor | Kalikavu | Monkey |
| 16 | Vijayan | Thannipoyil | Edavanna | Indian crested porcupine, Wild pig, Monkey |
| 17 | Madusudhan | Arnadampadam | Vazhikadavu | Wild pig, |
| 18 | Ahammad | Mayilumpara | Karulai | Elephant, Wild pig |
| 19 | Sivadasan | Keerypotty | Vazhikadavu | Elephant, Indian crested porcupine, Wild pig, Sambar deer |
| 20 | Wilson | Naranghapotty | Karulai | Elephant, Indian crested porcupine |
| 21 | Mathew | Erumamunda | Nilambur | Wild pig |

Table 12. Details of wild animals and crops damaged in the District

| Sl. No. | Species of animal | Crops damaged |
|---|---|---|
| 1 | Asian elephant | Coconut palm, Arecanut palm, Plantain, Rubber, Paddy, Teak, Mango tree |
| 2 | Wild pig | Coconut, Elephant foot yam, Tapioca, Colocasia, plantain, paddy |
| 3 | Indian crested Porcupine | Coconut, coconut palm, Rubber |
| 4 | Bonnet macaque | Coconut |
| 5 | Black-footed gray langur | Coconut |

The table 13 reports the highest number of coconut damaged in Kalikavu Range and the highest number of plantain damage recorded in Nilambur Range.

Table 13. Number of crops damaged by wild animals in the permanent quadrats in the study area.

| Sl. No. | Species | Plants cultivated in the quadrats | | No. of coconut trees in the quadrats | No. of coconuts damaged |
|---|---|---|---|---|---|
| | | Total plants cultivated | No. of plants damaged | | |
| Kalikavu Forest Range | | | | | |
| 1 | Rubber | 85 | - | 37 | 1482 |
| 2 | Plantain | 62 | 46 | | |
| 3 | Arecanut | 28 | - | | |
| Karulai Forest Range | | | | | |
| 1 | Rubber | 77 | - | 36 | 211 |
| 2 | Plantain | 71 | 40 | | |
| 3 | Arecanut | 6 | - | | |
| Vazhikadavu Forest Range | | | | | |
| 1 | Rubber | 80 | - | 59 | 539 |
| 2 | Plantain | 3 | - | | |
| 3 | Arecanut | 13 | - | | |
| 4 | Teak | 13 | | | |
| Nilambur Forest Range | | | | | |
| 1 | Rubber | 35 | - | 37 | 161 |
| 2 | Plantain | 182 | 165 | | |
| 3 | Arecanut | 41 | - | | |
| Edavanna Forest Range | | | | | |
| 1 | Rubber | 32 | - | 57 | 764 |
| 2 | Plantain | 5 | 4 | | |
| 3 | Arecanut | 16 | - | | |

### 5.2.1. Asian elephant (*Elephas maximus* Linnaeus)

Human-elephant conflicts were reported from the Nilambur South Forest Division and Vazhikadavu and Edavanna Ranges of the North Forest Division. The major places from where the elephant encounters were reported in the District are the following. Mayilumpara, Mundakadavu, Naranghamoola, Panichola, Namboorypotty, Thanipotty Narnghapotty, Theekadi, Palengara, Kalkulam, from the Karulai forest range, Chenappady, Kelunairpady, T.K Colony, Chenkodu, Pullangodu estate, Kalikavu, Munadi, Parayanmedu, Udharampoyil and Mayiladi ST colony of Kalikavu Forest Range; Chetiyaranghadi, Onichandam, Udhiramkulam, Thkepalodu, Anamari, and Moothedam of Vazhikadavu; Veetikunnu Colony of Edavanna Forest Range (Fig. 13). Forty-two cases of elephant encounters in the crop lands were reported during the study period which covered a total of 2.90 hectare area (Table 14). The human-elephant conflict was not reported in the Nilambur Forest Range.

The farmers in the fringe areas of forest were cultivating different varieties of crops namely rubber (*Hevea brasiliensis*), coconut (*Cocos nucifera*), arecanut (*Areca catechu*), plantain (*Musa paradisiaca*), paddy (*Oryza sativa*) and pineapple (*Ananas comosus*). Rubber was the major cash crop in the forest boundaries of the District. The crop species damaged by the elephant were plantain, coconut, arecanut, rubber, teak (*Tectona grandis*) and nutmeg (*Myristica fragrans*). Elephants fed mostly on plantain, arecanut, coconut and rubber. Teak and paddy also damaged in negligible quantity (Plate 09a to f). Karulai forest range, followed by Kalikavu and Vazhikadavu were facing severe crop damage (Fig. 14). Twenty-eight per cent of the herd composed of juveniles at the time of crop-raiding (n= 25).

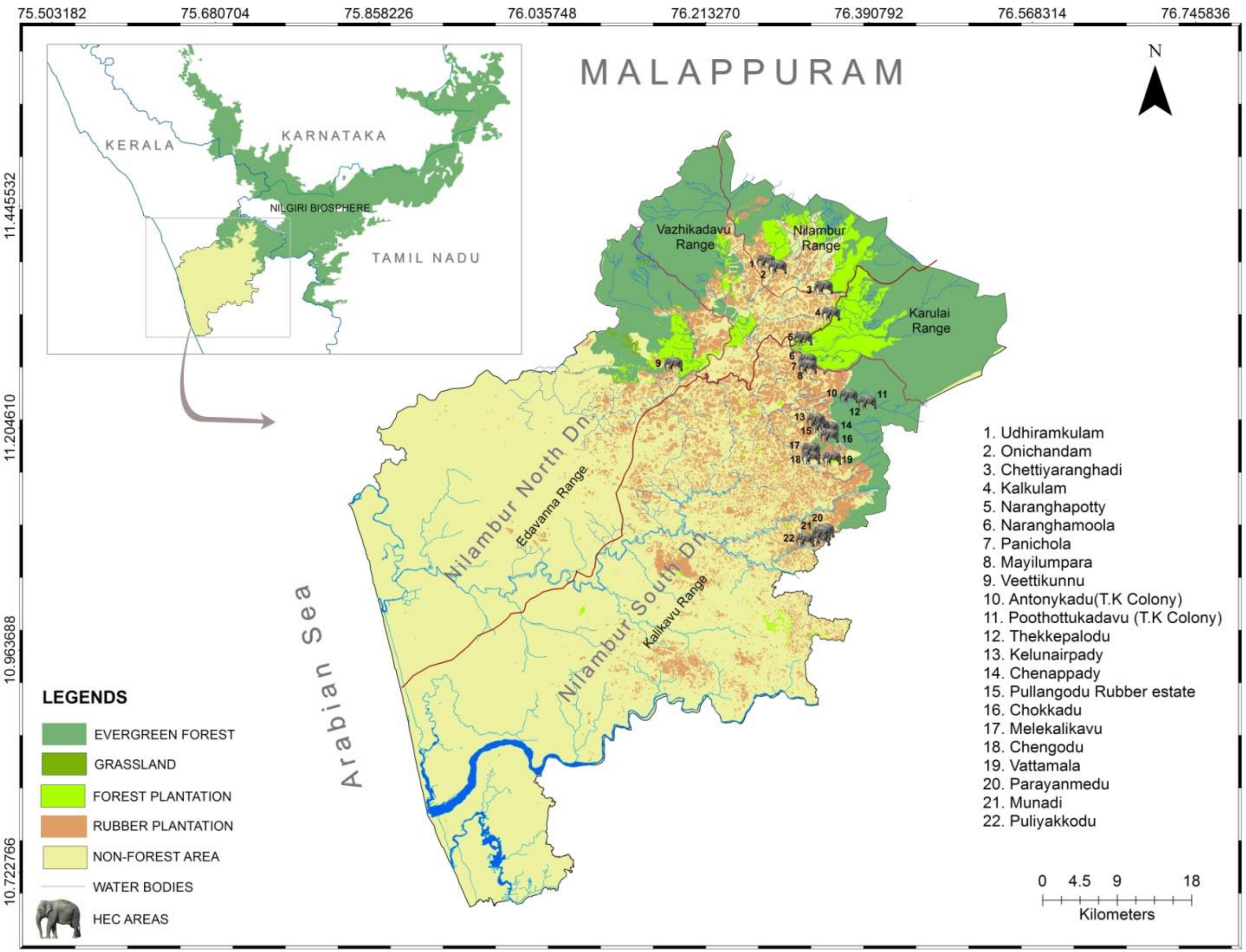



Fig. 13. Locations of crop damage by Asian elephants in Malappuram District

a. Plantain

b. Coconut palm

c. Arecanut palm

d. Paddy field

e. Teak

f. Nutmeg

**PLATE 09: Crops damaged by Asian elephant (*Elephas maximus*)**

Highest crop damage was reported during July and August (Fig. 15). Fifty-seven per cent of the total encounters occurred during the south-west monsoon (June-September). Only 28 per cent of the encounters occurred within 1 km from the Reserve Forest followed by 23.80% of encounters between 1 km-2 km, 16.66% (2 km-3 km), 11.90% (3 km-4 km), 7.14% (4 km-5 km), and 11.90% (5 km-6 km) (Fig. 16). The crop raiders intruded into the farms up to 6 km from the Reserve Forest. All the encounters between 5 km to the 6 km distance from the Reserve Forest occurred through the rubber plantations. Most of the encounters (52%) occurred in the early midnight (20.00 hrs to 24.00.hrs) (Fig. 17). The highest damaged crops by Asian elephants in the District were plantains (60.93%) followed by rubber (27.08%), arecanut (7.90%), coconut (32.97%), teak (0.93%), jackfruit (0.122%) and mango tree (0.04%). Ninety per cent of the arecanut palms were uprooted in the productive phase and the remaining 9.79 per cent was trampled during the immature phase. Most of the coconut trees (83.56%) were uprooted during the primary productive phase (10-34 years) and fifteen per cent during secondary productive phase (35-60 years). After pulling down the trees, Asian elephants consumed the central rachis of the stem along with the freshly formed leaves. The highest crop damage was recorded during the year 2014 (Fig. 18).

On an average of 4.24±2.74 elephants was recorded per herd during the time of crop-raiding (n=25) and forty per cent of the crop-raiding incidents were caused by solitary elephants. The area wise data of the damage showed that the highest damage was occurred in the Karulai Forest Range and lowest in Edavanna Range (Table 14).

Table 14. Locations of crop damage by Asian elephant in Malappuram (n=290)

| Forest Ranges | Total area of crops damaged (ha) |
|---|---|
| Karulai | 1.33 |
| Kalikavu | 0.97 |
| Vazhikadavu | 0.58 |
| Edavanna | 0.02 |
| **Total** | **2.90** |

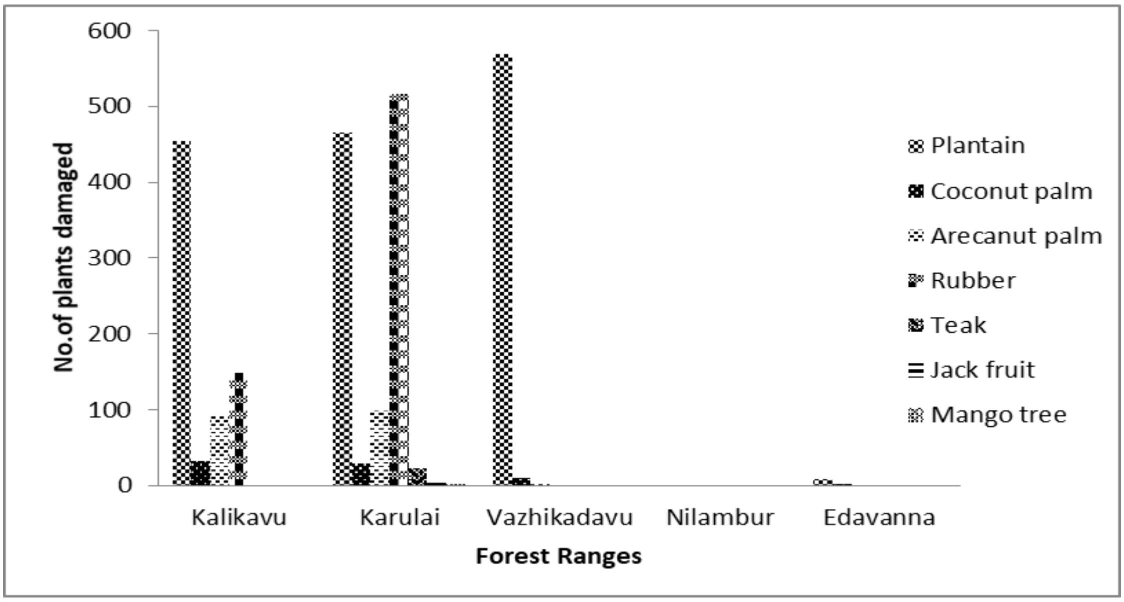



Fig. 14. Crop damage recorded from various Forest Ranges by Asian elephants

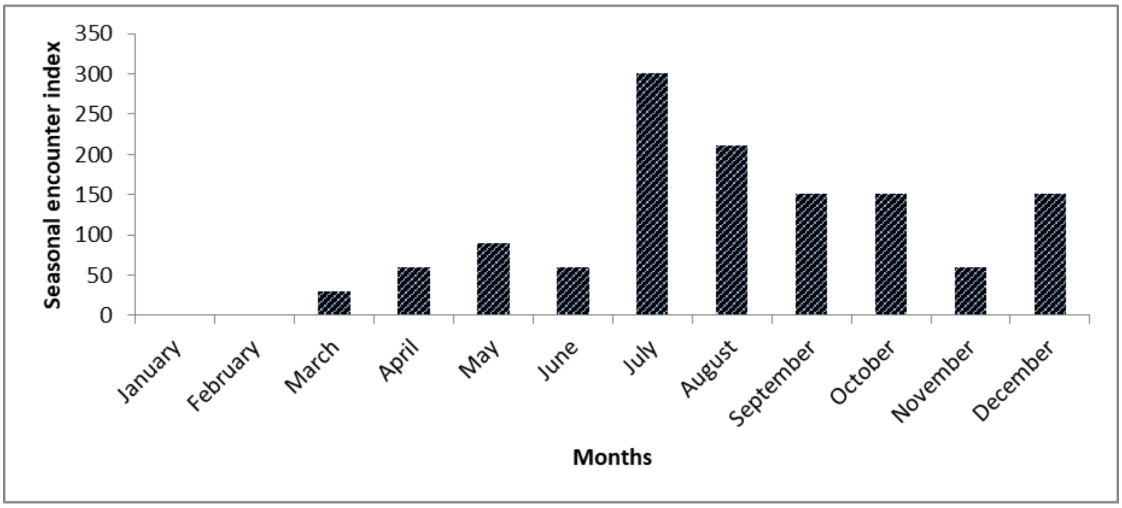



Fig. 15. Occurrence of crop damage during different months (n=42)

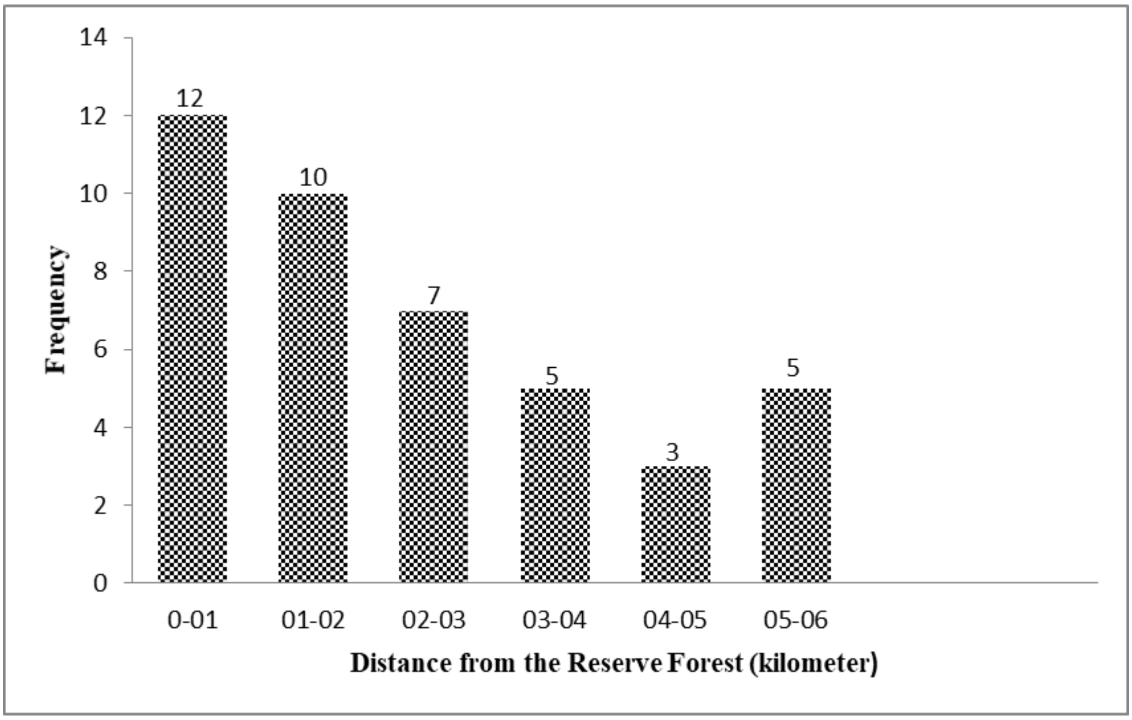



Fig. 16. Effect of distance from the forest on crop damage (n=42)

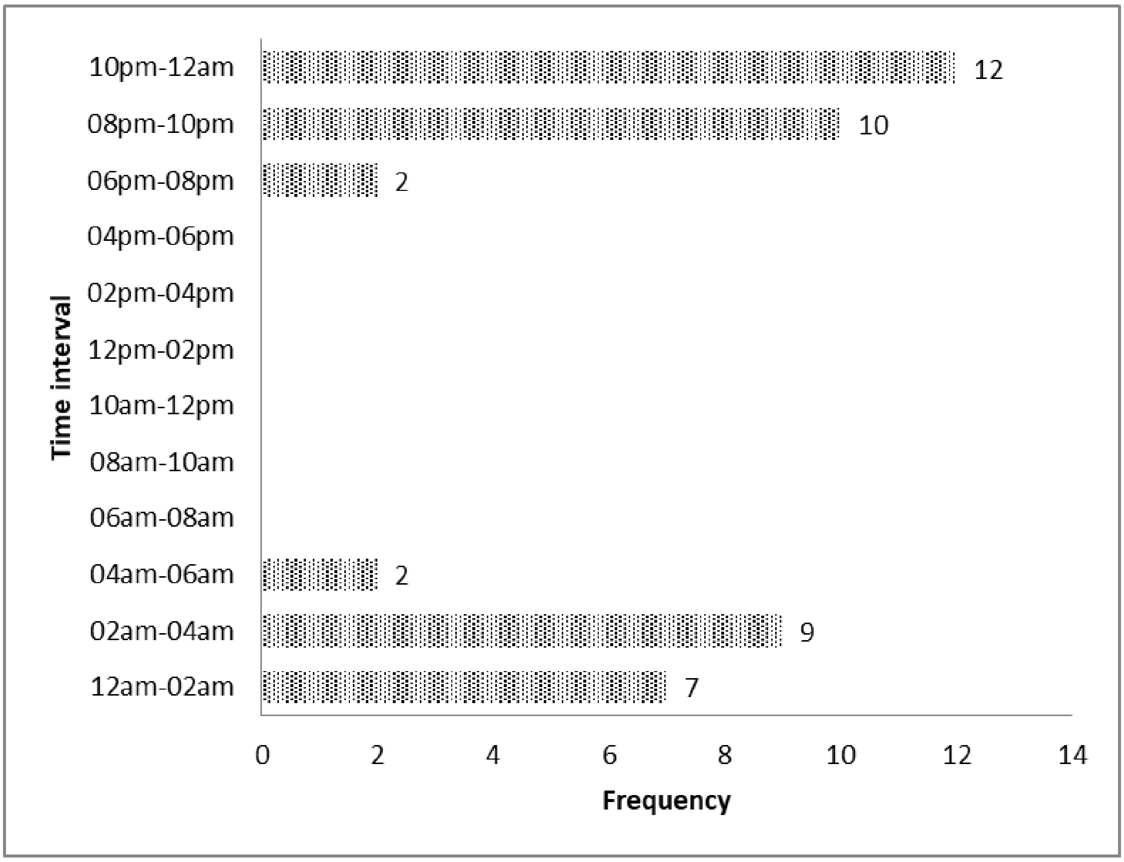



Fig.17. Occurrence of crop damage during different time periods of the day

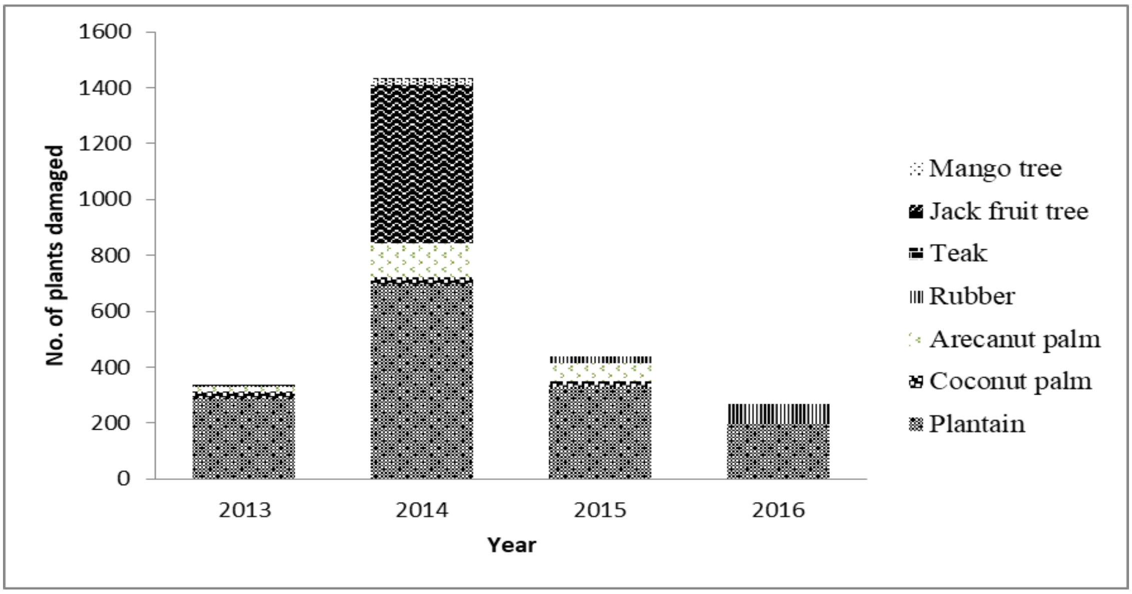



Fig.18. Intensity of crop damage by elephants over the years

**5.2.1.1. Damage to Rubber trees**

A total of 15 elephant encounters which resulted in rubber tree damage were recorded during the study period in the Nilambur South Forest Division (Fig. 19). Seventy-three per cent of the encounters have occurred in August-October and also 40 per cent of the encounters was recorded during the early midnight (22.00 -23.00) (Fig. 20 & Table 15).

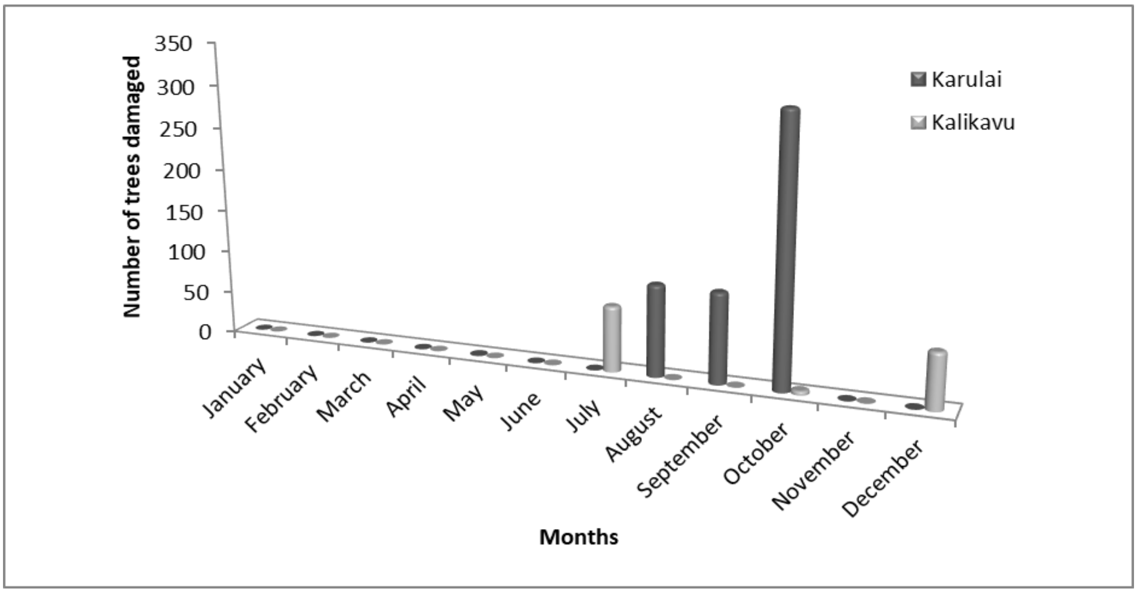



Fig. 20. Seasonal variation in rubber tree damage by Asian elephant

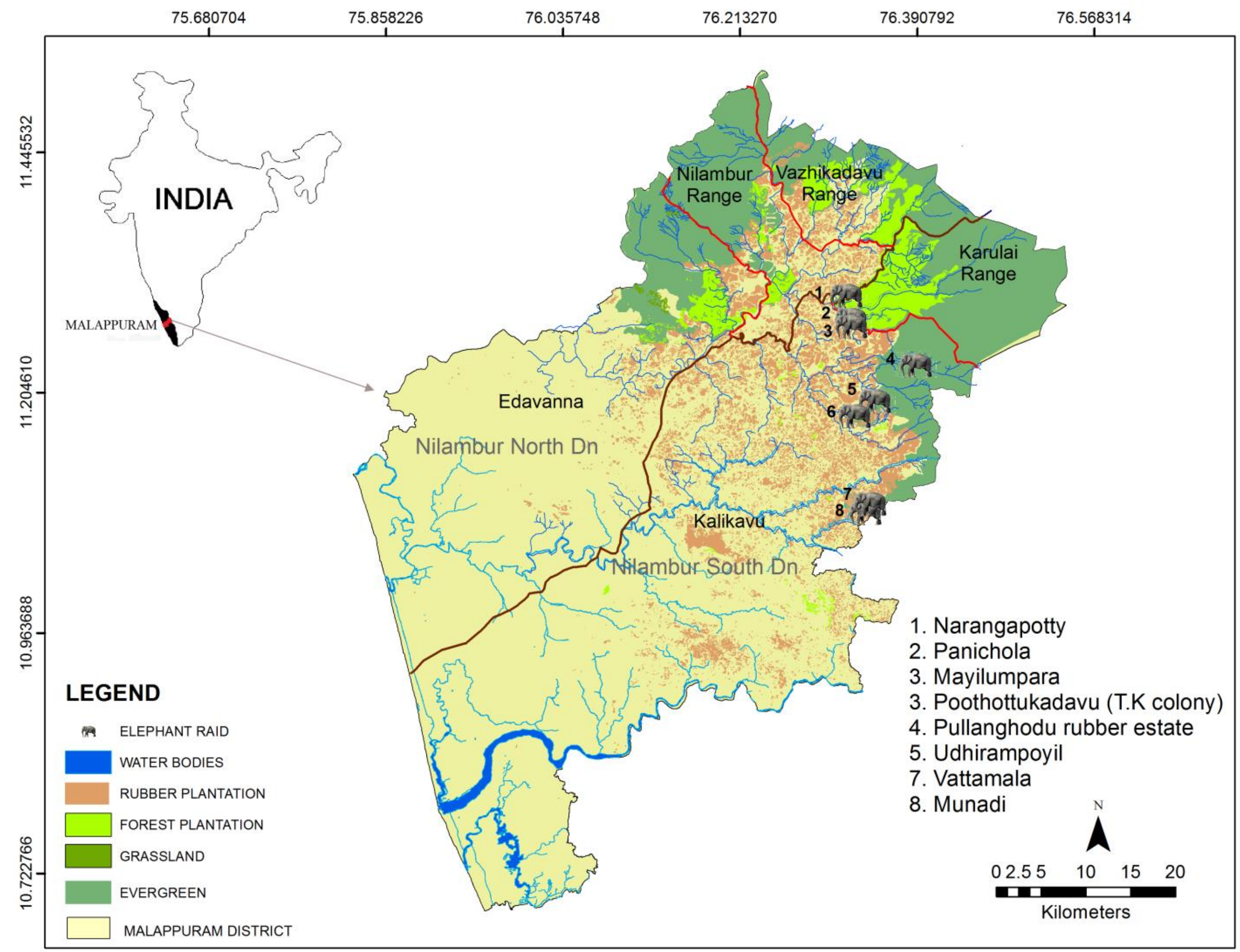



Fig. 19. Areas where Rubber trees were damaged by Asian elephant

Table 15. Details of the elephant encounter resulted in rubber tree damage (2013-2016)

| Sl. No. | Place of damage | Forest Range | Frequency of crop raid | Time of raid (hrs) | Distance to RF (m) |
|---|---|---|---|---|---|
| 1 | Naranghapotty | Karulai | 2 | 23.00 & 02.00 | 150 |
| 2 | Panichola | Karulai | 6 | 02.00,22.00,04.00,3.00, 22.00 & 02.00 | 50 |
| 3 | Mayilumpara | Karulai | 2 | 03.00 & 02.00 | 300 |
| 4 | Poothottukadavu (T.K Colony) | Kalikavu | 1 | 21.00 | 20 |
| 5 | Pullanghodu rubber estate | Kalikavu | 1 | 22.00 | 550 |
| 6 | Udhirampoyil | Kalikavu | 1 | 02.00 | 2500 |
| 7 | Vattamala | Kalikavu | 1 | 23.00 | 150 |
| 8 | Munadi | Kalikavu | 1 | 22.00 | 100 |

Forty per cent of the encounters occurred in Panichola under Karulai Forest Range and 74% of the total rubber tree damaged was also recorded from the same place which is only 50 m away from the Reserve Forest (Table 15). The area is planted with rubber trees of different age, owned by different farmers. Panichola is separated from the forest boundary by the River Cherupuzha and is continuing as a stretch of rubber plantation to the settlement area and other agriculture areas. Elephants damaged the rubber trees of Panichola in different ways such as trampling by elephant calves (rubber plants under 8 years of age) and feeding on bark by adult bulls (age of the plant is 10-20 years) (Plate 10a & b). Incidental damages to rubber trees occurred while elephants enter into the rubber plantation to feed on pineapple, where it was grown as an intercrop (Plate 10c).

a. Rubber trees damaged at Panichola (Karulai Forest Range)

b. Rubber trees damaged at Vattamala (Kalikavu Forest Range)

c. Pineapple cultivation within the rubber plantation

**PLATE 10**

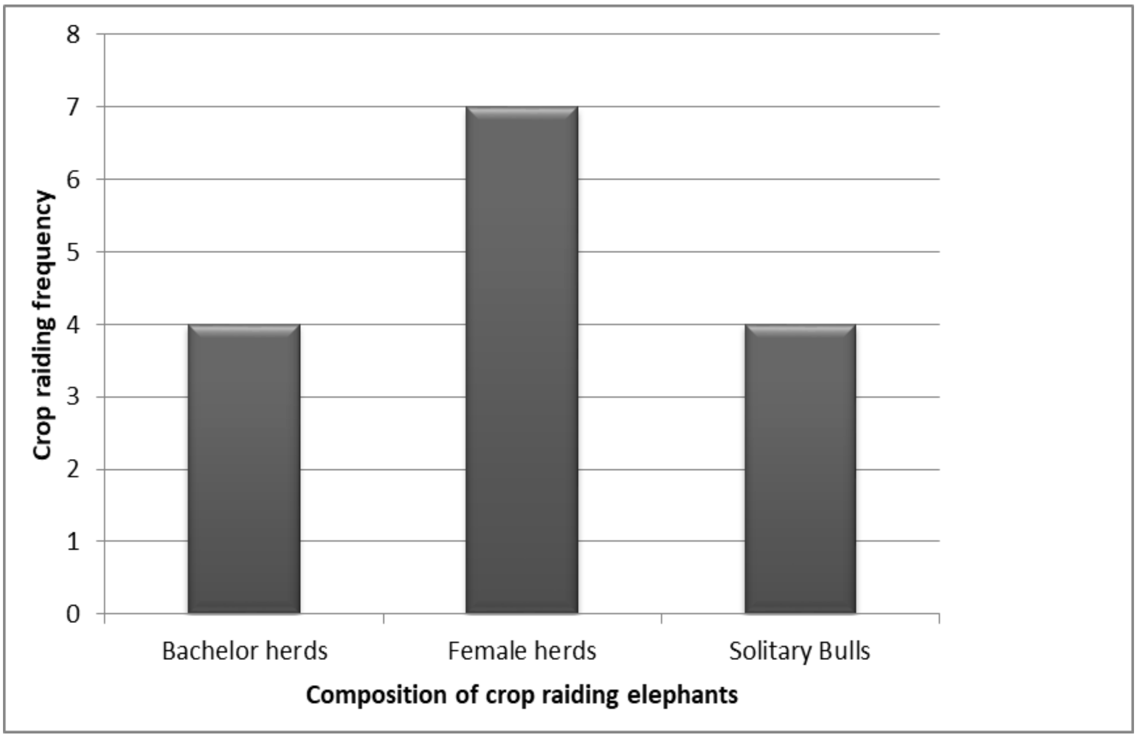



Fig. 21. Composition of crop-raiding elephants

About 27% of the encounters were created by bachelor herds, 26.67% by solitary elephants and 46.66% by the female herds (Fig. 21). The rubber trees in the immature stage were damaged mostly by trampling and breaking the stem due to the play of the elephant calves.

Fifty-nine per cent of the trees were damaged in the productive-primary stage (7-19 years) when the tapping processes were just started, which resulted in a substantial economic loss for the rubber farmers in the forest fringes. In most of the cases, the plants could not revert to its healthy growth. Details of the crop species damaged by Asian elephants in different parts of India is given in Table 16. Rubber (*Hevea braziliensis*), Nutmeg (*Myristica fragrans*) and cocoa (*Theobroma cacao*) are the new reports in the table 16 from this study.

Table 16. Crops damaged by Asian elephant in India

| Sl. No. | Crop Species | Malappuram District | Kerala * | Karnataka ** | Tamil Nadu *** |
|---|---|---|---|---|---|
| 1 | *Areca catechu* | + | + | + | + |
| 2 | *Cocos nucifera* | + | + | + | + |
| 3 | *Coffea Arabica* | - | + | + | - |
| 4 | *Musa paradisiaca* | + | + | + | + |
| 5 | *Hevea braziliensis* | + | - | - | - |
| 6 | *Coriandrum sativum* | - | - | + | - |
| 7 | *Tectona grandis* | + | + | + | + |
| 8 | *Cajanus cajan* | - | - | + | + |
| 9 | *Curcuma longa* | - | - | - | + |
| 10 | *Elaeis guineensis* | - | - | + | - |
| 11 | *Eleusine coracana* | - | - | + | + |
| 12 | *Gossypium arboreum* | - | - | + | + |
| 13 | *Macrotyloma uniflorum* | - | - | + | - |
| 14 | *Myristica fragrans* | + | - | - | - |
| 15 | *Oryza sativa* | + | + | + | + |
| 16 | *Saccharum officinarum* | - | - | + | + |
| 17 | *Theobroma cacao* | + | - | - | - |
| 18 | *Zea mays* | - | - | + | + |
| 19 | *Zingiber officinale* | - | - | + | - |
| 20 | *Ananas comosus* | + | + | - | - |

Damage reported (+); Damage not reported (-)

Jayson (1999)*; Gubbi (2012)**; Ramkumar, *et al.* (2014)***

#### 5.2.1.2. Influence of climatic parameters on crop damage by elephants

In order to substantiate the relationship between the climatic parameters and crop raid, the temperature and rainfall of the study area were correlated with the seasonal encounter index of the elephants. While significant positive correlation was observed with the rainfall (p= 0.046, Pearson's correlation coefficient, r= 0.584), no correlation was observed with temperature (r= 0.546, $P > 0.05$).

#### 5.2.1.3. Factors affecting the crop-raiding

Ten variables were selected to perform the binary logistic regression, and the result showed that only six independent variables have significant effects ($P < 0.05$) (Table 17). The presence of Arecanut cultivation and the distance to the forest were the two predictable variables included in the model that influenced the crop-raiding by Asian elephant. The odds of the occurrence of crop damage predicted by the model for the presence of Arecanut plantation was 18.717, which in turn points that the occurrence of crop damage was 18.844 times higher in the presence of Arecanut plantation (42.2%) ($X2 = 9.025$, $P < 0.05$) and only slight increase (0.021) for the decreased distance to reserve forest (40%) ($X2 = 18.679$, $P < 0.05$) which means that crop-raiding by Asian elephant was equally intensive up to a certain distance of the Reserve Forest (Table 18). The presence of rubber plantation had a crucial role for the elephant encounters to happen (46.7%) ($X2 = 3.972$, $P < 0.1$) and it showed positive correlation with the occurrence of human-elephant conflict ($rs = 0.297$; $P < 0.05$) (n=45).

Table 17. Variables considered in the logistic regression analysis

| Sl. No. | Variables | *P* values |
|---|---|---|
| 1 | Elevation (m) | 0.025 |
| 2 | Aspect | 0.884 |
| 3 | Slope (angle) | 0.025 |
| 4 | NDVI Value | 0.449 |
| 5 | Distance to RF (m) | 0.000 |
| 6 | Distance to River (m) | 0.458 |
| 7 | Arecanut | 0.003 |
| 8 | Plantain | 0.286 |
| 9 | Rubber | 0.046 |
| 10 | Coconut | 0.011 |

Table 18. Environmental variables selected in the binary logistic model

| Sl. No. | Variables | Regression coefficients (β) | Standard Error (SE) | Wald Statistic ($X^2$) | df | P Value Sig | Odds ratio Exp(B) |
|---|---|---|---|---|---|---|---|
| 1 | Elevation | 1.139 | 1.123 | 1.029 | 1 | 0.310 | 3.125 |
| 2 | Slope | 0.970 | 1.274 | 0.579 | 1 | 0.447 | 2.637 |
| 3 | Distance to Reserve Forest | -3.855 | 1.301 | 8.783 | 1 | 0.003 | 0.021 |
| 4 | Arecanut | 2.929 | 1.354 | 4.680 | 1 | 0.031 | 18.717 |
| 5 | Rubber | 2.267 | 2.621 | 0.748 | 1 | 0.387 | 9.650 |
| 6 | Coconut | 1.106 | 1.240 | 0.796 | 1 | 0.372 | 3.023 |
| | Constant | -2.023 | 3.473 | 0.339 | 1 | 0.560 | 0.132 |

Elevation = Reference category; low = 1 (< 67 m), high = 2 (> 67 m )
Slope = Reference category; low = 1 (< 8), high = 2 (> 8)
Distance to RF = Reference category; low = 1 (< 1785 m), high = (> 1785 m)
Presence of arecanut plantation =1; Absence = 0
Presence of rubber plantation = 1; Absence = 0
Presence of coconut plantation = 1; Absence = 0

Occurrence of HEC has a positive correlation with the presence of Arecanut cultivation ($r_s = 0.448$; $P < 0.01$) and a strong negative correlation with the distance from the Reserve forest ($r_s = -0.644$; $P < 0.01$) and distance from drainage ($r_s = -0.644$; $P < 0.01$) (n=45).

#### 5.2.1.4. Death of elephants

According to the data collected from Kerala Forest and Wildlife Department and also from the field visits, it was recorded that a total of 15 wild elephants were found dead from 2013 to 2016 in the Nilambur North Forest Division in which only two deaths were reported as natural deaths (Table 19). Reasons like pneumonia, bleeding and poisoning were attributed to all other deaths (Plate 11a). Sixty percentage of the deaths occurred to the male elephant, which can correlate with the risk-taking strategy of male elephants in the feeding behaviour (Fig. 22). They were always ready to take the risk to gain the nutritive food source so that they were the victim of human hostility to stop them entering the farms, especially from the pineapple cultivation within the rubber plantations and plantain cultivations in the immediate fringe of the forest.

Table 19. Details of the Asian elephant deaths reported from the Nilambur North Division (2013-2016)

| Sl. No. | Area where carcass was detected | Age | Forest Range | Sex | Date | Cause of mortality as per post mortem report |
|---|---|---|---|---|---|---|
| 1 | Edakodu Muvvayiram Malavaram | 30 | Edavanna | F | 27/12/2014 | Myocardilities to chronic walling disease |
| 2 | Nilambur | 7 | Nilambur | M | 01/05/2016 | natural death |
| 3 | Kuttikunnu | - | Vazhikadavu | M | 26/08/2013 | bleeding |
| 4 | Kariyam muriyam | - | Vazhikadavu | M | 23/01/2014 | unknown |
| 5 | Kuttikunnu | - | | M | 09/10/2014 | natural death |
| 6 | Maddalappara | 10 | Vazhikadavu | F | 21/12/2014 | pneumonia |
| 7 | Thottappala | - | Vazhikadavu | F | 07/02/2015 | pneumonia |
| 8 | Mathipotty | 3 | Vazhikadavu | MK | 01/03/2015 | fight with other elephant |
| 9 | Neendakkayam | 3 | Vazhikadavu | M | 17/10/2015 | anemia |
| 10 | Arattu bagam | 2 | Vazhikadavu | M | 20/05/2015 | pneumonia |
| 11 | Nellikuthu | - | Vazhikadavu | | 22/05/2015 | - |
| 12 | Kodalypoyil | 3 | Nilambur | M | 12/07/2015 | fell into an abandoned well |
| 13 | Maddalappara | 17 | Vazhikadavu | M | 27/07/2015 | Tiger attack |
| 14 | Puthiripadam | 15 | Vazhikadavu | M | 30/07/2015 | Poisoning |
| 15 | Thannikadavu | 1 | Vazhikadavu | F | 09/10/2015 | disease |

Note: M=Male, F=female, MK= Makhna

Thirty-one elephant deaths were reported from the Nilambur South Forest Division, among which, 77% were male elephants (Table 20 & Fig. 22). Twelve cases were confirmed as natural death by Kerala Forest and Wildlife Department and the remaining deaths were attributed to various reasons which were caused due to the result of conflict with the humans (Plate 11b & c). The pineapple cultivation within the rubber estates close to the Reserve Forest was one of the main attractions for the elephants in the area (n=5). In many parts of Kalikavu Forest Range, watchers were employed to protect the pineapple cultivation from the raids of Asian elephants with guns. Metal balls were used as the bullet in the gun to deter the elephants from the field and in one shot pellets will hit the different body parts of the targeted animal which may not cause any fatal effect at the time of the shot. However, later on, the pellets in the body of the animal will make them uncomfortable and leads to infection and ultimately to the death within two or three months.

Table 20. Details of the Asian elephant deaths reported from the Nilambur South Division (2013-2016)

| Sl. No. | Area where carcass was detected | Age | Forest Range | Sex | Date | Cause of mortality as per post mortem report |
|---|---|---|---|---|---|---|
| 1 | Vattikkal | - | Karulai | F | 25/04/2013 | Natural |
| 2 | Pathayappara | 30 | Kalikavu | M | 31/05/2013 | Natural |
| 3 | Moochiyila | 4 Mn | Karulai | M | 02/09/2013 | Natural |
| 4 | Sankaramgodu | 4 | Karulai | M | 08/11/2013 | Toxaemia |
| 5 | Kuppamala | 1.5 | Karulai | F | 10/12/2013 | Natural |
| 6 | Near Silent alley buffer zone | 3 | Kalikavu | M | 25/02’2014 | Fall from height |

a. Elephant death due to poisoning at Anamari (Vazhikadavu)

b. Postmortem of the elephant body (1 Year old)

c. Elephant death at Thannikadavu, Vazhikadavu Forest Range (near to cropland)

**PLATE 11: Death of Asian elephant (*Elephas maximus*)**

| | | | | | | |
|---|---|---|---|---|---|---|
| 7 | Kadannakkappu | 14 | Karulai | M | 21/08/2014 | Natural |
| 8 | Sankaramgode | 2.5 | Karulai | M | 05/09/2014 | Syncope associated with anemia due to heavy endo-parasitic load. |
| 9 | Pulimunda | 3 | Karulai | M | 10/09/2014 | Cardiac arrest |
| 10 | Kareeri padam | - | Karulai | M | 19/09/2014 | Natural |
| 11 | Parayanmedu | 15 | Kalikavu | M | 28/09/2014 | Natural |
| 12 | Chingakallu | - | Kalikavu | F | 27/10/2014 | Due to heavy flood |
| 13 | Karimpuzha | 20 | Kalikavu | M | 28/04/2015 | Conflict between elephants |
| 14 | Kondoda-Kakkara | 30 | Kalikavu | M | 06/05/2015 | Fall from height |
| 15 | Manaliyampadam | - | Kalikavu | F | 09/08/2015 | Septicemic shock is cause of death |
| 16 | T.K colony | 2 | Kalikavu | M | 24/08/2015 | Attack by tiger |
| 17 | Chingakallu | 1 Mn | Kalikavu | M | 14/09/2015 | Due to heavy flood |
| 18 | Chalikkundu | 1.5 Mn | Karulai | M | 06/11/2015 | Natural |
| 19 | Uchakkulam | 7 Mn | Karulai | M | 21/01/2016 | Natural |
| 20 | Vallipoola | 25 | Kalikavu | M | 23/01/2016 | Conflict between elephants |
| 21 | Mancheeri | - | Karulai | M | 04/02/2016 | Natural |
| 22 | Kareeri thodu | 2 Mn | Karulai | M | 16/02/2016 | Natural |
| 23 | Kundoda | - | Kalikavu | F | 29/02/2016 | Natural |
| 24 | Balamkulam-Pothamkulam | 3.5 | Karulai | M | 08/03/2016 | Conflict between elephants |
| 25 | Chokkadan river side | - | Kalikavu | M | 12/03/2016 | Under investigation |
| 26 | Near Kundoda Reeds valley estate | - | Kalikavu | F | 02/05/2016 | Natural |
| 27 | Kallenthodu 1969 TP | 12 | Karulai | F | 25/07/2016 | Unknown |
| 28 | Churulipotty 2003 TP | 1.5 | Karulai | M | 26/10/2016 | Disease |
| 29 | During treatment Amarambalam OP | 25 days | Kalikavu | M | 13/11/2016 | Disease |
| 30 | Pulvetta (Private land) | 10 | Kalikavu | M | 20/11/2016 | Electrocution |
| 31 | Mundakkadavu | 2.5 Mn | Karulai | M | 08/12/2016 | Accidental |

Note: M=Male, F=female, Mn= Months

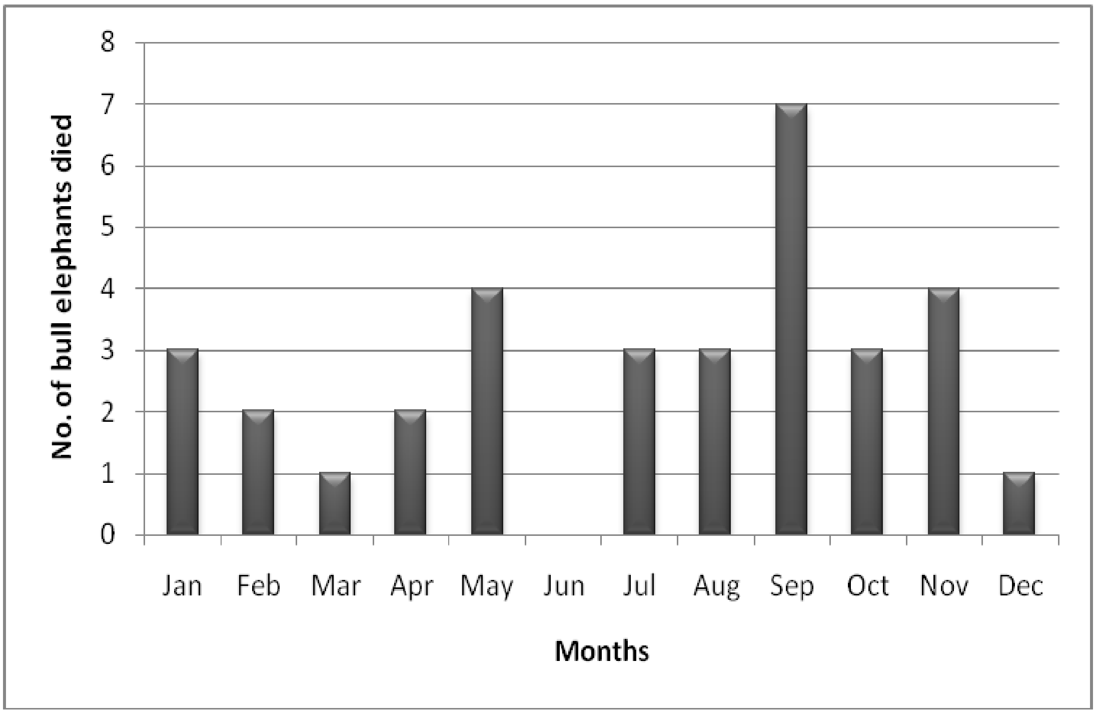



Fig. 22. Occurrence of bull elephant deaths (2013-2016) in Nilambur Forest Divisions

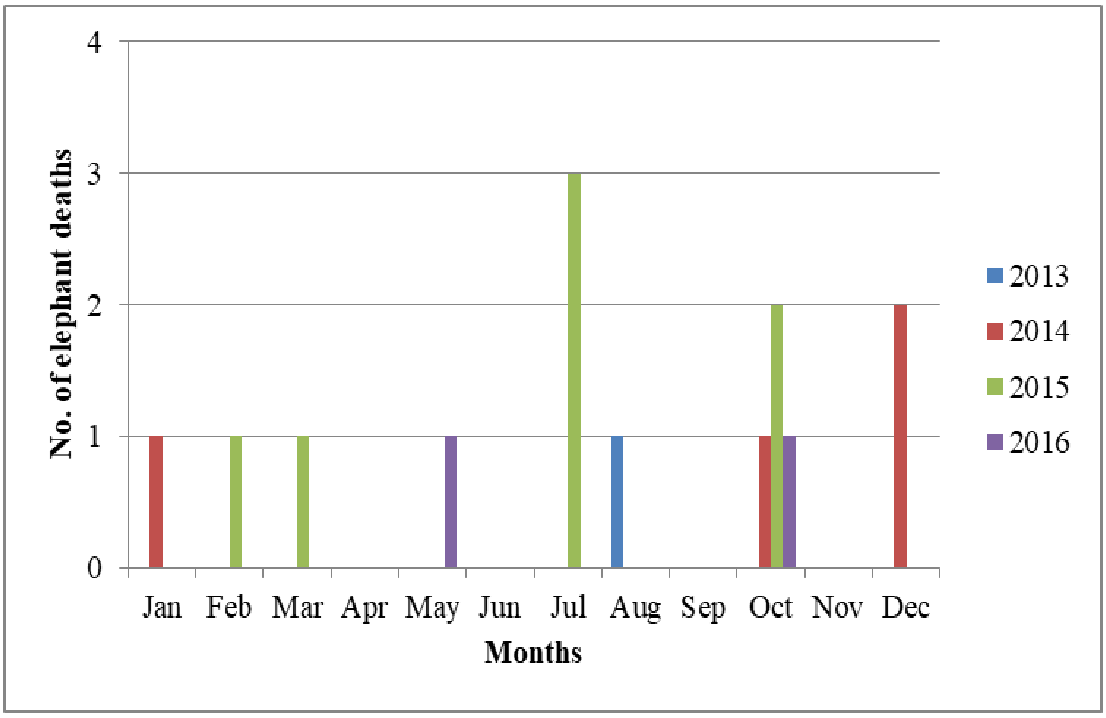



Fig. 23. Year wise comparison of elephant deaths at Nilambur North Division (n=15)

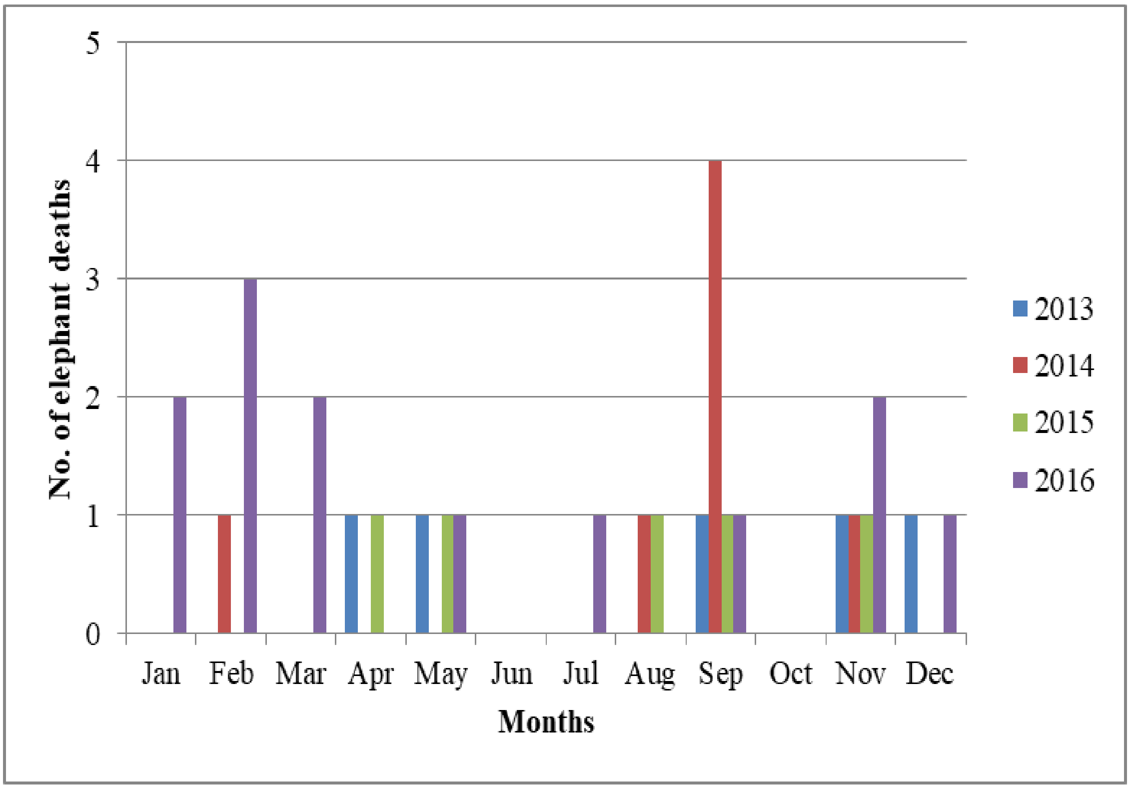



Fig. 24. Year wise comparison of elephant deaths at Nilambur South Division (n=31).

The highest number of elephant deaths from both the Forest Divisions of Nilambur was reported during the monsoon season (July-October) (Fig. 23 & Fig. 24).

### 5.2.2. Wild pig (*Sus scrofa* Linnaeus)

The wild pig has a cosmopolitan distribution, including different type of plantations and agricultural areas even if it is far away from the forest fringes. It usually feeds on underground root and rhizome of the crops and is known as a nocturnal feeder when raids the crop (Table 21).

Table 21. Crop damaged by wild pig in different areas

| Sl. No. | Crop Species | Malappuram District | Thrissur District* | Kerala** | North India*** |
|---|---|---|---|---|---|
| 1 | *Amorphophallus paeoniifolius* | + | + | + | + |
| 2 | *Arachis hypogaea* | - | - | - | + |
| 3 | *Brassica juncea* | - | - | - | + |
| 4 | *Brassica compestris* | - | - | - | + |
| 5 | *Citrullus vulgaris* | - | - | - | + |
| 6 | *Capsicum annum* | - | - | - | + |
| 7 | *Colocasia esculenta* | + | + | + | - |
| 8 | *Cocos nucifera* | + | + | + | + |
| 9 | *Cuminus cyminum* | - | - | - | + |
| 10 | *Dioscorea alata* | - | + | + | - |
| 11 | *Cyamopsis psoralioides* | - | - | - | + |
| 12 | *Hevea brasiliensis* | + | + | - | - |
| 13 | *Eleusine corocana* | - | - | - | + |
| 14 | *Hordeum vulgare* | - | - | - | + |
| 15 | *Ipomoea batatas* | + | + | + | + |
| 16 | *Lythyrus sativum* | - | - | - | + |
| 17 | *Manihot esculenta* | + | + | + | - |
| 18 | *Musa paradisiaca* | + | + | + | - |
| 19 | *Oryza sativa* | + | + | + | + |
| 20 | *Pennisetum typhoides* | - | - | - | + |
| 21 | *Phaseolus mungo* | - | - | - | + |
| 22 | *Plantago ispaghula* | - | - | - | + |
| 23 | *Pisum sativum* | - | - | - | + |
| 24 | *Saccharum officinarum* | - | - | - | + |
| 25 | *Sesamum indicuam* | - | - | - | + |
| 26 | *Sorghum vulgare* | - | - | - | + |
| 27 | *Trigonella corniculata* | - | - | - | + |
| 28 | *Triticum aestivum* | - | - | - | + |
| 29 | *Vigna aconitifolius* | - | - | - | + |
| 30 | *Zea mays* | - | - | - | + |
| 31 | *Zingiber officinale* | - | + | + | + |

Damage reported (+); Damage not reported (-)
*Jayson (2013); **Jayson (1999); ***Chauhan *et al.* (2009)

Six crop species were mainly damaged in the District, namely plantain, coconut, paddy, tapioca, rubber and colocasia (*Colocasia esculenta*). Damage to the agricultural crop was recorded from all the five Forest Ranges, namely Kalikavu, Karulai, Nilambur, Vazhikadavu and Edavanna (Table 22). Highest damage was recorded from Nilambur followed by Edavanna, Vazhikadavu, Kalikavu and Karulai (Fig. 25). Plantain and fallen coconuts were the most severely targeted crop species. The highest damage to plantain and fallen coconuts were recorded from Nilambur and Vazhikadavu Forest Ranges, respectively. The rhizome of the plantain and tubers like tapioca, colocasia were consumed by trampling the plant by using its tush and snout (Plate 12a). Wild pig consumed 0.20±0.09 coconut/tree/month (n=215). It consumed the coconuts by removing the mesocarp and endocarp and feeding on the endosperm. The mesocarp was removed exactly like humans, which is considered as an indirect sign of wild pig in the field. As this species prefers an omnivorous diet, it feeds on soil organisms by grubbing the soil and it also has the wallowing behaviour to regulate the body temperature. Paddy fields were the most targeted place to exhibit these kinds of practice causing damages to the paddy (Plate 12b). Debarking on the rubber trees was recorded from both Edavanna and Kalikavu Forest range (n=47 trees).

Table 22. Occurrence of wild pig in the study area in different years

| **Forest Ranges** | **2013 (n=7)** | **2014 (n=12)** | **2015 (n=12)** | **2016 (n=5)** |
|---|---|---|---|---|
| Kalikavu | 7 | 9 | 12 | 4 |
| Karulai | 7 | 11 | 8 | 2 |
| Vazhikadavu | 7 | 12 | 12 | 5 |
| Nilambur | 7 | 11 | 12 | 5 |
| Edavanna | 7 | 12 | 12 | 5 |

a. Plantain damaged by wild pig

b. Paddy field damaged by wild pig

**PLATE 12: Crops damaged by wild pig (*Sus scrofa*)**

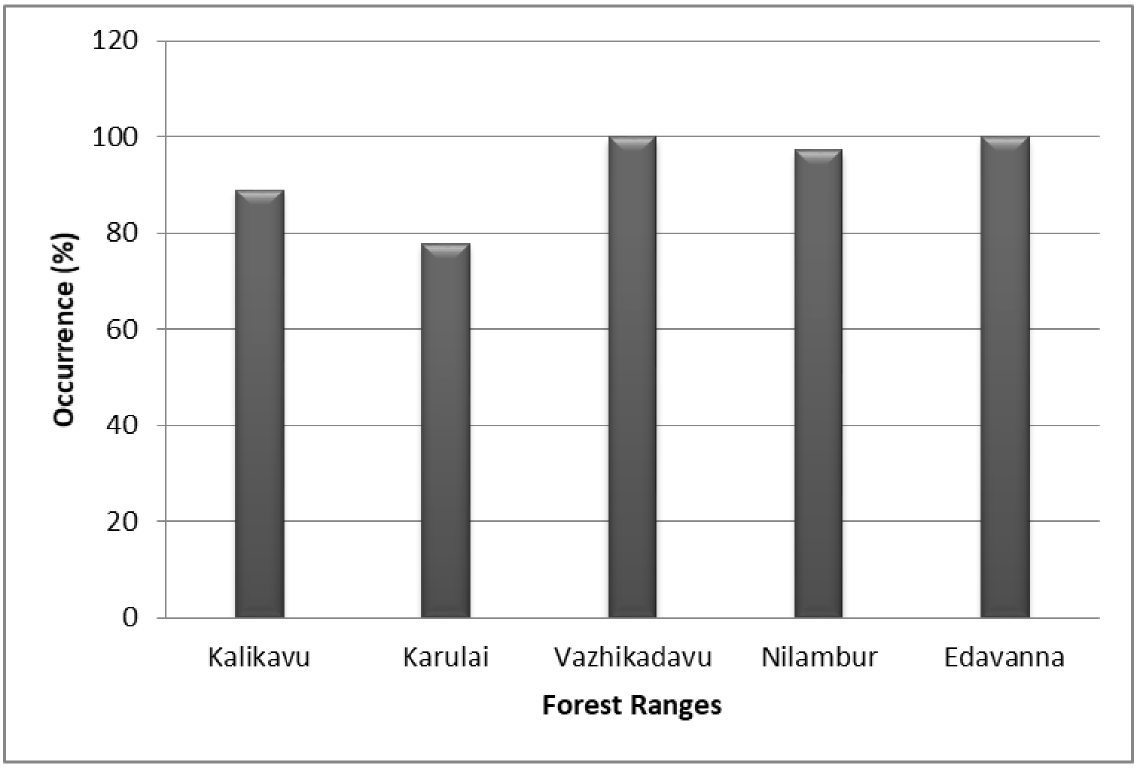



Fig. 25. Crop damage by wild pig in various forest ranges

The occurrence of the wild pig was detected from all the five forest ranges whereas 100 per cent of occurrence was recorded from the crop field of Vazhikadavu and Edavanna Forest Range. There was no significant difference among the forest ranges concerning the sightings of wild pig in the cropland (ANOVA, F= 2.583; $P > 0.05$).

### 5.2.3. Indian crested porcupine (*Hystrix indica* Kerr)

It is the largest rodent in India which is considered as a serious pest of agriculture crops. The presence of Indian crested porcupine was recorded from all the forest ranges except Nilambur Range in the Malappuram District (Table 23). The highest occurrence was recorded from Edavanna Forest Range, followed by Karulai, Vazhikadavu and Kalikavu (Fig. 26). Severe damages were recorded in the coconut plantation both as consuming the fallen coconuts and by debarking the basal portion of coconut palms (n=31) (Plate 13a). Indian crested porcupine consumed 0.12±0.09 coconut/tree/month (n=91). The fallen coconuts were consumed by removing the mesocarp and endocarp and then consuming the endosperm. Occasionally it was seen to carry the coconuts into the forest for consumption. As the Indian crested porcupine belongs to the order Rodentia, they removed the mesocarp with sharp edges with uniform size, which was considered as the indirect sign of porcupine in the field. The debarking behaviour of porcupine on the rubber plants (n=27) and consumption of newly formed bamboo culms (n=42) were also recorded from the Edavanna forest range (Plate 13b). In the case of coconut palms, the average length of the basal portion without bark from the ground level was 18.3 (±3.03) cm and it started from the exposed root system itself. The debarking on a tree as girdling was not observed in a coconut tree. In rubber trees, the average height of the basal portion from the ground in which bark removed by Indian crested porcupine was 9.65 (±1.83) cm. The debarking marks on the coconut palm were observed more frequently during the months of October to February.

Table 23. Occurrence of Indian crested porcupine in the study area in different years

| **Forest Ranges** | **2013 (n=7)** | **2014 (n=12)** | **2015 (n=12)** | **2016 (n=5)** |
|---|---|---|---|---|
| Kalikavu | 4 | 2 | 1 | 0 |
| Karulai | 5 | 6 | 10 | 5 |
| Vazhikadavu | 2 | 4 | 10 | 2 |
| Nilambur | 0 | 0 | 0 | 0 |
| Edavanna | 7 | 11 | 12 | 4 |

a. Coconut palm debarked by Indian crested porcupine

b. Rubber tree debarked by Indian crested porcupine

**PLATE 13: Debarking behaviour of Indian crested porcupine (*Hystrix indica*)**

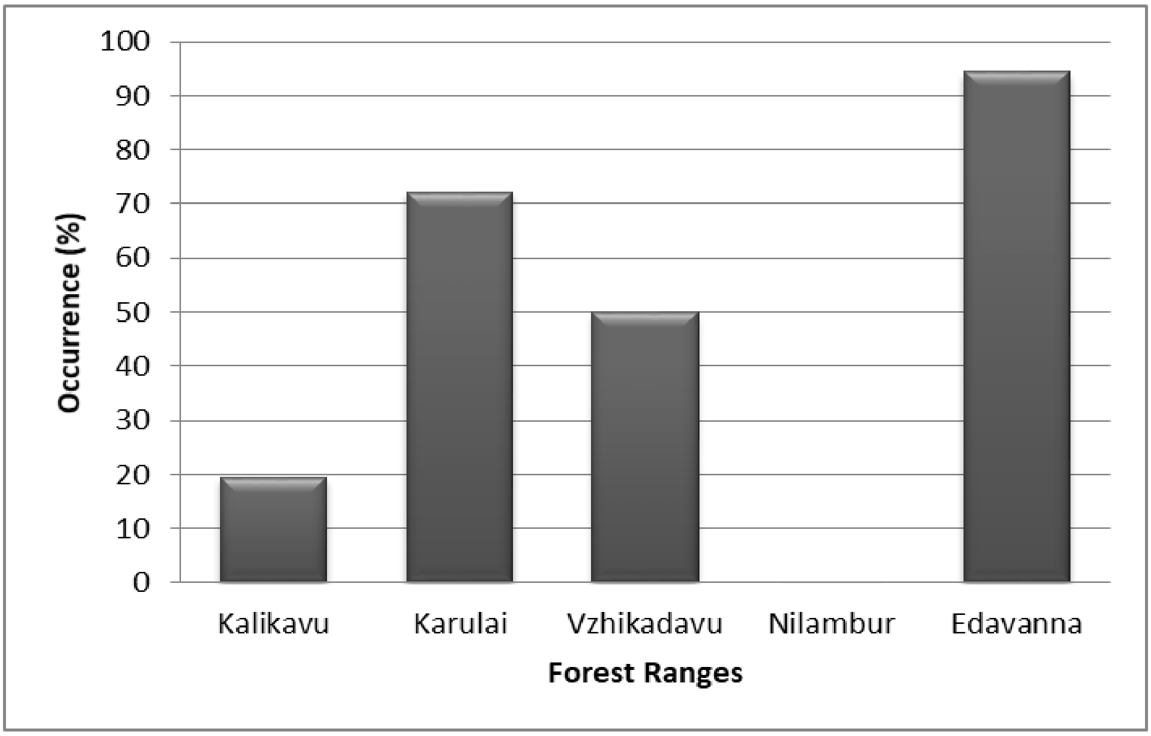



Fig. 26. Incidence of crop damage by Indian crested porcupine in various ranges

### 5.2.4. Bonnet macaque (*Macaca radiata* Geaffroy Saint-Hilaire)

The bonnet macaque (*Macaca radiata*) is an endemic primate found in southern India and is listed as least concern species under IUCN red list. It is a great menace to agricultural crop due to its behaviour of crop-raiding in troops of large numbers. The crop-raiding occurred throughout the day but mostly in the morning and evening hours (n=27). They were feeding on the tender coconuts by plucking it from the coconut palm and most of the time by sitting on the top of the palm itself. The mode of attack was by tearing the mesocarp from one side and making the hole on the side of the top. After drinking the water inside the nut, they scraped out the endosperm of the tender coconut by using their forelimbs. The mean size of the removed mesocarp (husk) was 0.95 ± 0.14 cm in breadth (n=50).

The shape and size of the coconut husk removed by bonnet macaque Indian crested porcupine and the wild pig have a definite pattern which was an excellent indirect sign to the presence of these animals in the cropland (Plate 14a to c). The highest occurrence was recorded from Kalikavu forest range. Being an arboreal animal, their control in the field was very difficult. Use of crackers and guarding dogs were the two control methods observed against the crop-raiding primates in the field (n=3). They were found to habituate with the presence of dogs in the coconut plantation (direct observation from Kalikavu forest range). However, the barking of a dog was acting as an indication for the presence of macaques in the plantation and thereby watchers can raid them away (Table 24).

Table 24. Effectiveness of mitigation measures against crop-raiding bonnet macaque in Kalikavu Forest Range (n=7).

| Sl. No. | Bonnet macaque | Guarding dog | Bark of the guarding dog followed by manual chasing | Remark |
|---|---|---|---|---|
| 1 | + | + | - | Bonnet macaques stay back in the plot |
| 2 | + | + | - | Bonnet macaques stay back in the plot |
| 3 | + | + | + | Bonnet macaques moved into the forest |
| 4 | + | + | - | Bonnet macaques stay back in the plot |
| 5 | + | + | + | Bonnet macaques moved into the forest |
| 6 | + | + | + | Bonnet macaques moved into the forest |
| 7 | + | + | + | Bonnet macaques moved into the forest |

+ presence: - absence

a. Coconut mesocarp removed by Indian crested porcupine

b. Coconut mesocarp removed by bonnet macaque

c. Coconut mesocarp removed by wild pig

**PLATE 14: Comparison of coconut mesocarp removed by wild animals**

### 5.2.5. Black-footed gray langur (*Semnopithecus hypoleucos*)

The coconut palms close to the forest boundary were targeted by Black-footed gray langurs and they were shy and scary to the presence of human beings or any disturbance when they approached the coconut palms. There is no considerable change between the mode of attack of bonnet macaques and Black-footed gray langurs. A single troop of 23±2 individuals were recorded from one selected plot of the Kalikavu Forest Range during the study period (n=8) (Plate 15a).

## 5.3. Assessment of economic loss

Eight species of crops were damaged by five species of wild animals in the District. The method of calculating the economic loss is described in chapter 4. The price of the crops varied during the period of the study and this was collected from the Farm Information Bureau, Kerala (Table 25).

Table 25. Market price of different crops (2013-2016)

| Sl. No. | Cash crops | Market price (Rs) (Mean ± SD) |
|---|---|---|
| 1 | Coconut | 8.096 ± 1.523 per nut |
| 2 | Arecanut | 139.17 ± 22.85 per kg |
| 3 | Rubber | 123.883 ± 25.14 per kg |
| 4 | Banana (Nendra) | 30.694 ± 7.733 per kg |
| 5 | Banana (Palayamthodan) | 16.32 ± 3.34 per kg |
| 6 | Plantain (Nendra) | 368.33 per plant |
| 7 | Plantain (Palayamthodan) | 326.4 per plant |

### 5.3.1. Asian elephant

The economic loss due to the Asian elephants in the District calculated from the potential value of perennial crops (Table 26). Asian elephant mainly damaged the perennial crops (coconut tree, arecanut tree and rubber) and plantains. Elephants damaged crops worth Rs. 22,62,822/- (US$ 32,051) per annum in the District other than rubber (Table 27). The highest loss was recorded from Karulai forest range and the lowest from the Edavanna forest range.

Asian elephant damaged rubber trees worth of Rs. 28,59464/- per annum (US$ 39,938) from 0.8 ha in the two forest ranges of Nilambur South Forest Division (Table 28). In many occasions, the elephants fed on the bark of the rubber trees in the primary productive stage (from focus group discussions and field visits).

Table 26. Potential value of perennial crops damaged by Asian elephants in the Malappuram District

| Sl. No. | Species | Economic life period (Years) | Average yield per annum | Categorization | | Age class (Years) | Potential value (Rs.) |
|---|---|---|---|---|---|---|---|
| 1 | Rubber tree | 32 | 5.5 kg of dried rubber | Immature phase | | 0 – 6 | 80.00 |
| | | | | Productive phase | Primary stage | 7 – 19 | 21,803.40 |
| | | | | | Secondary stage | 20 – 32 | 10,901.70 |
| 2 | Coconut tree | 60 | 80 coconuts | Immature phase | | 0 – 9 | 75.00 |
| | | | | Productive phase | Primary stage | 10 – 34 | 32,384.00 |
| | | | | | Secondary stage | 35 – 60 | 16,192.00 |
| 3 | Arecanut tree | 20 | 16 kg of nut | Immature phase | | 0 – 5 | 15.00 |
| | | | | Productive phase | Primary stage | 6 – 13 | 33,400.80 |
| | | | | | Secondary stage | 14 – 20 | 16,700.40 |

Table 27. Economic loss due to Asian elephants in the study area

| Sl. No. | Forest range | Loss of coconut/ annum (Rs.) | Loss of arecanut/annum (Rs.) | Loss of plantain /annum (Rs.) | |
|---|---|---|---|---|---|
| | | | | Nendra | Palayamthodan |
| 1 | Kalikavu | 3,13,095.33 | 6,45,788.80 | 47,269.01 | 7,507.40 |
| 2 | Karulai | 2,59,097.00 | 6,95,905.00 | 45,672.92 | 1,0,118.40 |
| 3 | Vazhikadavu | 1,07946.67 | 44,534.40 | 59,792.24 | 8,921.60 |
| 4 | Edavanna | 16,192.00 | - | 982.21 | - |

Table 28. Rubber trees damaged by Asian Elephants in Nilambur South Forest Division

| Sl. No. | Forest Range | Total number of rubber trees damaged | Immature phase (0-6) | Productive phase | |
|---|---|---|---|---|---|
| | | | | Primary Stage (7-19) | Secondary stage (20-32) |
| 1 | Karulai | 526 | 180 | 304 | 42 |
| 2 | Kalikavu | 148 | 77 | 64 | 7 |

A total of 42 incidents of elephant encounter which resulted in crop damage were recorded during the study period. The crop damage by elephant was recorded from nine grama panchayaths of the eastern part of the District. The highest number of incidents was recorded from Moothedam Grama Panchayath (Table 29). The elephants crossed the Kalikavu Nilambur state highway 39 for the first time in a place called Kelunairpady (GPS-11$^{0}$12'29.1"N and 076$^{0}$20'12.2"E) during the study period.

Table 29. Panchayath wise data of elephant encounters.

| Sl. No. | Name of Grama Panchayaths | Frequency of crop-raiding | Name of the place |
|---|---|---|---|
| 1 | Mampad | 1 | Veetikuth |
| 2 | Edakkara | 3 | Udhiramkulam, Onichandam |
| 3 | Vazhikadavu | 2 | Chettiyaranghadi, Anamari |
| 4 | Moothedam | 21 | Mayilumpara, Panichola, Naranghapotty, Naranghamoola, Kalkulam |
| 5 | Amarambalam | 2 | Poothottukadavu, Antonykadu |
| 6 | Kalikavu | 6 | Chokad, Melekalikavu, Pullanghodu rubber estate, Chenkodu |
| 7 | Karuvarakundu | 1 | Vattamala |
| 8 | Edapatta | 3 | Munadi, Parayanmedu, Puliyakkodu |
| 9 | Chokad | 3 | Thekkepaladu, Kelunairpady, Chenappady |

### 5.3.2. Wild pig

Wild pig caused massive loss to the plantain and coconut farmers in the District with 88.83 per cent of loss to plantain (Nendra- 73.04 per cent and Palayamthodan 15.79 per cent) and 11.16 per cent to coconut. The highest damage was recorded from Nilambur Forest Range followed by Kalikavu, Karulai, Vazhikadavu and Edavanna. The mean economic loss was estimated as Rs. 34,460.34/- per ha per annum (Table 30).

Table 30. Economic loss due to wild pig in Malappuram District

| Sl. No. | Forest Range | Species and economic loss (Rs.) | | |
|---|---|---|---|---|
| | | **Coconut Ha/annum** | **Plantain Ha/annum** | |
| | | | Nendra | Palayamthodan |
| 1 | Kalikavu | 2455.80 | 28,238.63 | - |
| 2 | Karulai | 1430.30 | 19,030.39 | 4896.60 |
| 3 | Vazhikadavu | 6692.69 | - | - |
| 4 | Nilambur | 2172.45 | 78,577.07 | 20,128.00 |
| 5 | Edavanna | 6503.78 | - | 2176.00 |

### 5.3.3. Indian crested porcupine

The mean economic loss by Indian crested porcupine in the District was Rs.1322/- per ha per annum and the highest damage was recorded from Edavanna Forest Range followed by Karulai, Vazhikadavu and Kalikavu (Table 31).

Table 31. Economic loss due to Indian crested porcupine

| Sl. No. | Forest Range | Economic loss |
|---|---|---|
| | | Coconut<br>Ha/annum |
| 1 | Kalikavu | 364.32 |
| 2 | Karulai | 1416.80 |
| 3 | Vazhikadavu | 580.21 |
| 5 | Edavanna | 2928.05 |

#### 5.3.3.1. Discussion

Porcupines were responsible for several complaints from the respondents as an agricultural pest. However, they had little effect on agriculture income around the Jigme Singye Wangchuk National Park, Bhutan (Wang *et al.*, 2006 a). The mean economic loss of Rs. 1,322 per ha per annum due to Indian crested porcupine is a high value compared to the Rs. 615.47 estimated in a similar study in Thrissur District (Jayson, 2013). Indian Crested Porcupine is a major pest on forest plantations (Ahmad and Chaudhry, 1977; Sharma and Prasad, 1992; Khan *et al.*, 2010; Khan *et al.*, 2014). However, its debarking behaviour at the basal portion of rubber trees over 15 years of age is reported for the first time. The girdling on the basal part of the rubber trees will affect its health so that it creates the enormous psychological problem for the farmer and also causing economic loss as the affected tree has to be treated with some chemicals for curing. The animal can cause the mortality of the trees due to its act of girdling (Ahmad and Chaudhry, 1977; Greaves and Khan, 1978; Sharma and Prasad, 1992). The porcupines damaged the basal portion of the rubber trees in the Edavanna Forest Range. The forest edge was sharing the boundary of the rubber plantations filled with bamboo. The bamboo clumps sprouting occurred from October to December and during this period, the attraction of Indian crested porcupine shifted from rubber to bamboo clumps. No new attack was observed on the rubber plants in this period whereas the consumption of newly formed bamboo clumps recorded. However, no such change was there on the consumption of fallen coconuts in the same location (Fig. 27).

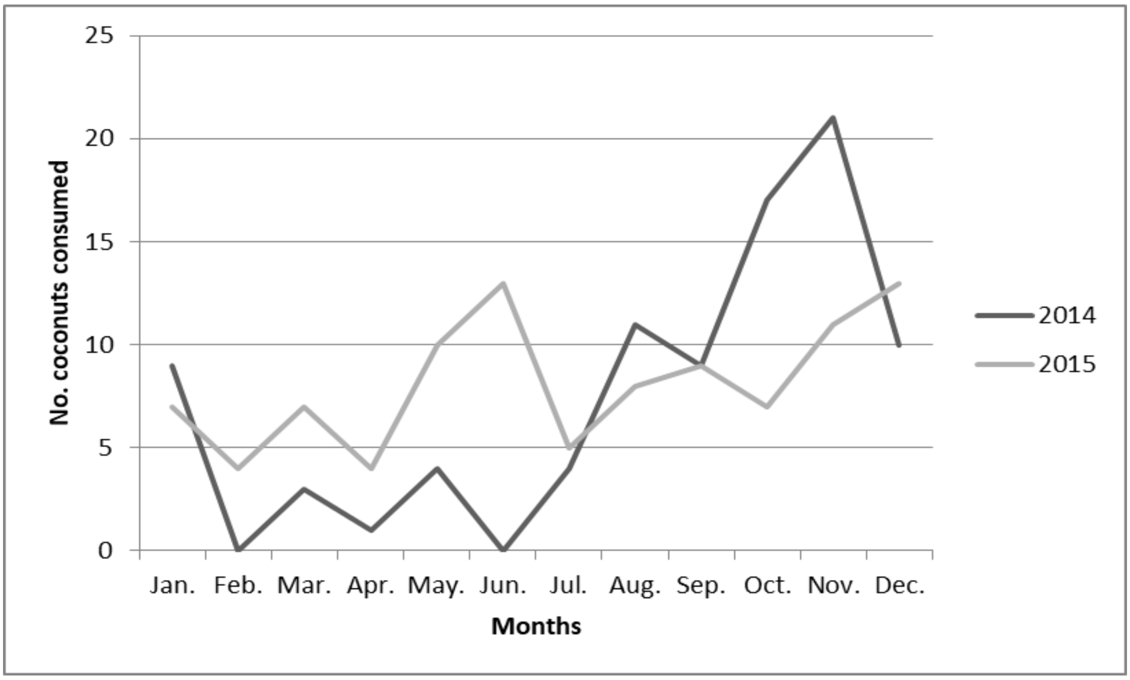



Fig. 27. Yearly difference in the coconut consumption by Indian crested porcupine

Indian crested porcupine is considered as a generalist herbivore in the diet as its food includes both vegetative matter and animal matter. There is a significant difference in the content of bark in the diet according to the season (Akram *et al.*, 2017). The crop species like maize, potato and groundnut are recognized as vulnerable to Indian crested porcupine (Brooks *et al.*, 1988; Khan *et al.*, 2000; Mian *et al.*, 2007) but in this study, fallen coconuts were the most damaged crop item which caused financial loss to the farmers. The absence of crop species mentioned above and the availability of coconut plantation in the forest fringes may be the reason for this damage. The mode of feeding by the Indian crested porcupine on the coconut observed in this study was similar to earlier reports from Thrissur District, Kerala (Govind and Jayson, 2018). The debarking behaviour of Indian crested porcupine on coconut palm was recorded from October to February, which is similar to the finding from Karnataka (Chakravarthy and Girish, 2007). The damage to the seedling of arecanut and coconut by Indian crested porcupine reported in Karnataka was not recorded in my study area even though both the plant species were present here (Chakravarthy and Girish, 2007). The crop damage by Indian crested porcupine was severe near the Reserve Forest area and the damage on fallen coconuts, rubber trees and coconut palms by Indian crested porcupine were recorded within a distance of 300 m from the Reserve Forest (Chakravarthy and Girish, 2007).

Trees with debarked basal portion, the presence of coconut husk with sharp edges, the presence of quills and nail marks were the main indirect signs of Indian crested porcupine. Porcupine is active during midnight hours (11 pm to 2 am) (Fattorini and Pokheral, 2012). So that direct sighting of the animal in the field was very difficult thus the population estimations were carried out by considering its indirect signs in the field. Breeding was reported throughout the year (Prakash, 1971) and the lifespan of the animal is within a range of eight to twenty years (Robert, 1977). After a drastic decrease in the population of Indian crested porcupine in 2002, compared to 1997, in both the Forest Divisions, it again resurged into a high figure in 2011 (Table 32).

Table 32. Population estimation of Indian crested porcupine (indirect signs)

| **Sl. No.** | **Year** | **Forest Division** | **Animal density (No. /Km²)** |
|---|---|---|---|
| 1 | 1997 | Nilambur north | 575.01 |
| | | Nilambur south | 930.10 |
| 2 | 2002 | Nilambur north | 46.11 |
| | | Nilambur south | 38.96 |
| 3 | 2011 | Nilambur north | 1844.21 |
| | | Nilambur south | 1481.88 |

Easa and Jayaraman, 1998; Easa *et al.*, 2002; Sivaram *et al.*, 2013

The bark and stem of the perennial trees are sensitive and well-protected resource that will be used by various mammals only in crucial situations (Baxter and Hansson, 2008). The different hypothesis proposed on tree debarking behaviour of the ungulates says that it is due to the presence of trace elements and minerals in the bark, quality variation in the nutritional level of twigs and barks and the less availability of high-quality forage (Mclntyre, 1972). These hypotheses can also be attributed to Indian crested porcupine as it is a mammal and there is no other established hypothesis to explain its debarking behaviour. The farmers have negligence towards the fallen coconut in the field and they were giving overhype on the crop-raiding incidences of large mammals like the elephant and wild pig. The lack of quantified data on the crop loss to Indian crested porcupine was the primary reason for the increased occurrence of Indian crested porcupine in the plantation crops near the forest. No one has given attention to implementing proper mitigation measures against the crop damage of Indian crested porcupine in the area.

### 5.3.4. Bonnet macaque

The highest loss of coconuts (Eight nuts/tree) due to bonnet macaque was recorded from the Kalikavu Forest Range followed by Edavanna (Fig. 28). An economic loss of Rs. 11914/- per ha/annum was estimated from Kalikavu Forest Range followed by Rs. 877/- per ha/annum from Edavanna Forest Range (Table 33 & 34). Bonnet macaque destroyed only the coconuts in the District.

Table 33. Number of coconuts destroyed by Bonnet macaque in different years from Kalikavu Forest Range

| Year | Number of nuts destroyed | Number of nuts destroyed /tree |
|---|---|---|
| 2013 (n=7) | 257 | 7 |
| 2014 (n=12) | 334 | 9 |
| 2015 (n=12) | 446 | 12 |
| 2016 (n=5) | 118 | 3 |
| | **Mean nuts destroyed/tree** | **8** |

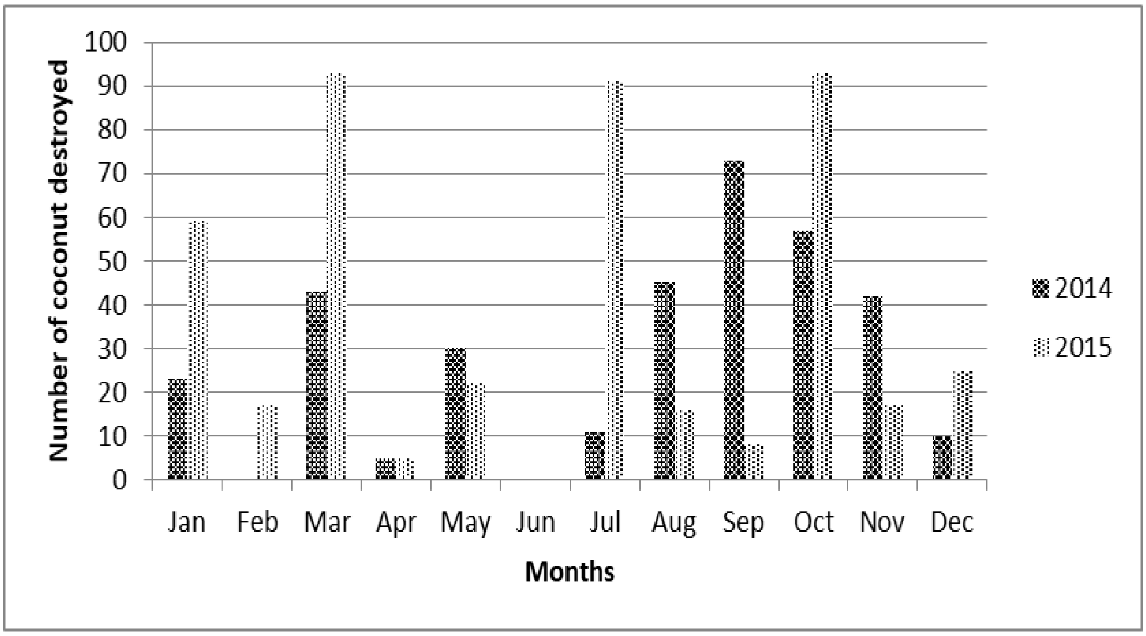



Fig. 28. Coconut damage by *Macaca radiata* from Kalikavu Forest Range (2014-2015)

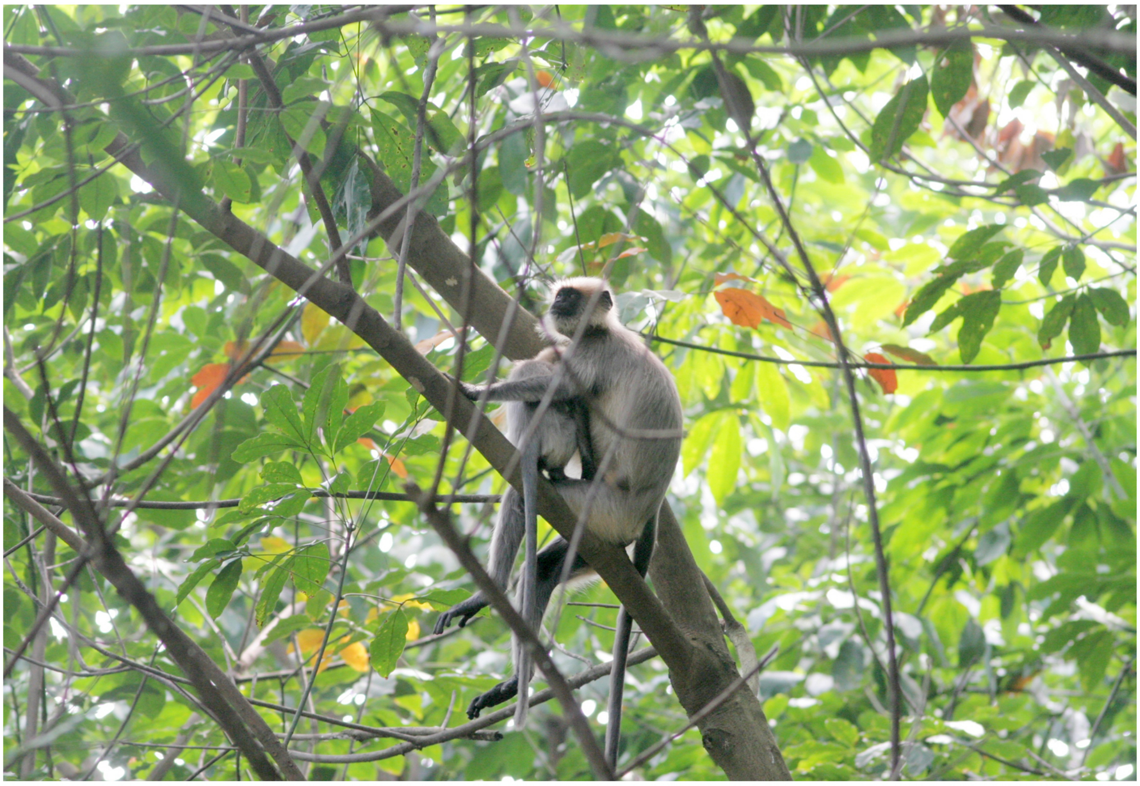
Table 34. Economic loss due to bonnet macaque and Black-footed gray langur

| Sl. No. | Forest Range | Animal species | Crop species |
|---|---|---|---|
| | | | Coconut/ha/annum (Rs.) |
| 1 | Kalikavu | Bonnet macaque | 11,239.95 |
| | | Black-footed gray langur | 4412.32 |
| 2 | Edavanna | Bonnet macaque | 877.07 |

### 5.3.5. Black-footed gray langur (*Semnopithecus hypoleucos*)

Black-footed gray langur caused an economic loss of Rs.4412 per annum in the Kalikavu Forest Range. The presence of this langur in the selected plot was observed only in the Kalikavu Forest Range. The Black-footed gray langurs consumed the new sprouts of rubber trees in the Kalikavu and Karulai forest ranges (n=13) (Plate 15b).

a. Black-footed gray langur (*Semnopithecus hypoleucos*) feeding on leaves (Kalikavu Forest Range)



b. Black-footed gray langur (*Semnopithecus hypoleucos*) on the rubber trees

**PLATE 15: Black-footed gray langur (*Semnopithecus hypoleucos*)**

## 5.4. Human casualties and cattle lifting

Asian elephant, wild pig, leopard, bonnet macaque and gaur were the animal species which caused injury to the human beings (Fig. 29).

### 5.4.1. Asian elephant

A total of eight cases of human casualties due to Asian elephant were recorded in the District in which five human lives were lost (Table 35 & 36). Three human deaths occurred in the rubber plantations and all the three victims were nontribals employed in the rubber plantation. The remaining two incidents happened in the Reserve Forest and both the victims were tribals (one lady belonging to Aranadan tribe and one man belonging to Kaatunaykar tribe).

**Case 1.** A rubber estate employee was killed by a lone tusker in front of his quarters at Pullanghodu rubber Estate (11°11’49.34”N and 76°20’49.62”E). This elephant had been recorded in the human habituated area for more than two years. The elephant was sighted in farmland on the other side of the Kalikavu-Nilambur road in the early morning hours which was 3 km away from the natural forest and the elephant was chased by the people into the forest. The man was unknowingly caught in front of the elephant with his two-wheeler while he was going for his job. The elephant was very aggressive as it was chased by the people and it smashed on the bike using its trunk and trampled him against the rock. The incident has happened 2 km away

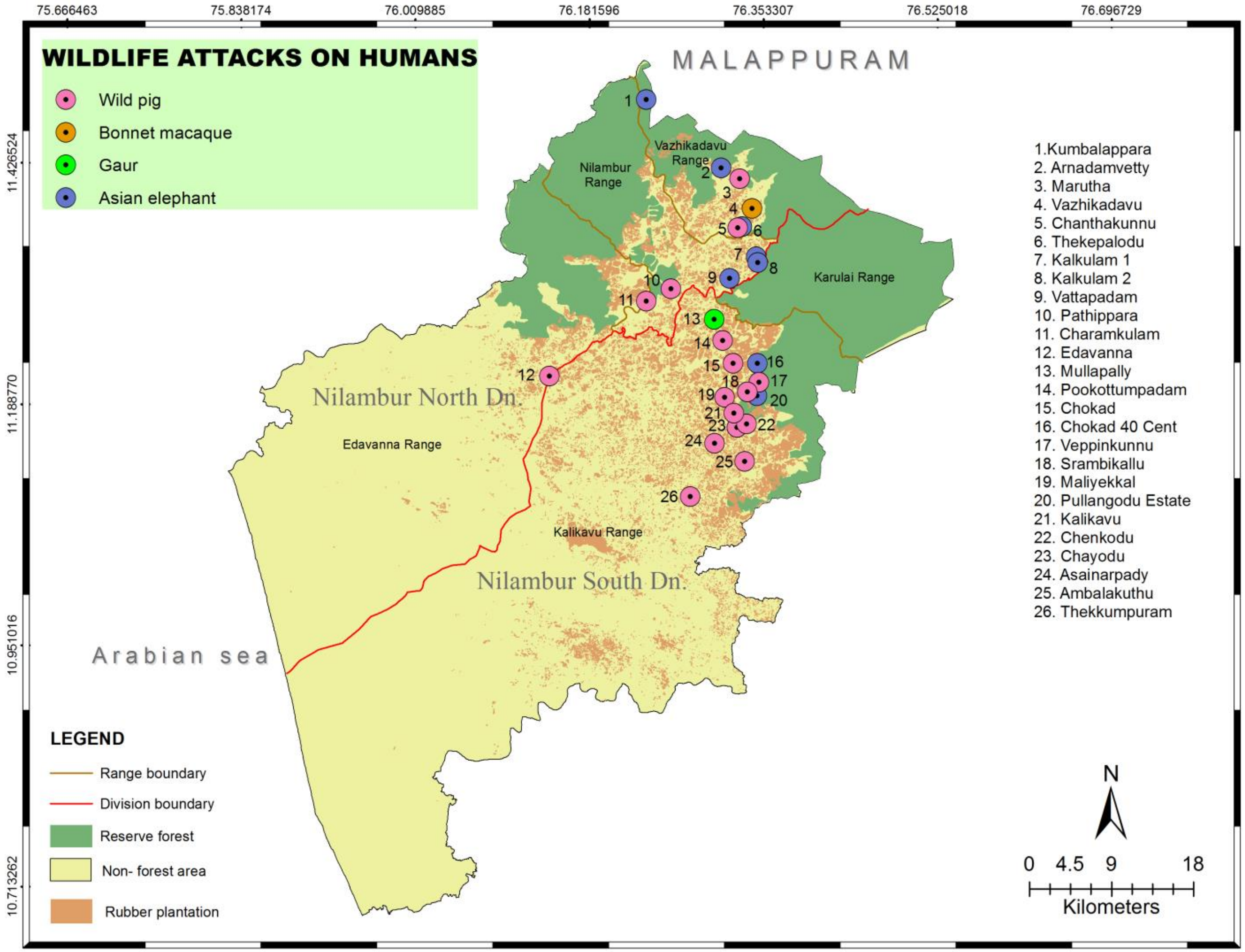



Fig. 29. Wildlife attack on humans in Malappuram District (2013-2017)

from the Reserve Forest. This was the third incident in which human life lost by an elephant in the estate and the other two past incidences happened in 1969 (Focus group discussion).

**Case 2.** A lady of Aranadan tribe slept in the open space which is 3 km inside the forest and was 100 m away from their hut at Arnadamvetty (11°25’17.8”N & 76°18’42.1”E) in Vazhikadavu Forest Range. The elephant trampled the head of the lady and the dead body was found in the early morning only, as no other damage was done by the elephant in the area. The tribal people were residing in the area for more than 60 years and no such incidents were reported earlier.

**Case 3.** Another incident happened in the Munderi forest, 4 km away from the Kumbalappara tribal colony (11°29'21.12"N and 76°14'15.7"E). An elephant attacked the man while he was inside the forest for collecting Non Timber Forest Products (NTFP). The victim was a tribal from Kumbalappara tribal colony.

Table 35. Details of human deaths caused by Asian elephants in Malappuram District (2014-2018).

| Sl. No. | Group composition of elephants | Age of the victim | Sex | Time (hrs) | Forest Range |
|---|---|---|---|---|---|
| 1 | Lone tusker | 52 | Male | 06.30 | Kalikavu |
| 2 | Lone tusker | 45 | Female | 22.30 | Vazhikadavu |
| 3 | Lone tusker | 36 | Male | 17.00 | Vazhikadavu |
| 4 | Lone tusker | 41 | Male | 03.30 | Nilambur |
| 5 | Lone tusker | 39 | Male | 04.00 | Kalikavu |

Table 36. Human injuries due to Asian elephants in Malappuram District

| Sl. No. | Group compo-sition of elephants | Age & sex of the victim | Latitude & Longitude | Time (hrs) | Place & Forest Range | Dist-ance to the forest (m) | Remarks |
|---|---|---|---|---|---|---|---|
| 1 | Lone tusker | 52, F | 11°20' 2.25"N 76°20' 47.14" E | 22.00 | Kalkulam & Nilambur | 1500 | Fell down after the unexpected sighting of the elephant close to the kitchen. Injury on the forehead and right leg |
| 2 | Lone tusker | 17, M | 11°19' 42.55" N 76°20' 52.71" E | 22.30 | Kalkulam & Nilambur | 1500 | Unexpected encounter with the elephant close to the house. Injury on both hands. |
| 3 | Lone tusker | 36, F | $11^{0}$21' 50.3" N $76^{0}$ 19' 56.4" E | 01.00 | Theke-paladu & Vazhi-kadavu | 1000 | Unexpected encounter with elephant while it was chased away from the crop field, it was first time elephant was sighting from there |

#### 5.4.1.1. Discussion

Human-elephant conflict in terms of crop-raiding patterns and human injuries were studied and documented by many authors in the last few decades (Blair *et al.*, 1979; Seidensticker, 1984; Sukumar, 1985, 1989, 1990; Desai and Krishnamoorthy, 1992; Sitati *et al.*, 2003). Some of the studies explored the factors behind the problem (McKay, 1973; Olivier, 1978; Hoare, 1999; Prasad *et al.*, 2011; Pozo *et al.*, 2017) and others investigated the economic implications of the problem (Mishra, 1971; Blair *et al.*, 1979; Sukumar 1985, 1989; Madhusudan, 2003). In the present study, all the three facets of the issue were studied to get an overall picture of HEC in the District.

A meta-analysis of data covering over 20 years of experimental research on corridors found that the presence of corridors increased the movement of species between habitat patches by 50% from connected to non-connected patches (Gilbert-Norton *et al.*, 2010). A crucial elephant corridor in south Garo Hills is used for mining limestone on a large scale by lease, resulted in increased incidents of HEC in the area (Williams and Johnsingh, 2004). The identified elephant corridors in Kerala are given in Table 37.

The fragmentations of the forest in the District lead to the loss of elephant corridors. The Nilambur North and Nilambur South Forest Divisions have only one elephant corridor which passes through the Vazhikadavu range, but the passage of elephants through this corridor was blocked with rubber plantation by Plantation Corporation of Kerala (PCK) in the Punchakolly bit and Vaniyampuzha bit. In Munderi, it is owned by the agricultural department and there the elephants are forced to pass through the habitation areas at Ventekkumpotty, which resulted in severe damages (Joju, 2015).

Table 37. Details of elephant corridors in Kerala

| Sl. No. | Name of the corridor | Area | Forest type | Legal status | Major land use | Habitations in corridors | Village dependent on corridors |
|---|---|---|---|---|---|---|---|
| 1 | Nilambur Kovilakom-New Amarambalam (Vazhikadavu) Nilambur North Division | Length-1 km Width-0.5 | Tropical Semi evergreen | RF | Forest & Plantation | Nil | Vazhikadavu & Karakkodu |
| 2 | Periyaat Pakranthalam North Wayanad Division | Length-0.5 km Width-0.2 km | Tropical moist Deciduous | RF | Forest, Fallow land & Settlement | Pakranthalam & Panoth | Pakranthalam, Panoth & Niravil puzha |
| 3 | Tirunelli-Kudrakote North Wayanad Division | Length-6 km Width-1-1.5 km | Tropical moist Deciduous & Teak plantation | RF with small part as patta lands | Forest settlements, agriculture & plantation | Edayurvayal | Appapara, Vaduvakkalim, Edayurvayal, Pulayankolli, Thirunelli, Padaladi |
| 4 | Kottiyoor-Periya Kannur North Wayanad Division | Length-0.5 km Width-0.1 km | Tropical Semi evergreen | RF | Forest settlement | Periya, Pokkottu-Chapparam, Chandanathodu & CRP Kunnu | Periya, Pokkottu-Chapparam, Chandanathodu, CRP Kunnu & Alatti |

Source: Administration Report 2015-16, Kerala Forest and Wildlife Department

The intermediate habitat fragmentation does not displace elephants from their natural ranges. The secondary forest and the agricultural areas near primary forest provided sufficient habitat for the elephants and they will reside and utilize the subsequent regrowth as a resource of protein-rich foliage (Rood *et al.*, 2008). Many of the elephant habitats have already been converted to agricultural lands which result in the constrained occupancy of the elephant population in specific patches of forest (Sukumar, 1989 and 1990). The repeated occurrence of human-elephant conflict in places like Parayanmedu and Munadi under Kalikavu forest Range was the result of this fragmentation happened in the past. The presence of 60 ha forest patch close to the tribal settlements of Parayanmedu was acting as the temporary resting place for elephants which came from the buffer zone of the Silent Valley National Park all the way through the rubber plantation. This fragmented forest area has no connection with the Silent Valley National Park. However, the elephant herds always tended to be there, which in turn allows them to stay close to the cropland, especially the arecanut and plantain cultivations.

The distance to the nearest water body, refuge areas and villages, density of crops and humans were some of the environmental variables influencing the HEC (Nyhus *et al.*, 2000; Parker and Osborn 2001; Sitati *et al.*, 2005; Wilson *et al.*, 2013). The presence of arecanut cultivation and the distance to the forest were the two predictable variables included in the model that influenced the crop-raiding by Asian elephant in Malappuram District. The intercropping of plantain, along with the arecanut plantations was recorded as a common practice in the District (n=22). The variables which influenced the HEC in the Agali Forest Range of Attapady were identified as canopy density, distance to human settlements, distance to Reserve Forest, slope and elevation (Prasad *et al.*, 2011). In South China, the proximity to protected areas, increasing distance from roads and lower settlement density are the factors influencing the crop damage by Asian elephants (Chen *et al.*, 2016). In my study area, the occurrence of HEC showed a strong negative correlation with the distance to drainage which is similar with the finding that the drought season attracts elephant towards the artificially maintained water sources (Sukumar, 1990; Sutton, 1998; Thouless, 1994). During the season of crop damage, the elephants avoid crop fields and stay close to corridors and their presence is found in the proximity to waterholes and distant to crop fields and thereby the space use of elephant and crop damage are non-linearly related (Pozo *et al.*, 2018).

The concentration of human-elephant conflict consistently has a high rate in the villages, which are less than 3 km away from the protected area (Attia *et al.,* 2018). Despite the strong negative correlation of distance from the Reserve forest with the occurrences of HEC, it has a weak predictability (odds ratio= 0.021) on the same in the study area. The elephant herds usually do not prefer to venture more than 1 km from a forest boundary (Sukumar, 1989). In contrast, more than 60 per cent of the incidents happened between 5 km to 6 km distance from the Reserve Forest in the District. This is because of the presence of rubber plantations in the immediate forest boundary giving enough protection for the elephants to travel through and to reach the nearby farms. As expected from the land use pattern of Malappuram District, the HEC have a positive correlation with the presence of rubber plantation (($r_s = 0.297$; $P < 0.05$). The farmers were opting monoculture plantation of rubber trees as a cash crop in the immediate border of the forest due to the high demand of latex in the market. Furthermore, it is less prone to damage by other wild animals.

The HEC usually occurs between dusk and dawn (Venkataraman *et al.*, 2005) however, more than fifty per cent of the crop-raiding incidents in the current study have occurred in the early midnight hours. This may be due to the advancement of technology along with the availability of electricity in every house in the forest fringes made the people late sleepers which increased the risk of an encounter with a human being in the dusk and early night hours. The frequency of crop-raiding and the extent of damage by Asian elephant is significantly less in crop fields which were guarded by farmers so that strengthening of the traditional crop guarding practices will effectively reduce annual crop loss (Nath *et al.*, 2015). The farmers in the fringe areas of Malappuram District depended on several low-cost traditional mitigation measures to prevent the elephant encounters, among these the use of spotlight was found more effective than others. Besides these, properly maintained electric fences and the beehive fence experimented in the field was also found effective against the crop-raiding elephants. Compared to other traditional measures, proper electric fencing is much more effective as 80% success rate has been reported from a study in Malaysia

(Sukumar, 2003). Human-elephant conflict is an inevitable occurrence as long as the humans and elephants share the same landscape so that the peaceful co-existence with minimum damage on both sides is the practical approach for this problem (Hoare, 2001; Madhusudan, 2003; Sitati *et al.*, 2003; Chong and Dayang Norwana, 2005). It can be achieved only through the popularization of low cost effective mitigation measures like beehive-fence which was beneficial to the local communities.

Sutradhar *et al.* (2018) studied the fatal effect of gunshot on the Asian elephant in Bangladesh and reported that penetration of bullet into the pharynx caused the damage of blood vessels and nerves which usually result in loss of function of the pharynx that called pharyngeal paralysis. The partial pharyngeal paralysis caused due to incomplete injuries by the gunshot result in the inanition followed by starvation which lead to the death of the elephant. The condition in which the elephant was not able to consume food and also the food was dropped while grasping it in the mouth is indicating the dysphagia developed from pharyngeal paralysis. The reasons like pneumonia, bleeding and infection as the cause of death of elephants in the District were the result of the previous encounter with humans in the crop field and their illegal use of deterrent methods. More than seventy-one per cent of the elephants died in the District were male and most of the elephant death cases were detected in and around the farmland and occurred during the monsoon season. From the previous studies it was clear that the bulls are well known to raid crop more frequently than family herds (Sukumar, 1989, 1991; Santiapillai and Jackson, 1990; Appayya, 1995;

Daniel *et al.*, 1995). The fatality of bull elephants while engaged in crop damage is higher than the females.

While crop-raiding, the elephants also injured or killed farm workers and it was observed that between 1980 and 2003, more than 1150 humans and 370 elephants died as a result of human-elephant conflicts in north-east India alone (Choudhury, 2004). The majority of the forest fringe villegers in Malappuram District expressed their psychological stress and fear due to the unexpected encounters with the elephant (Rohini *et al.,* 2016 a). Among the five human deaths due to Asian elephant reported in the Malappuram District, two were the member of tribes who were killed inside the Reserve Forest and other three were the workers in the rubber plantations, which again proved that the association of Asian elephants with the rubber plantations.

In contradictory to the general belief prevailing in the area that elephants come out of the forest during the summer season due to the shortage of food and water within the forest, the results showed that highest crop damage occurred during the monsoon season (June-September). Seasonal encounter index of the elephant showed a positive correlation with rain fall (P= 0.046, Pearson's correlation coefficient, r= 0.584) of the study area. It can be better explained that the wild elephants were attracted towards the highly palatable and matured crops during this season. In spite of food shortage within the forest, availability of palatable crop in the forest fringes act as an attraction for the elephants both in Asia and Africa (Sukumar, 1990; Compose-Arceiz *et al.*, 2009; Bhima, 1998). During dry season (January- April), browsing is important for elephants whereas in the rainy season (May-August) they prefer to eat the freshly grown tall grass but when the tall grass becomes unpalatable, they will consume protein rich fodder during the north-east monsoon season (September-December). For this they may come to low elevation area (Sukumar, 1985). Most cases of crop depredation in West Garo Hills District occurred between June and December, with high peaks in July and August, and a lower peak in November (Williams and Johnsingh, 2004).

Plantain contributed to more than 50 per cent of the total crop damaged by the Asian elephant even though it is guarded by the farmers in most of the forest edges in the Malappuram District. Price of banana reached highest during the month of August (Rs. 37.33±7.57/- per kg) and September (Rs. 39±12.17/- per kg) (Source Farm Information Bureau, Kerala) and this is because of the Onam festival season in the Kerala (Fig. 30).

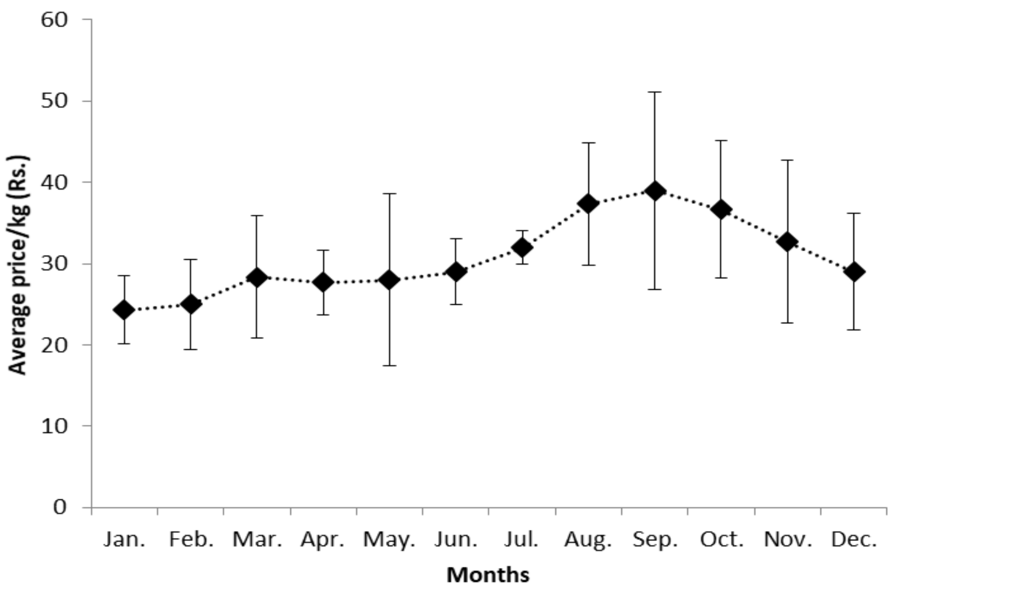



Fig. 30. Price variation of banana over the months (2014-2016)

Most of the farmlands filled with the mature plantains during this season, aiming the high price for the product and which will in turn attract the elephants towards the crop. Plantain was recognized as a major attractive crop for the elephant in many studies (Saaban *et al.*, 2011; Ekanayaka *et al.*, 2011).

The tropical countries have a considerable financial loss due to crop damage by Asian elephant (Monroe and England, 1978; Sekhar, 1998; Rao *et al.*, 2002; Zhang and Wang, 2003; Salman and Nasharuddin, 2003; Madhusudan, 2003; Karanth *et al.*, 2013). My study estimated the potential economic loss of US$ 72553 [US$ 32051 (Other than Rubber) +US$ 40502 (Rubber)] per annum from 2.9 ha of the District as crop loss due to Asian elephants which is comparable with many of other studies as follows (Table 38).

The average age of the rubber trees prone to damage by elephant encounter was 2.9 years (Chen *et al.*, 2013) but in this study, fifty-four per cent of the rubber trees were damaged in their primary productive stage (7-19 years of age). Instead of the incidental damage here, the elephants attempted to feed on the rubber bark, preferably of this age. The central rachis of the palms and pineapple were the preferred food items for elephant as found in Jayson (1998). Farmers are the least tolerant of damage of high-value cash crops (Messmer, 2000). The pineapple cultivation within the rubber plantation was the main attractant for the elephants in the study area. The farmers from two of the five locations removed pineapple cultivation from the rubber plantation due to the high menace of the elephants within the plantations.

Table 38. The comparison of economic loss due to Asian elephant from different studies

| Sl. No. | Economic loss | Major crop | Area | Study duration (year) | Source of information |
|---|---|---|---|---|---|
| 1 | 72553 US$ per annum | Plantain, Coconut palm, Arecanut palm, Rubber | Malappuram District (Kerala, India) | 3 | This study (2019) |
| 2 | 24434 US$ per annum | Plantain, Coconut palm, Arecanut palm | Thrissur District (Kerala, India) | 3 | Jayson (2013) |
| 3 | 5139 US$ | Plantain, Finger millet | Karnataka (India) | 1 | Venkataramana *et al.* (2017) |
| 4 | 182320 US$ | Oil palm | Malaysia | 2 | Salman and Nasharuddin (2003) |
| 5 | 18711810 US$ | Oil palm | Malaysia | 4 | Monroe and England (1978) |
| 6 | 314600 US$ | Rice, Corn, Plantain | China | 4 | Zhang and Wang (2003) |

Note: The values were converted into US dollars from its respective units.

### 5.4.2. Wild pig

A total of 19 human-wild pig encounters recorded from the study area and 8 of them were the collision with vehicles (2 autos and 6 motorbikes). The number of victims was twenty-six, including three women (Table 39). All three victims were above 55 years of age. Two of them attacked while they were watering the crops cultivated near their house and a rabid pig attacked another victim. Solitary pigs caused most (84.21%) of the human-pig encounters and the remaining 15.78 per cent caused by the sounders. The highest number of human fatalities were recorded in the age group of 50- 55 years and none of them was vehicle collision.

Table 39. Human injuries due to wild pig in the Malappuram District (2013-2016)

| Sl. No. | Name of place | Date | Time | Panchayath/ Municipality | Forest Range | Nature of attack | GPS point |
|---|---|---|---|---|---|---|---|
| 1 | Chayodu | 14/08/2013 | 08.30 | Kalikavu | Kalikavu | Two persons were injured (Vehicle collision & Direct attack) | 11$^{0}$09'57.4"N 76$^{0}$19'37.8"E |
| 2 | Srambikallu | 17/08/2013 | 06.30 | Chokad | Kalikavu | Collision with auto (newspaper carrier). | 11$^{0}$12'03.3"N 76$^{0}$20'15.2"E |
| 3 | Veppinkunnu | 03/10/2013 | 08.30 | Chokad | Kalikavu | Biting on the hand and incision with tusk. | 11$^{0}$12'37.6"N 76$^{0}$20'56.5"E |
| 4 | Maliyekkal/ Valiyaparambu | 05/10/2013 | 10.30 | Chokad | Kalikavu | Deep incision on the leg of the victim by the tusk of pig. | 11$^{0}$11'44.5"N 76$^{0}$18'54.9"E |
| 5 | Pookottumpadam/ kavalamukkatta | 23/04/2014 | 09.30 | Amarambalam | Kalikavu | Motor bike collision- One person had fracture on the left leg below the knee. | 11$^{0}$15'5.7"N 76$^{0}$18'48.0"E |
| 6 | Chenkodu | 16/08/2013 | 08.30 | Kalikavu | Kalikavu | Auto collision-Two persons were injured. | 11$^{0}$09'57.4"N 76$^{0}$19'37.8"E |
| 7 | Thekkumpuram | 05/08/2014 | 18.30 | Thuvvur | Kalikavu | Three persons were seriously injured while walking on the road. | 11$^{0}$05'52.3"N 76$^{0}$16'52.5"E |
| 8 | Pathipara | 06/07/2014 | 18.30 | Nilambur Municipality | karulai | Three persons were seriously injured on their hand, legs and buttock. | 11$^{0}$18'08.9"N 76$^{0}$15'44.2"E |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 9 | Kalikavu | 26/08/2014 | 06.00 | Kalikavu | Kalikavu | Motor bike collision - One person injured. | 11°10'47.5"N 76°19'27.3"E |
| 10 | Marutha | 12/12/2014 | 05.00 | Vazhikadavu | Vazhikadavu | Motor bike collision - One person injured. | 11°24'39.5"N 76°19'47.1"E |
| 11 | Charamkulam | 25/07/2015 | 18.30 | Nilambur Municipality | Nilambur | Rushed into the house- Damage to house hold materials. | 11°17'24.8"N 76°14'16.2"E |
| 12 | Chokad | 21/01/2016 | 06.00 | Chokad | Kalikavu | Collisions with motor bike- Two persons were injured. | 11°13'44.1"N 76°19'24.6"E |
| 13 | Ambalakunnu (kuttathi) | 11/01/2016 | 09.00 | Karuvarakundu | Kalikavu | One lady of 62 years was severely injured while. watering the crops | 11°07'57.2"N 76°20'05.4"E |
| 14 | Ambalakunnu (kuttathi) | 24/01/2016 | 13.00 | Karuvarakundu | Kalikavu | One man was severely injured from the farmland. | 11°08'10.5"N 76°19'41.1"E |
| 15 | Nilambur Chanthakunnu | 04/07/2016 | 11.00 | Nilambur Municipality | Nilambur | Rushed into the barber shop and Vaidyasala- One person injured. | 11°17'13.0"N 76°14'21.2"E |
| 16 | Pulliyil | 06/07/2016 | 11.00 | Karulai | karulai | The victim was attacked while the pig crossing the road. | 11°17'5.8"N 76°16'51.4"E |
| 17 | Chanthakunnu | 06/07/2016 | 10.00 | Nilambur Municipality | Nilambur | Hit from the back while in the crop land. | 11°17'18.5"N 76°14'42.4"E |
| 18 | Edavanna | 06/07/2016 | 11.00 | Edavanna | Edvanna | Rushed into a house- One person was injured | 11°12'51.0"N 76°08'32.2"E |
| 19 | Asainarpady | 25/09/2016 | 07.30 | Kalikavu | Kalikavu | Motor bike collision- Myself injured on legs and hands while returning from the field | 11°9'0.69"N 76°18'8.5"E |

Most of the incidents were occurred in Kalikavu Forest Range (63.15%) followed by Nilambur (15.78%), Karulai (10.52%), Vazhikadavu (5.26%), and Edavanna (5.26%) (Fig. 31).

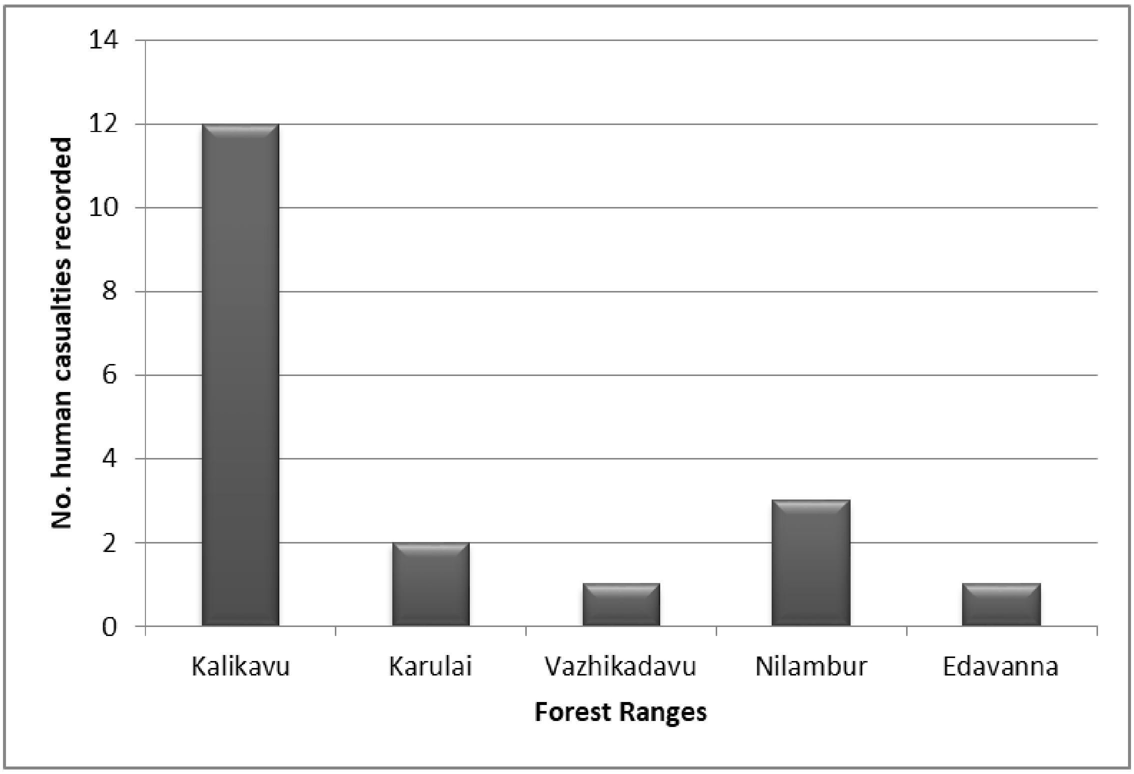



Fig. 31. Human- wild pig encounters in different Forest Ranges (n=19)

Majority of the incidents (31.57%) occurred during 08.00-10.00 hrs followed by 21.05% during 10.00-12.00 hrs, 15.78% each during 04.00 – 6.00 hrs and 18.00 - 20.00 hrs, 10.52% during 6.00 -8.00 hrs and 5.55% during 12.00 - 14.00 hrs (Fig. 32). It indicated that even though the wild pigs are nocturnal feeders, their activity is not restricted in the night hours only, there is a chance of an encounter with the wild pig at any point of time in a day in the District.

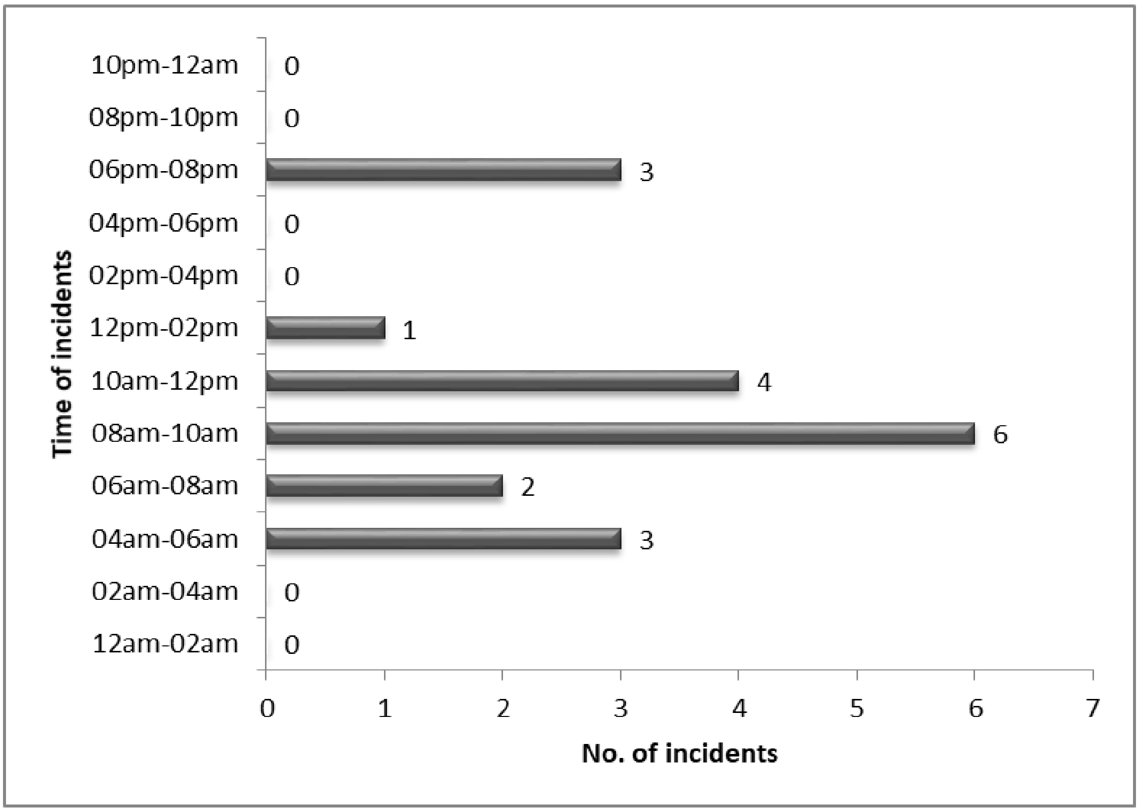



Fig. 32. Human-wild pig encounters in different time period of the day (n=19)

#### 5.4.2.1. Different modes of attacks by Wild pig

The number of human injuries due to wild pig was highest in July-August (Fig. 33).

**Case 1**:- The incident occurred at Maliyekkal situated near to Pullangodu Estate (11°11’44.5”N and 076°18’54.9”E) where Mr. Abdhurahiman was attacked by a wild boar while he was on the way to his house. It was a solitary pig which charged at him and slashed him upward with its tusks which made a deep incision on the right leg of the victim. The important observation was the time of the attack, 10.30 hrs which is not usually the active time for wild pigs moreover it is the peak time for human activity (Plate 16a).

**Case 2**:- The place Veppinkunnu lies on the foot of Pullangodu Estate (11°12' 37.6"N and 076°20'56.5"E). A solitary male pig charged aggressively towards the victim who was standing in front of his house, repairing the water pipe at 08.30 hrs. He got seriously injured on his legs and arms. Arms had sizeable open laceration and deep wound with upwardly slashed tusk and due to the biting of the pig (Plate 16b). The pig attacked him without any provocation and after the first hit it returned to him aggressively for a second attack, he got injured in his arms while he tried to avoid. Most of the estate was planted with rubber and had small patches of shrubs scattered here and there. These shrubs acted as favourable camouflage location for the wild pigs (n=21) so that the number of wild pigs in the nearby area was very high which is contributing to the increased occurrence of human-wild pig conflict at Kalikavu forest range.

**Case 3**:- The incident happened at Charamkulam (11°17'24.8"N and 076°14' 16.2"E) Nilambur Forest Range, Nilambur municipality, ward no. 4 which is only 500 m away from the forest. Even though the presence of wild pig was frequent in the area, no human casualties by a wild pig reported earlier. In this particular incident, one solitary wild pig rushed into a house inhabited by seven members with four adults and three children. The pig entered into the bedroom and destroyed the household materials. No one injured during the attack.

According to the local people (n=80) an extirpation in the population of dhole (wild dog) in the forest contributed to an explosion in the population of wild pig (Piglets are the main prey species for the dhole) and the population data of the dhole was showing a decline over the years (Table 40).

Table 40. Population status of Wild dog in Malappuram District

| **Sl. No.** | **Year** | **Forest Division** | **No. of animals sighted in sampled blocks** |
|---|---|---|---|
| 2 | 2002 | Nilambur north | 16 |
| | | Nilambur south | 6 |
| 3 | 2011 | Nilambur north | 2 |
| | | Nilambur south | 0 |

Easa *et al.*, 2002; Sivaram *et al.*, 2013

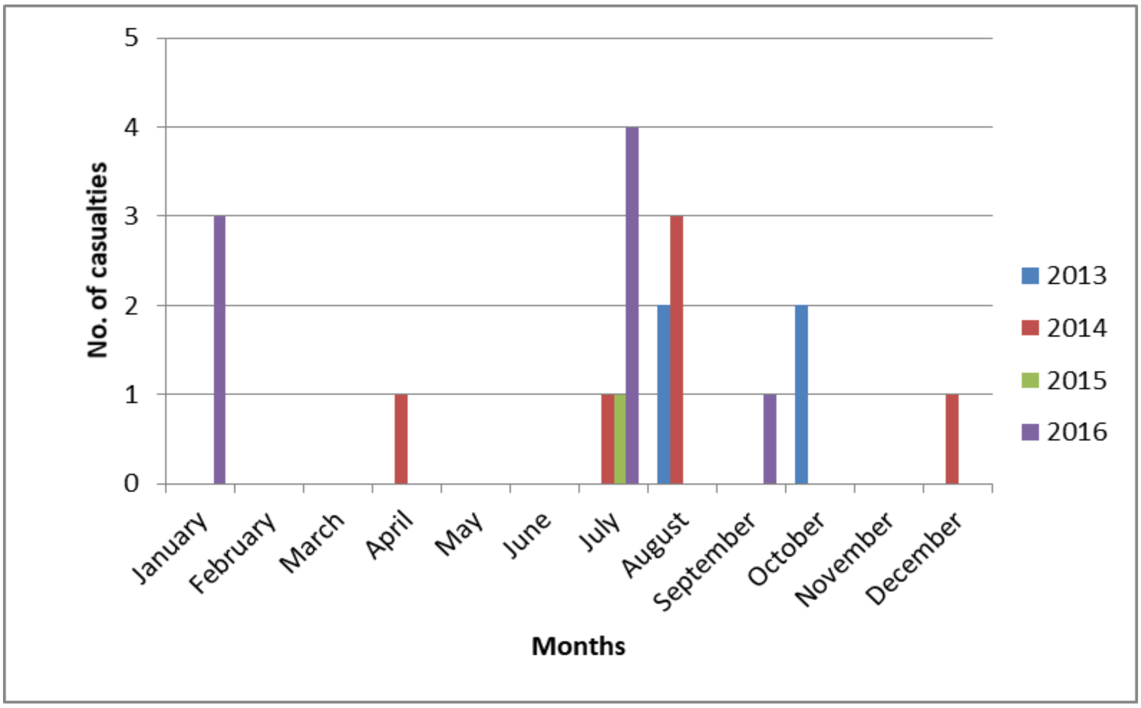



Fig. 33. Number of human injuries due to wild pig in different months (2013-2016) (n=19)

#### 5.4.2.2. Wild pig-Vehicle collision

Eight cases of wild pig- vehicle collision (WPVC) were recorded from the District (Fig. 34). Sixty-two per cent incidents occurred during the early morning (05.00 - 06.30 hrs) and late evening (18.00 – 19.30 hrs), and the death of pig due to WPVC was also recorded in one incident

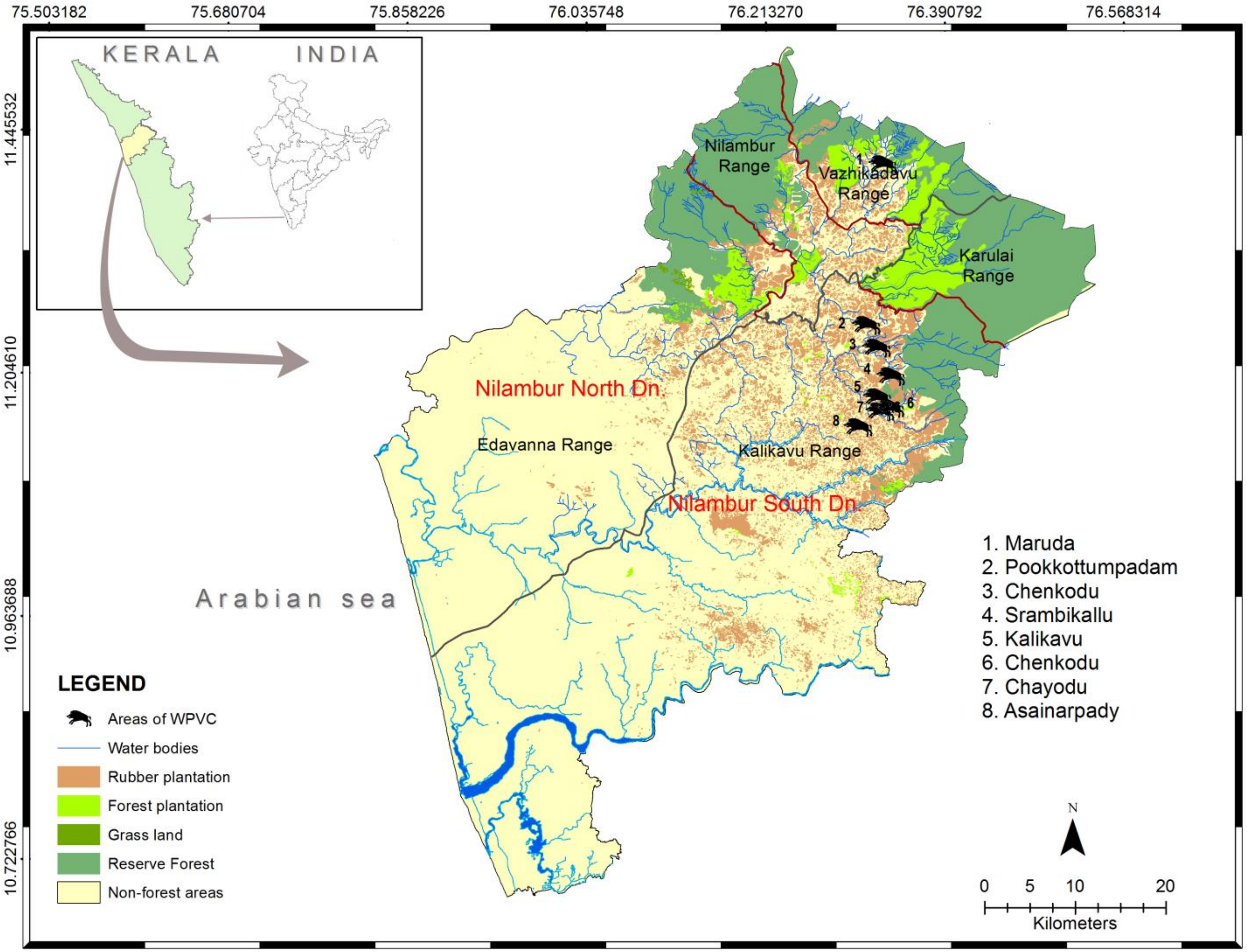



Fig. 34. Locations of wild pig- vehicle collision

(Plate 16c). Highest (62.5%) encounters were recorded during the months of August-September followed by January (12.5%), April (12.5%) and December (12.5%).

Table 41. Details of wild pig-vehicle collision

| Sl. No. | Date | Name of the places | Distance to the RF (m) | Age of the victim | Time of attack | Nature of injury |
|---|---|---|---|---|---|---|
| 1 | 12/12/2014 | Marutha | 950 | 32 | 05.00 | Right leg fracture |
| 2 | 23/04/2014 | Pookkottum-padam | 2700 | 28 | 09.30 | Deep wound in the knee of left leg |
| 3 | 21/01/2016 | Chokad | 2900 | 24 & 26 | 06.00 | Right leg fracture and wound in the forehead |
| 4 | 17/08/2013 | Srambikallu | 1600 | 40 & 38 | 06.30 | Wound in the chest, palm and fingers |
| 5 | 26/08/2014 | Kalikavu | 2850 | 21 | 06.00 | Right leg fracture and shoulder injury |
| 6 | 16/08/2013 | Chenkodu | 1400 | 38 & 34 | 08.30 | Facial injury |
| 7 | 14/08/2013 | Chayodu | 2400 | 31 & 28 | 08.30 | Leg and rib fracture |
| 8 | 29/09/2016 | Asainarpady | 5200 | 29 | 19.30 | Wound on the chest, leg and palms |

One incident of WPVC has happened more than 5 km away from the Reserve Forest (Table 41). The highest number (75%) of incidents was happened on the road near the rubber plantations (n=8). The presence of monoculture plantations like teak and rubber in the District provided suitable and undisturbed hiding places for the wild pig. The majority

a. Injury on leg by wild pig

b. Wild pig bite on the hand

c. Wild pig-vehicle collision on the road edged by rubber plantation

**PLATE 16: Human-wild pig (*Sus scrofa*) interaction**

(87%) of the incidents occurred in the Kalikavu Forest Range. The unmanaged chicken wastes throughout the District were one of the major attractants for the wild pig to the non-forest area. According to 2012 Census report, the number of poultry farms in Malappuram District was 61 (Source: District Animal Husbandry office Malappuram). According to the data collected from Kalikavu Panchayath office, 53 licensed poultry farms were functioning under the Panchayath alone.

**5.4.2.3. Wild pig rabies**

The aggressive behaviour of a rabid wild pig was recorded from Pathippara (11°18’08.9”N and 76°15’44.2”E). The attack of a wild pig on human beings is a rare incident in the area. In this incident, a wild sow first appeared in a house near a teak plantation on 06/07/2014, where it damaged vessels and other household materials including the dress hanging outside. On its journey of 6 km from the forest through the human settlements, it attacked four cattle in three houses and also three persons, namely Mr. Pokkar, Mr. Babu and Mrs. Mariyakutty. Mr. Pokkar lost his eight fingers of his hands in the attack by the pig. He was on his way home from the mosque at 6.30 pm when attacked. Mr. John was attacked while he came out of the house after hearing the sound of his cattle at 7 pm. The mad sow charged at him without any provocation and he lost one of the fingers from his left hand and also got injured on his right hand while he was trying to take out his fingers from the mouth of the pig (Plate 17a). His wife Mariyakutty was also severely attacked on her buttocks, legs and hands while she was trying to get rid of the animal from the hand of her husband (Plate 17b). Based on the apple green fluorescence by conducting fluorescent antibody test (FAT), the rabies case was confirmed by the Department of Pathology, College of Veterinary and Animal Sciences, Mannuthy, Thrissur. Fluorescent antibody test is considered a golden standard for the diagnosis of rabies as it is more sensitive (Daily *et al.*, 2014). All the three persons provided with anti-rabies vaccination and the hospital charges paid by the Kerala Forest and Wildlife Department. The animal waste dumped in the area was attracting stray dogs to the forest fringes and this played a vital role in spreading disease between wild and domestic animals (Nair and Jayson, 2016 a).

**5.4.2.4. Discussion**

A substantial increase in the population and distribution of wild pig in the world was observed in many studies (Apollonio *et al.*, 2010; Massei *et al.*, 2011) and it has one of the broadest geographical distribution (Groves, 1991), due to its ability to occupy the wide range of environment (d'Huart, 1991). The incidents of crop damage by wild pigs have been reported for decades by farmers in the Indian subcontinent (Chauhan *et al.*, 2009) and it became a severe problem of farmers in Bhutan (Choden and Nagmay, 1996). Six agricultural crops were mainly found damaged by the wild pig in the area, namely plantain, coconut, paddy, tapioca, rubber and colocasia.

a. Rabid pig bite on left hand finger

b. Rabid pig attack on hand

**PLATE 17: Wild pig (*Sus scrofa*) rabies**

As it is an omnivorous animal, food items like roots, tubers, bulbs, fruits, insects, mollusks and remains of carnivore's kill, are contributing towards its diet (Prater, 1980; Tisdell, 1982; Seshadri 1986). The major component of wild pigs diet is always one energy-rich plant food from the agricultural crops and among animal food they consume insects, earthworms, birds and mammals with a lesser amount of amphibians reptiles and gastropods (Schley and Roper, 2003). The uprooting and digging behaviour of wild pig in search of invertebrate prey and underground plant parts will make holes in considerable depth on the ground and it was causing substantial damage to grasslands and crops (Ahmed, 1991; Jeyasingh, 1999; Punidan *et al.*, 2003). Due to this behaviour, wild pig caused heavy damage to the paddy cultivation of the District by plowing and wallowing in the paddy fields (n=13) in search of soil organism and also feeding on the milky stage of the paddy. Similar mode of damage was reported from the wheat fields of north-east Iberia by Herrero *et al.* (2006).

Frequency of damage to crops by wild pig decreased with increasing distance from the forest (Thurfjell *et al.*, 2009). Plantain and fallen coconuts were the most targeted crops by the wild pig in the area. Damage to these two crops with a loss of 88 per cent and 11 per cent respectively were recorded in the District irrespective of the distance from forest. Damage to these two species was reported previously from Kerala (Jayson, 1999; 2013, Veeramani and Jayson, 1995). In North Indian states of Uttar Pradesh, Himachal Pradesh and Madhya Pradesh finger millet (38%), maize (14%) and paddy (26%) were the highest damaged crops respectively (Chauhan *et al.*, 2009). Maize, wheat, barley, rye, oats, rice, sorghum, potatoes, grasses and sugar beets were the destroyed crops of wild pig in Europe, which resulted in huge economic loss and farmer's irritation towards the animal (Schley and Roper, 2003). Maize and potato were recognized as vulnerable crops to wild pig depredation in and around Giant Panda Reserve, China (Cai *et al.*, 2008). In European countries, the crop-raiding by wild pig follows a seasonal pattern based on the species of the cultivated crops (Schley *et al.*, 2008; Herrero *et al.*, 2006; Amici, 2012). No such seasonal pattern in the crop-raiding of wild pig was observed in the present study because they have no preference for the particular growing stage of plantains and fallen coconuts were always available in the farms. Hundred per cent of occurrence of wild pig was recorded in the crop field of Vazhikadavu and Edavanna Forest Ranges irrespective of the seasons.

Presence of wild pig caused severe effects on economy and environment in the ecosystem in which it lives (Herrero *et al.*, 2006). Mean economic loss in the District was estimated as INR 34,460.34/- (US$ 502.04) per ha per annum. There are many studies around the world on economic loss due to crop damage by wild pig (Chhangani and Mohnot, 2004; Pimentel *et al.*, 2005; Jayson, 2013; Poudyal *et al.*, 2017). The loss estimated in this study was higher than the mean economic loss of INR 3,736/- (US$ 54.48) per ha per annum estimated in the Thrissur District of Kerala (Jayson, 2013) (Table 42).

Table 42. The comparison of economic loss due to wild pig from different studies

| **Sl. No.** | **Area** | **Economic loss reported (US$)** | **Major crops damaged** | **Main season of attack or months** | **Source of information** |
|---|---|---|---|---|---|
| 1. | Malappuram (Kerala, India) | US$ 502.04 /ha/annum | Plantain & fallen coconut | All the months | This study (2019) |
| 2. | Thrissur (Kerala, India) | US$ 54.48/ha/ annum | Fallen coconut & plantain | All the months | Jayson (2013) |
| 3. | Rajasthan | US$ 2500-3000/ annum | Maize (*Zea mays*) & Sugar cane (*Saccharum officinarum*) | August to October | Chhangani and Mohnot (2004) |
| 4. | Australia | US$74.22 million/ annum | Sugar cane (*Saccharum officinarum*) | May to November | Choquenot *et al.* (1996) |

The wild pig has become more dangerous and was even attacking and killing people in Bhutan (Choden and Nagmay, 1996). Majority (84.21%) of the human injuries was caused by solitary pig and the remaining 15.78 per cent was caused by the sounder and the time of the attack was during 08.00-12.00 hrs (52.62%) which is comparable to the observations from five North Indian States (Chauhan *et al.*, 2009). The highest number of human fatalities was in the age group of 50- 55 years and none of them was vehicle collision and most (57.89%) of the human casualties occurred during July and August and no human deaths were reported in the District. In the North Indian States, the highest number of human casualties was in the age group of 41-50 years which occurred in November (Chauhan *et al.*, 2009).

Wild pigs are colonizing in new habitats such as densely populated urban areas and landscapes dominated by agriculture (Cahill and Llimona, 2004; Keuling *et al.*, 2009; Podgórski *et al.*, 2013). Fifty-seven per cent of the wild pig encounters on people were recorded on the tarred roads or close to the road in highly populated areas and three incidents occurred in a populated town center. Due to hunting pressure and human activity during the day, the wild pig become more nocturnal in their activity (Mayer and Brisbin, 2009) where as in the areas with minimum disturbance the animal tends to be diurnally active (Mayer, 2013). India has very stringent Wildlife Protection Law and wild pig comes under schedule III of the Wildlife Protection Act (1972). Most of the people in the District were well aware about the consequences of the violation of wildlife law and because of this wild pigs are roaming around the human habituations. Due to these circumstances, in contrast to the observations of the most number of attacks within the forest land by Chauhan *et al.* (2009) in the North Indian states, all the attacks on human beings in this study were occurred outside the forest land.

Thirteen people were seriously injured due to the WPVC on the road in the district. It is reported that one of the animal species majorly contributing towards the vehicle collision on the roads is the wild pig (Lagos *et al.*, 2012). The risk of wildlife collision with vehicle increase in area with the higher number of forest patches and a higher total length of forest edges in Northern Poland (Jakubas *et al.*, 2018) whereas in the

Malappuram District more than the close proximity of the Reserve Forest the road edged by rubber plantations contributed to the risk of WPVC. Eighty-seven per cent of WPVC occurred during the early morning period (05.00 - 06.30 hrs) and late evening (18.00 – 19.30 hrs) even though the same observation was made in many other studies on ungulate-vehicle collision (Haikonen and Summala, 2001; Putzu *et al.*, 2014), Mayer and Johns (2007) in their analysis of 179 wild pig-vehicle collisions from west-central South Carolina found that wild pig-vehicle collisions occurred throughout the 24 hrs daily time period and most accidents were at night. It was found that all the four victims of the wild pig-motor bike collision happened in the early morning hours were rubber tapping employees because by the nature of their duty they have to reach in the rubber plantation in the early morning hours. So, as they rush through the road and wild pig were also very active in the morning hours.

Due to the lack of thermoregulatory system in wild pigs, in hot and dry air conditions, they always love to stay in shaded, water logged and cool moist places (Howe, *et al.,* 1981, Dexter, 1998). Unavailability of shelter areas will reduce the wild pig population in a particular area (Herrero *et al.,* 2006). A number of unmanaged lands with thick vegetative undergrowth were recorded in many locations of the District, especially associated with rubber plantations, which are acting as the resting and homing place for the wild pigs. The cover of permanent crops, urban areas, forests and scrublands and the distance from the shelter areas were identified as the most important variables explaining the presence of wild pig damage (Lombardini, 2016).

Wang *et al.* (2006 a) opinioned that the extermination of wild dogs (*Cuon alpinus*), which is the principal predator in the early 1980s, could be the reason for the elevation of wild pig population as a serious problem.

Table 43. Population status of wild pigs in Malappuram District

| Sl. No. | Year | Forest Division | Animal density (No./km$^2$) |
|---|---|---|---|
| 1 | 1997 | Nilambur north | 0.1989 |
| | | Nilambur south | 0.2149 |
| 2 | 2002 | Nilambur north | 0.5029 |
| | | Nilambur south | 0.2300 |
| 3 | 2011 | Nilambur north | 0.1313 |
| | | Nilambur south | 0.1918 |

Easa and Jayaraman, 1998; Easa *et al.*, 2002; Sivaram *et al.*, 2013

Due to its high reproductive output and dispersal potential with its great adaptability to a wide range of environments, wild pigs establish its population rapidly. So that it can be seen in all the places including the human altered environment (Fadeev, 1975; Erkinaro *et al.*, 1982; Ahmed, 1991).

The population estimation of the wild pig showed that there is an increase in its density in both the Forest Divisions during 2002 census compared to 1998 census. But in the next population estimation after eight years of gap again marked a decrease in the animal density in the two Forest Divisions of Malappuram District (Table 43). The crop damage is positively related to the abundance of wild pigs in the area (Schley *et al.*, 2008). However in the study area this variation in the population size did not made any difference in their occurrence in the agricultural lands or in the damage to agriculture crop because it remains in the same intensity as before (Personal observation during field visit and data from Kerala Forest and Wildlife Department).

### 5.4.3. Bonnet macaque

An aggressive behavior from a solitary bonnet macaque was recorded in Vazhikadavu town (11°22’54.4”N and 76°20’30.9”E). It has regularly stolen vegetables and fruits from the traders by suddenly entering into the stalls. It was also aggressive towards the people without any provocation. Three school students were injured severely by its attack on their way to school in the morning. The school was in the town itself which provided enough food sources for the macaque. The Forest Department had set up the cage near the school to trap the animal. After five months the monkey left the area as a result of the proper waste management system assured in the school compound and also the vegetable stalls and other shops in the town center were protected by using a green coloured nylon net to avoid the dust from the road. “Nadukani churam” is only 3 km away from the Vazhikadavu town in which the monkeys were quite often fed by tourists as it is the resting place for the travelers towards the major tourist place Ooty in Tamil Nadu.

#### 5.4.3.1. Kyasanur Forest Disease

Kyasanur Forest Disease (KFD) is a viral disease caused by a member of the virus family *Flaviviridae*. Virus of Kyasanur Forest

Disease was first reported in 1957 as it was isolated from an infected monkey in the Kyasanur Forest in Karnataka (formerly Mysore) State, India. Eight cases of death of monkeys due to infection with KFD virus recorded from Karulai forest range and two cases from Kalikavu forest range. The disease outbreak in Nilambur Forest Divisions occurred during the middle of 2014. The presence of virus in the dead bodies was confirmed from the Pookod Veterinary College, Wayanad. Four cases of positive KFD were identified from tribal under Karulai forest range and all victims were above 15 years of age, no human death reported during the period by KFD. The cases were tested at National Institute of Virology, Pune by Ig M ELISA and RTPCR also.

**5.4.3.2. Discussion**

Potential economic loss due to crop damage by macaques was estimated as Rs.17203.99/- (U.S.$ 236) per ha per annum (Rs.12791.67/- by Bonnet macaque and Rs.4412.32/- by Hanuman langur) in the District. Annual crop loss per household caused by macaques has been reported as U.S$ 66 in India (Maikhuri *et al.*, 2001), U.S.$ 112 in Nepal (Studsrod and Wegge 1995), and U.S.$ 53 in Tibet (Jackson, 1998).

Guarding dogs along with watchers was effective to some extent against the crop-raiding monkeys. Translocation is identified as the most successful method to reduce the human-monkey conflict of an area in many studies (Southwick *et al.*, 1984; Imam, 1991; Imam and Malik, 1997). Along with dogs, continuous vigilance by watchers in the field to chase the macaques away from the plantation by using crackers and producing sounds was found effective to reduce the damage by macaques.

The coconut plantation was the highly targeted area by the macaques. The damage was caused due to the consumption of the tender coconut and thereby reducing the final yield of coconuts. The economic loss estimated in this study was only from the damage to coconuts. Both species of macaques consumed coconuts after climbing the coconut palm and the coconuts were not carried away for consumption. All the damaged coconuts can be counted from the ground right below the coconut palm. Consumption of immature coconuts by Colobus monkeys was reported in Tanzania (Siex and Struhsaker, 1999). Rice, maize, cardamom and millet were the major crops damaged by macaques in Nepal and among these, cardamom was the most damaged one. They were following a seasonal pattern for raiding as most of these crops were raided few weeks prior to harvesting (Ghimirey *et al.*, 2018). The highest percentage of conflict cases by urban rhesus macaques in Asola-Bhatti Wildlife Sanctuary was during the summer season (March-June) and least in the monsoon season (July-September) (Ganguly *et al.*, 2018). No such seasonal patterns were observed in the present study as the availability of coconut was throughout the year.

Hanuman Langur is an arboreal and diurnal species which prefers spending their time by jumping from tree to tree and during foraging time some members of the species may become habituated to living close to the human settlements (Tritsch, 2001). The mean troop size of the hanuman langurs in Kumbhalgrah, Rajasthan was 23 (Vogel, 1971) and in Kanha National Park, Madhya Paradesh, was 21 (Newton, 1987). A single troop of hanuman langur with a troop size of 23 individuals was recorded in the Kalikavu Forest Range and they were sharing habitat with bonnet macaque. During the foraging time, the langurs always targeted the coconut palms very close to the Reserve Forest, where as bonnet macaques were always ready to tolerate human presence, so that they can concentrate the coconut palms which were more close to the human habitations.

The primates were creating problems when they start to supplement their natural food with stolen food from people or with the garbage found around the Reserve Forest, picnic sites and suburban areas (Sharma, *et al.*, 2011). The aggressive behaviour of the solitary bonnet macaque in the Vazhikadavu town was due to the unmanaged garbage in and around the vegetable market and school compound. The monkey attacked the school boys as it was attracted towards the school compound and also due to the provoking behaviour of the students. In Dehradun every aggression between macaque and humans was happened due to some kind of provocation from either side (Beisner *et al.*, 2015). More than old aged people, young and adults were the victims of monkey attack, because they were involved in provoking the macaques more frequently than the others (Ganguly *et al.*, 2018). Most of the conflicting events between macaques and human beings in Delhi NCR occurred on road sides, temple premises, open garbage disposal sites and vegetable markets (Ganguly *et al.*, 2018).

Kyasanur Forest Disease had been endemic to Shimoga, Uttara Kannada, Dakshina Kannada, Chikkamagaluru and Udupi Districts of Karnataka State until 2012. A total of 823 confirmed cases and 28 deaths were reported from Karnataka during 2003-2012 (Holbrook, 2012). The disease outbreak occurred in the study area also and death of ten monkeys was confirmed. After the death of infected monkeys, the ticks detach from the carcasses to the surrounding areas and thereby producing hot-spots of infectious ticks (Mourya *et al.*, 2014; Murhekar *et al.*, 2015). It is very dangerous to visit the spot when monkey deaths are reported due to the high chance of exposure to the infected ticks (Sadanandane *et al.*, 2017). The humans were affected with the disease most of the time through the bite of an infected nymph (Trapido, 1957; John *et al.*, 2014). In the present study, all the affected human victims were from tribal communities who frequently came into contact with the monkeys and ticks. Moreover the Kattunayakan tribes were living deep inside the forest and they have a habit of trapping monkeys for meat. The first case of KFD in the Kerala part reported in Noolpuzha-Alathur colony of Wayanad District In 2013 (Sadanandane *et al.*, 2017). The Wayanad forest is sharing its boundary with the Bandipur, Chamarajanagar District of Karnataka and also with the Reserve Forest of Malappuram District so the movement of infected monkeys can happen through this and spreading of disease also occurred.

### 5.4.4. Live stock depredation by large carnivores

As in other developing countries livestock holding and agricultural practices were inevitable part of rural people’s livelihood in the study area. They were depending on cattle and goat as their livestock in the forest fringe areas and the grazing of these domesticated animals in and around the reserve forest is a usual practice. The forest fringes in the Malappuram District were covered with Rubber plantations. After the early morning hours of rubber taping, usually no human presence will be there in the plantations. This situation created a favorable condition for the wild carnivores to attack the domesticated animals.

Table 44. Details of cattle lifting incidents by carnivores.

| Sl. No. | Places | Species involved | Prey species | Time of attack | Date | Distance from the forest (m) |
|---|---|---|---|---|---|---|
| 1 | Kuruniyambalam | Leopard | cow | 03.00 | 16/01/2015 | 200 |
| 2 | Vallipoola | Leopard | goat | 18.00 | 03/01/2015 | 50 |
| 3 | Mulliyarkurussi | Leopard | cow | 06.00 | 08/05/2015 | 15000 |
| 4 | Arnadampadam | Leopard | goat | 18.30 | 23/06/2015 | 114 |
| 5 | Kalkundu | Wild dog | goat | 18.00 | 11/12/2015 | 300 |
| 6 | Venghaparutha | Leopard | goat | 18.30 | 10/07/2014 | 10 |

A total of six cattle-lifting incidences recorded and five of them were by the leopard (*Panthera pardus*) and one was by the wild dog (*Cuon alpines*). The prey species involved were ten goat and three cows (one calf and two adults) (Fig. 35 & Table 44). The highest number (5) of incidents was recorded in Kalikavu Forest Range (Fig. 36). Four incidences occurred while the cattle and goats were out for grazing near the rubber plantation which shared its boundary with Reserve Forest. One calf of ten months old predated by leopard from the corral itself in the early morning and it happened only 200 m away from the Reserve forest. The pugmark of leopard identified from the site of the attack (Plate 18a).

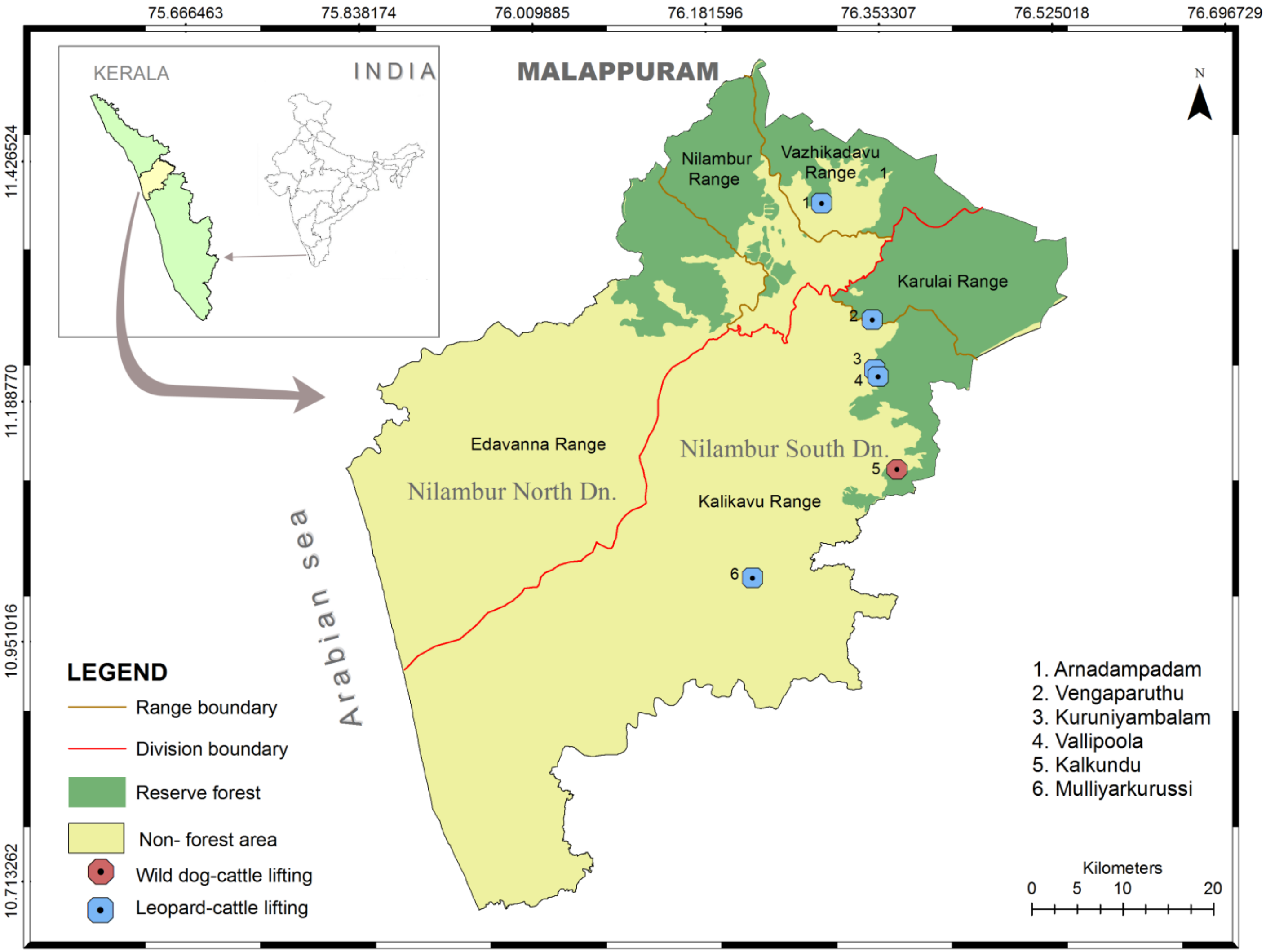



Fig. 35. Locations where cattle lifting incidences occurred

Leopard killed the prey by biting on the neck and dragged it to near to the forest. The carcass of the calf found eaten from the abdominal part, which is the typical feeding sign of leopard (Plate 18b). There is no seasonal pattern in the attack of a carnivore on domestic animals (Fig. 37).

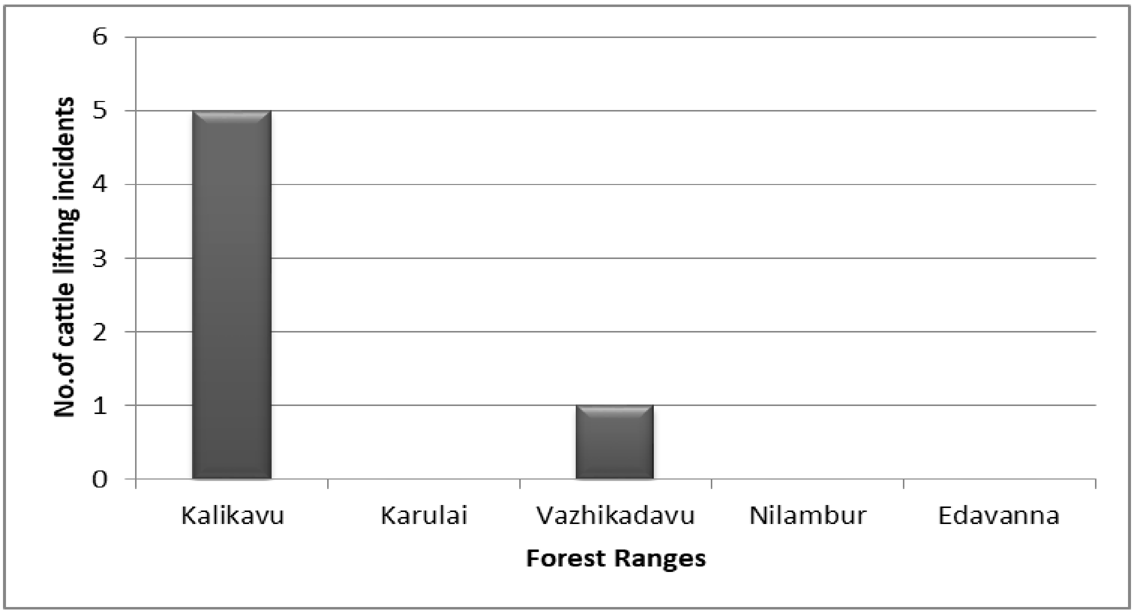



Fig. 36. Cattle lifting incidents recorded in different Forest Ranges

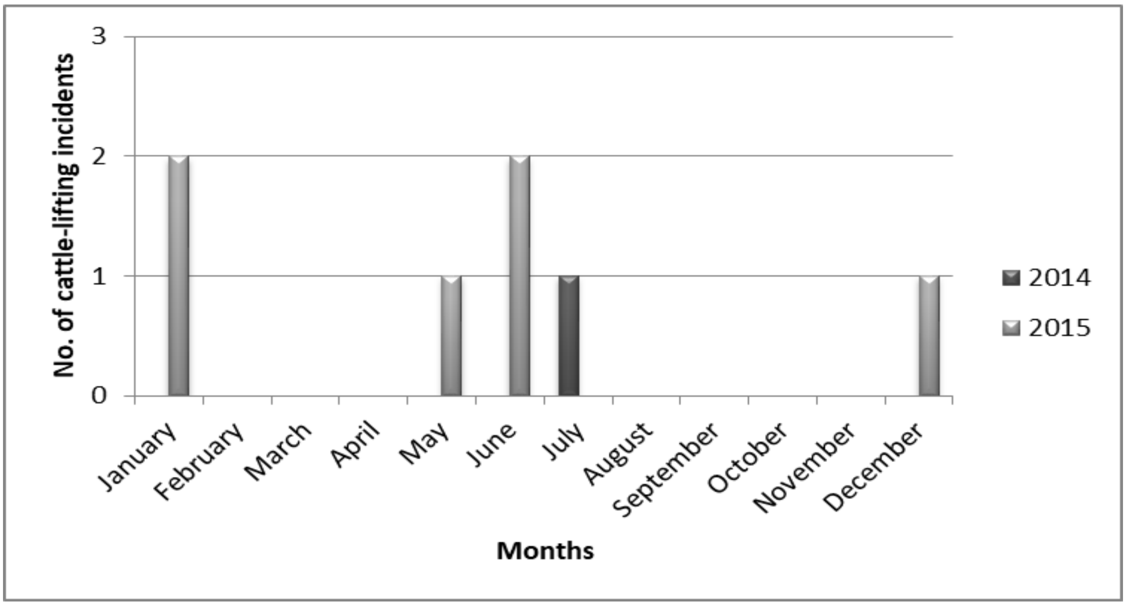



Fig. 37. Month wise record of cattle lifting incidents (2014-2016)

a. Pugmark casting in plaster of paris

b. Leopard (*Panthera pardus*) attack on cattle

**PLATE 18**

The case of Dhole (*Cuon alpinus*) attack occurred at Kalkundu region (11°7’17.69”N and 76°22’16.99”E) under Kalikavu forest range. Four goats attacked by a pack of wild dogs while the goats were out for grazing in the rubber plantation close to the reserve forest. The time of the attack was 18.00 hrs. The area was well known for the presence of wild dogs for the past two years. Wild pigs were occasionally predated by wild dogs in the forest and nearby forest. Sighting of Dhole was reported from the area by the local people in the last 4 months (focus group discussion). The site of the attack was 2 km away from the Silent Valley National Park buffer zone and is near to Koomban para. The presence of the elephant was rare in the area because of the steepness of Koomban para.

A leopard killed two cattle while they were out for grazing in the open space near Kaikottenadi mala (76°13'42.26”E and 11°0'50.49”N). The presence of a leopard was reported from the area a few months back and the officials from Mannarmala Forest Station (Kalikavu Forest Range) placed a camera trap and confirmed the presence of a leopard. A cage with bait was positioned there for 20 days but no animal was trapped. After the cattle lifting incident, Kerala Forest and Wildlife Department tried a second attempt and a five-year-old leopard trapped in the cage by using the same cattle kill (Plate 19a). The animal caught from a six-acre rubber plantation which shared its boundary with a patch of forest (Kaikottanadi mala) at 06.00 hrs. A case of retaliation killing of a leopard also recorded from the T.K Colony.

Sixty-six per cent of the attacks on cattle occurred during the evening hours from the grazing field close to forest. Only in one incident the cattle was lifted from an open cattle pen.

#### 5.4.4.1. Discussion

The depredation of domestic animals by wild animals have became common in areas were wild prey are depleted due to hunting, habitat depredation and competition with livestock (Madhusudan and Mishra, 2003). The leopard is the most widely distributed of all the wild cats in the world (Nowell and Jackson, 1996) and is found throughout the Indian subcontinent with the exception of deserts, the Sundarbans mangroves, and densely settled areas (Khan, 1986; Johnsingh *et al.*, 1991) and is highly adapted to tolerate human presence as well as have great capability to hide itself from the human eyes. Being an edge species, it always shows a tendency to come out of the forest mainly for praying on the livestock. Out of the six incidences in the present study, five were by the leopard. It was observed that most of the houses who keep livestock in the forest fringes will also have dogs for their protection. In addition to these, livestock were provided with cage for their safety. Eighty three percent of the attacks by leopard occurred in the grazing ground which was near a rubber plantation close to the forest boundary. Dogs and livestock were identified as the preferred food items of leopard in many past studies (Gee, 1964; Santiapillai *et al.*, 1982; Daniel, 1996) but leopard killing dog was not recorded in the study area.

Even though there were instances of leopards hunting during the light, especially when the sky is overcast, the leopard is a nocturnal creature. Day time is spent by resting or sleeping on the branches of tress, underneath rocks or in the grass (Khalil and Hussain, 2008). Sixty six percent of incidents occurred during the evening hours (18.00 hrs – 19.00 hrs) and the remaining cases occurred in the early morning. One cattle was lifted from the cattle pen and the other one was from the open space near to rubber plantation which was 15 km away from the Reserve Forest and both these incidences occurred in morning hours by leopard.

Leopard being a generalist can survive by feeding on large as well as medium to small sized prey when the prey availability was low. Leopards can be an efficient scavenger and is not averse to preying upon domestic stock, a behaviour that brings it into direct conflict with humans (Bailey, 1993). Most (74%) of the prey animals of the leopard were medium sized animals.

Livestock, due to their reduced escape abilities compared to wild herbivores, become especially vulnerable to predation (Nowell and Jackson, 1996). During day time the risk of predation of livestock grazing in open habitat was less, if the herd size is small and also if it is accompanied by dogs as well as human herders whereas during the night, the risk of attack was lowest for herds held in enclosures with dense walls, pierced by few gates, where both men and domestic dogs were present (Woodroffe *et al.*, 2007). In the present study neither dogs nor human herders were accompanied with the livestock during the time of carnivore attack.

Dhole were previously widespread in Bhutan but were perceived as pests of livestock and poisoning by farmers exterminated the population. As a result, the wild pig population increased thus resulting in serious crop damage (Choden and Namgay, 1996; Wang and Macdonald, 2006). Increases in crop depredation rates following the establishment of protected areas and implementation of conservation rules have similarly been documented in India (Saberwal *et al.*, 1994; Mishra, 1997; Maikhuri *et al.*, 2001). Kerala Forest and Wildlife Department disbursing some amount as ex-gratia for the affected persons but which was not enough to meet their loss (Fig. 38).

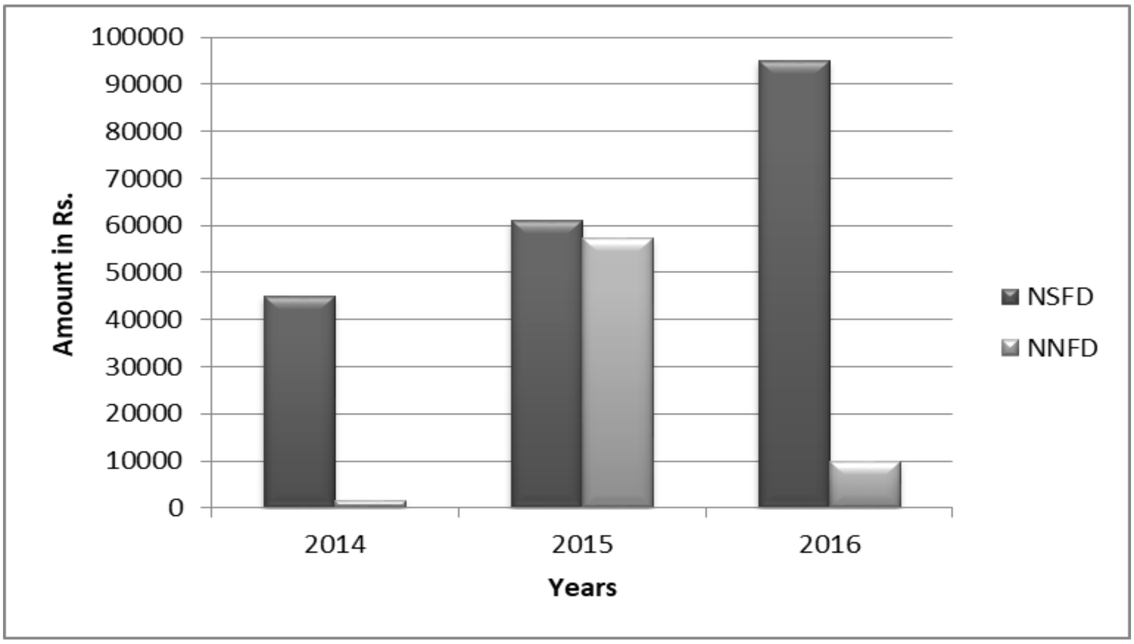



Fig. 38. Details of the Ex-gratia disbursed for the livestock predation.
Note: NSFD= Nilambur South Forest Division, NNFD= Nilambur North Forest Division.

### 5.4.5. Gaur (*Bos gaurus*)

Gaur is the largest bovine in the peninsular India which is in the vulnerable status of the IUCN Red List. Most often they are seen in herds, but old bulls can be solitary or in the company of younger bulls. The habitat of gaur includes evergreen/semi-evergreen forest and plantations. Normally the animal is calm in its nature, whereas once it gets disturbed and feared it would run amok and it lowers the head and raises its tail if a threat is indicated.

**Case study:**

A solitary gaur was first spotted at Mullapally in the Karulai Forest Range (11°16'20.7"N and 76°18'16.7"E) in a rubber plantation close to the Reserve Forest at 6.30 am. It came into the villages of Mayilumpara and Mullapally which was only 2 km away from the Karulai Reserve Forest. When the people started to chase it away from the village, the gaur became aggressive and began to run amok. The uncontrolled rush of the gaur damaged the house walls, the door of a house, a motorbike and cattle pens. The accidental encounter with the gaur caused severe injuries to three people and one of them underwent urgent surgery for survival. The gaur used most of its time to stand in front of its domestic partners like cow and buffalo. Due to the presence of uncontrolled crowd around the gaur and their response to it by throwing stones and also the attempt of people to capture mobile pictures and videos, the situation became worst. The forest officials were forced to shoot the gaur with the help of local police to prevent further damage (Plate 19b).

#### 5.4.6. Ex-gratia disbursed by Kerala Forest and Wildlife Department

The data collected from Kerala Forest and Wildlife Department also revealed that crop damage has a significant role in human-wildlife conflict in the Malappuram District (Table 45 & 46). Both Divisions were equally prone to crop damage by wild animals. Cattle lifting incidents were high in the Nilambur South Forest Division as reported in this study. As the frequency of elephant encounters was high in the

a. Leopard trapped at Mulliyarkurussi

b. Gaur killed at Mayilumpara (Karulai Forest Range)

**PLATE 19**

Nilambur South Forest Division (NSFD), the application for the compensation of property damage was also recorded only in the NSFD. The amount disbursed was highest for crop damage followed by human death, injury, cattle loss and property damage. The death due to snake bite was eligible for the ex-gratia, which was not considered in this study.

Table 45. Ex-gratia disbursed during 2014-17 in Nilambur North Forest Division

| Years | Type of case | No. of application | Amount sanctioned |
|---|---|---|---|
| | Crop damage | 108 | 7,90,039 |
| | Human Death | - | - |
| | Injury | 07 | 1,13,614 |
| **2014-15** | Property Damage | - | - |
| | Cattle loss | 1 | 1,650 |
| | **Total** | **116** | **9,05303** |
| | Crop damage | 50 | 5,08405 |
| | Human Death | 1 (Elephant) | 100000 |
| | Injury | 4 | 36,605 |
| **2015-16** | Property Damage | - | - |
| | Cattle loss | 4 | 57,293 |
| | **Total** | **59** | **7,02303** |
| | Crop damage | 77 | 5,76,355 |
| | Human Death | 2 (Elephant) | 3,00000 |
| | Injury | 1 | 23,575 |
| **2016-17** | Property Damage | - | - |
| | Cattle loss | - | - |
| | **Total** | **80** | **8,99,930** |

Table 46. Ex-gratia disbursed during 2014-17 in Nilambur South Forest Division

| Years | Type of case | No. of application | Amount sanctioned |
|---|---|---|---|
| | Crop damage | 117 | 11,17,535 |
| | Human Death | 13 (Snake bite) | 13,00,000 |
| | Injury | 18 | 4,73,890 |
| **2014-15** | Property Damage | 7 | 66,678 |
| | Cattle loss | 3 | 45,000 |
| | **Total** | **158** | **30,03,103** |
| | Crop damage | 56 | 5,41,980 |
| | Human Death | 8 (Snake 7, Elephant 1) | 12,00,000 |
| **2015-16** | Injury | 6 | 1,92,400 |
| | Property Damage | 3 | 48,800 |
| | Cattle loss | 6 | 61,000 |
| | **Total** | **79** | **20,44,180** |
| | Crop damage | 83 | 13,95,795 |
| | Human Death | 6 (Snake bite) | 6,00,000 |
| | Injury | 13 | 4,50,748 |
| **2016-17** | Property Damage | 6 | 43,760 |
| | Cattle loss | 8 | 95,050 |
| | **Total** | **116** | **25,85,353** |

### 5.4.7. Death of wild animals

The HWC has strictly had a loss on wild animals. The number of wild animal species lost their life during the study period is given in Table 47. The reasons like unmanaged waste disposal near the forest area, uncontrolled involvement of mass into the situation of wildlife rescue, the retaliatory response against the wild animals were contributed much to the death of wildlife reported in this study.

Table 47. Details of Wild animal death in the Nilambur Forest Divisions (2013-2016)

| Sl. No | Name of species | No. of death | Remarks |
|---|---|---|---|
| 1 | Asian elephant | 46 | Various reasons |
| 2 | Wild pig | 2 | Vehicle collision and Rabies |
| 3 | leopard | 1 | Reported retaliatory killing |
| 4 | Bonnet macaque | 8 | Kyasanur Forest Disease |
| 5 | Gaur | 1 | Shot dead by the officials |

Each animal has its role to play in this ecosystem. So any strange events that cause its removal from the ecosystem will definitely affect the ecological balance. That has to be addressed appropriately to understand the depth of ecological impact. So the future research needs to focus on this area, especially on all the tangible and intangible effects and that should express in monetary loss.

## 5.5. Conservation attitude

### 5.5.1. Introduction

The conservation attitude of the farmer community in the Malappuram District was assessed with the help of questionnaires as described in the method. A sufficient understanding of the perceptions of the people concerning human-wildlife conflict is essential to solve or mitigate the human-wildlife conflict as it is a social need.

Three hundred households were surveyed from twenty-five Panchayaths in the District (Table 48). The most households were surveyed from Kalikavu Forest Range (53.33%) followed by Nilambur Range (16.66%). Twenty-five Panchayaths were included in the survey and most of the settlements were spread out (95.33%) with the remaining (4.67%) clustered (less than 10 m apart distance).

Table 48. Panchayaths surveyed from different Forest Ranges

| **Sl. No.** | **Forest Ranges** | **Name of the Panchayaths surveyed** | **Number of grids selected** |
|---|---|---|---|
| 1 | Kalikavu | Amarambalam, Mambad, Chokkad, Wandoor, Thiruvali, Kalikavu, Thrikalamgodu, Porur, Karuvarakundu, Thuvvur, Pandikkad, Edapatta, Keezhattur | 32 |
| 2 | Karulai | Karulai | 4 |
| 3 | Edavanna | Urngattiri, Keezhparambu, Edavanna, Areekkode, Kavannoor, Kuzhimanna | 9 |
| 4 | Vazhikadavu | Pothukallu, Vazhikadavu, Edakkara | 5 |
| 5 | Nilambur | Chungathara, Nilambur | 10 |

### 5.5.2. Demography

Both male and female responded to the structured questionnaire survey. The age limit was between 18 to 80 years and all of them were permanent residents of the area. Ninety-five per cent of the respondents depended on open well as their source of drinking water. Educational status revealed that 10.7 per cent of the respondents attended lower primary school and 31 per cent attended upper primary school. Among them, 45 per cent completed high school education and 12.3 per cent underwent more than high school education. Only 1 per cent of the respondents were illiterates.

### 5.5.3. Crop damage

A total of 8 crops were cultivated by the respondents in the Malappuram District, namely coconut, arecanut, rubber, turmeric, ginger, plantain, cassava and vegetables. Eighty-two per cent of the respondents reported wild pig as the major crop-damaging species followed by Bonnet macaque (11.16%), Asian elephant (6.05%) and Indian crested porcupine (0.47%) (n=215) (Fig. 39). According to the majority of respondents (62.33%), the time of crop-raiding was during night hours followed by diurnal (8.33%) and both diurnal and nocturnal (2.33%). The remaining 27% answered that either they have no crop loss due to animals or they were unaware about the time of crop-raiding.

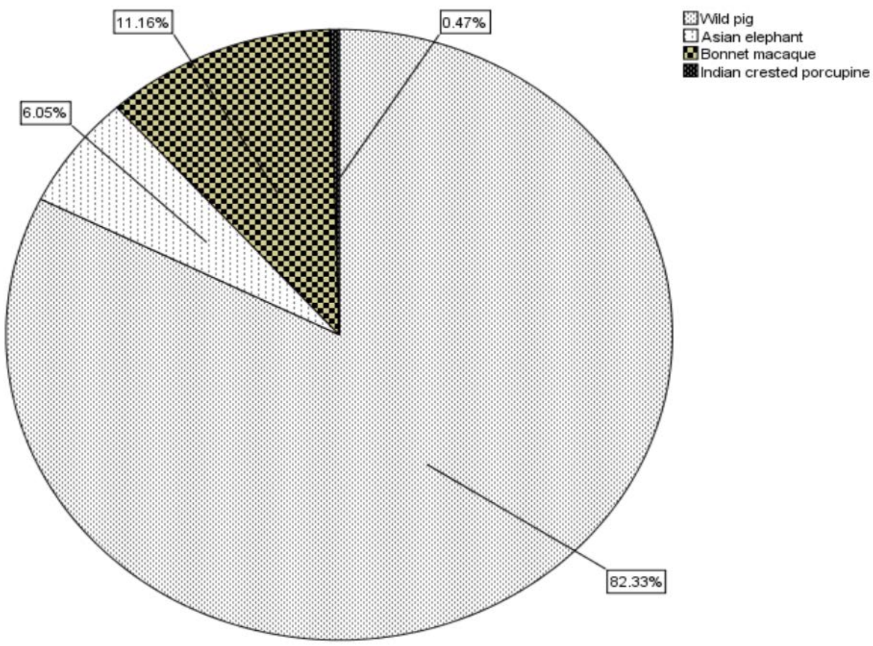



Fig. 39. Major crop damaging species recorded in the District (n=215).

Forty per cent and above crop damage reported by 52.1 per cent of the respondents. Most of the respondents (68.3%) were unaware of the ex-gratia paid by the Kerala Forest and Wildlife Department for the crop loss and only 3 per cent received any compensation for the crop loss. According to the farmers, the most vulnerable crop was plantain (61.93%) followed by coconut (21.10%), tuber crops (7.34%), paddy (4.59%), rubber (2.75%), vegetables (1.38%) and arecanut (0.92%) (n=218). Fifty-one per cent of the farmers were not using any kind of mitigation measure against crop-raiding animals, 35% used fences around the farm, 6.3% of the farmers were using crackers to deter the animals, 3% were using both crackers and fence, 1.3% fence and watch and ward, 1.3% crackers and watch and ward, 0.7% fence, watch and ward and crackers, 0.3% watch and ward, 0.3% animal guarding and 0.3% watch and ward and animal guarding.

Regarding the frequency of wild animal attack in the farmland, most (38.67%) of the households reported the daily presence of wild animals in the farmland (Fig. 40). Wild pigs and Bonnet macaques were the two animal species responsible for the daily crop-raiding reported in the District. Twenty six per cent of the household surveyed were not reported any damage due to wild animals.

A positive correlation ($r_s = 0.188$; $P < 0.01$) is observed between the extent of agriculture land possessed by the farmers and the percentage loss reported by them and there is a negative correlation ($r_s = -0.304$; $P < 0.01$) between the per cent of crop loss to wild animals per year to the distance from reserve forest (n=300). An average of 45.02±13.59 per cent of loss was estimated in the annual income of the farmers (n=216) due to the crop damage by wild animals.

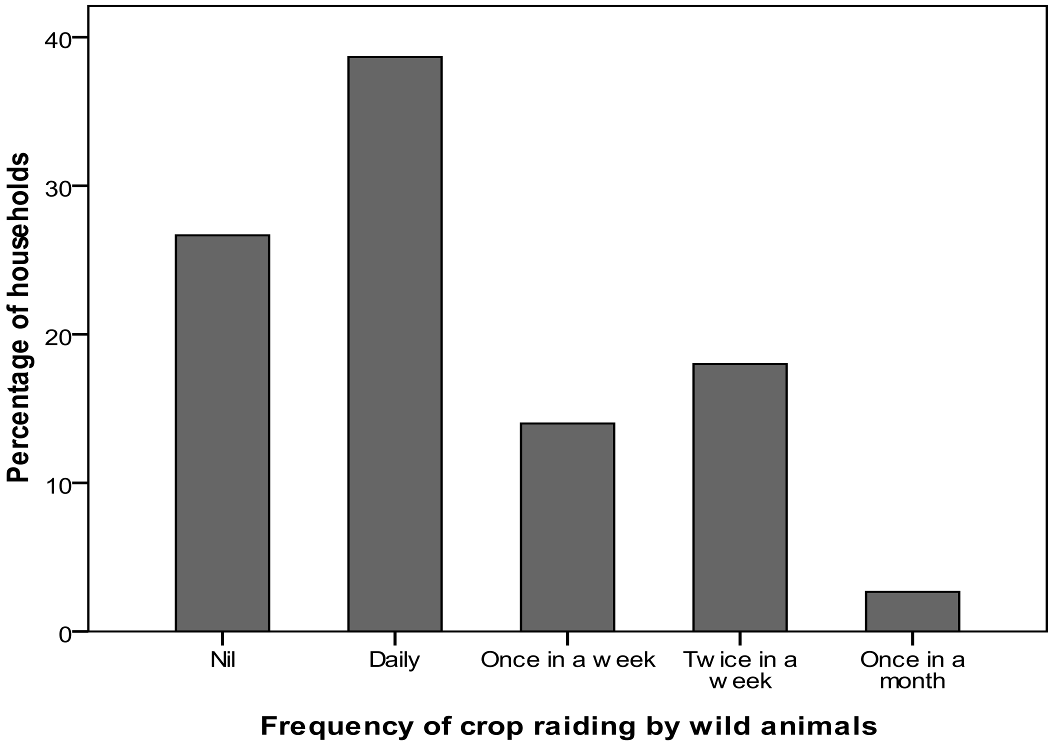



Fig. 40. Frequency of crop-raiding by wild animals in the District (n= 300)

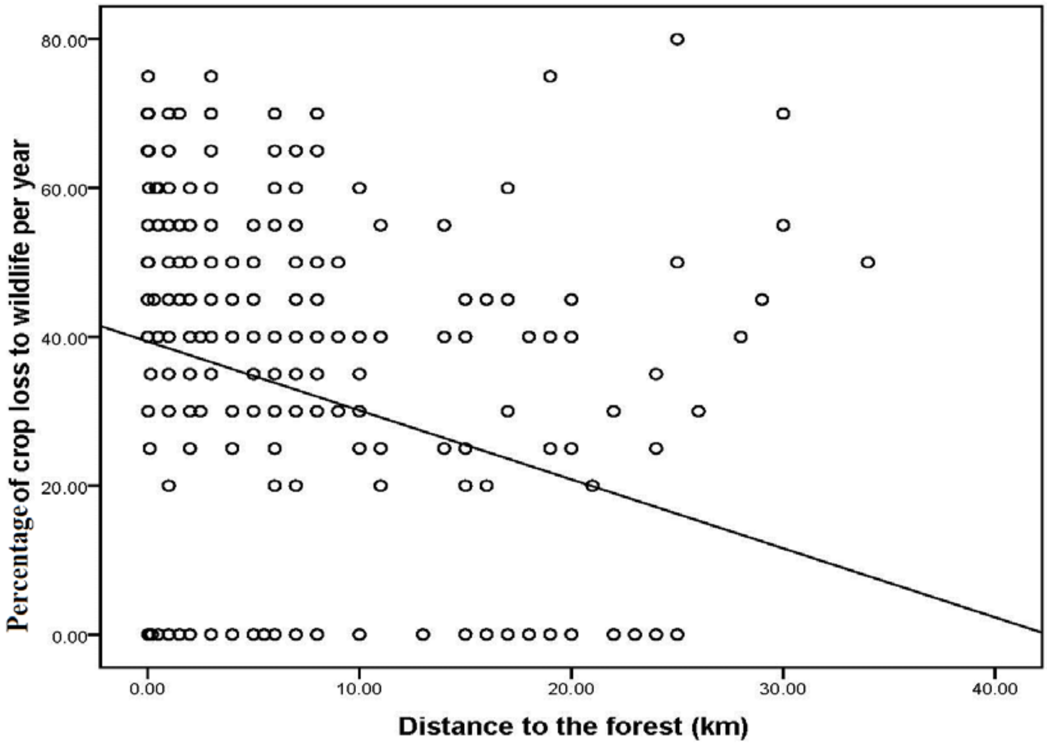



Fig. 41. Relationship between distance to forest and crop loss to wildlife (n=300) ($F(1,298)=30.313$, $p < 0.001$) with an $R^2$ of 0.092

A simple linear regression was performed to predict the effect of distance from the forest on the reported crop loss. A significant regression equation was found ($F(1,298)=30.313$, $P < 0.001$) with an $R^2$ of 0.092. The predicted crop loss is equal to 39.381-0.927(distance to forest) percentage when the distance was measured in kilometer (Fig. 41).

### 5.5.4. Prediction of potential areas of crop loss in the District

Twenty priori models were prepared using seven explanatory variables which may influence the prediction of potential areas of crop loss in the District (Table 49). Out of these, four factors were identified to have an influence on the prediction of crop damage by wild animals around the Reserve Forest of Malappuram District. They are elevation, residing duration, Number of crop-damaging animal species and number of cultivated crops (Table 50 & 51). Elevation ($\beta$= 0.017) and Residing duration ($\beta$= -0.031) has a little effect on the prediction as its value of beta coefficient is comparatively low. Residing duration has a negative coefficient which means the crop loss will decrease with increasing duration of settlements. Number of crop-damaging animal species ($\beta$= 14.71) and the number of cultivated crops in area ($\beta$= 2.044) are the two variables which have major effects on the prediction of crop loss. The mean estimated probabilities of crop loss for households around the Reserve Forest was 0.271 (S.E = 0.009, range 0.06 – 0.57). The prediction map showed that all the forest ranges except Edavanna Range have the places with a high value of crop loss. The major places identified to have a high value for crop loss to animals are Manimooly from Vazhikadavu Range, Veralimunda from Karulai Range and Munadi from Kalikave Range (Fig. 42). A median value of crop loss was estimated in most of the eastern part of the District irrespective of their close proximity to the Reserve Forest.

Table 49. Models included for the selection of best model using $AIC_C$ value

| Sl. No. | Model | AICc | $\Delta i$ | $w_i$ |
|---|---|---|---|---|
| 1 | agriland + distrf + ncrcult | 1793.797 | 147.205 | 0 |
| 2 | agriland + distrf + ncrdsp | 1665.783 | 19.191 | 0 |
| 3 | agriland+ ncrdsp+elev | 1665.751 | 19.159 | 0 |
| 4 | **ncrdsp + ncrcult + residu** | **1646.776** | **0.184** | **0.476** |
| 5 | **ncrcult + elev+ ncrdsp** | **1646.592** | **0.000** | **0.524** |
| 6 | elv+ ncrdsp+distrf | 1670.112 | 23.520 | 0 |
| 7 | ncrdsp + distrf + residu | 1670.364 | 23.772 | 0 |
| 8 | agriland + distrf | 1858.313 | 211.721 | 0 |
| 9 | distrf + ncrcult | 1791.962 | 145.370 | 0 |
| 10 | ncrcult+ agriland | 1817.187 | 170.595 | 0 |
| 11 | agriland + residu | 1882.508 | 235.916 | 0 |
| 12 | residu+ ncrcult | 1817.181 | 170.589 | 0 |
| 13 | agriland + ncrdsp | 1664.321 | 17.729 | 0 |
| 14 | distrf + ncrdsp | 1668.922 | 22.330 | 0 |
| 15 | elev +ncrcult | 1807.654 | 161.062 | 0 |
| 16 | elev + ncrdsp | 1668.995 | 22.403 | 0 |
| 17 | agriland +nasetlm | 1880.710 | 234.118 | 0 |
| 18 | distrf + nasetlm | 1864.748 | 218.156 | 0 |
| 19 | ncrcult + distrf + nasetlm | 1790.917 | 144.325 | 0 |
| 20 | Ncdsp+nsettle | 1867.836 | 221.244 | 0 |

Agriland- Agriculture land area in acres; Distrf- Distance to reserve Forest; Nsettle- Nature of settlement; Ncrcult- No. of crops cultivated; Ncdsp- No. of crop damaging species; Elev- Elevation; Residur- Residing duration.

Table 50. Top ranked models (cumulative weight>1) for predicting the crop damage around the Reserve Forest of Malappuram District

| Sl. No. | Model No. | 4 | 5 |
|---|---|---|---|
| | | $w_{i=}$ 0.476 | $w_{i=}$ 0.524 |
| | Intercept | 4.036 (2.610) | 2.772 (2.40) |
| 1 | Elevation | NA | 0.017 (0.26) |
| 2 | Residing duration | -0.031 (0.06) | NA |
| 3 | No. of crops cultivated | 3.882 (0.77) | 3.772 (0.75) |
| 4 | No. crop damaging species | 14.804 (0.97) | 14.655 (1.00) |
| | Model $AIC_C$ | 1646.776 | 1646.592 |
| | $\Delta$ $AIC_C$ | 0.18 | 0.00 |

Note: Standard errors in bracket, $w_i$ is the AIC model weight, $\Delta$ $AIC_C$ is the difference in values between lowest AIC model and each model.

Table 51. Composite model and coefficients for predicting the crop damage around the Reserve Forest of Malappuram District

| Sl. No. | Model No. | 4& 5 |
|---|---|---|
| | | Cumulative $w_{i=}$ 1 |
| | Intercept | 3.370 (2.57) |
| 1 | Elevation | 0.017 (0.26) |
| 2 | Residing duration | -0.031 (0.06) |
| 3 | No. of crops cultivated | 2.044 (1.91) |
| 4 | No. of crop damaging species | 14.71 (0.98) |
| | Model $AIC_C$ | 1646.776 & 1646.592 |

Note: Standard errors in the bracket; $w_i$ is the $AIC_C$ model weight.

### 5.5.4.1. Discussion

People living close to the wildlife habitats gradually learned to avoid the presence of animals in their cropland. As the duration of settlement increases the reaction of people against wild animals around their

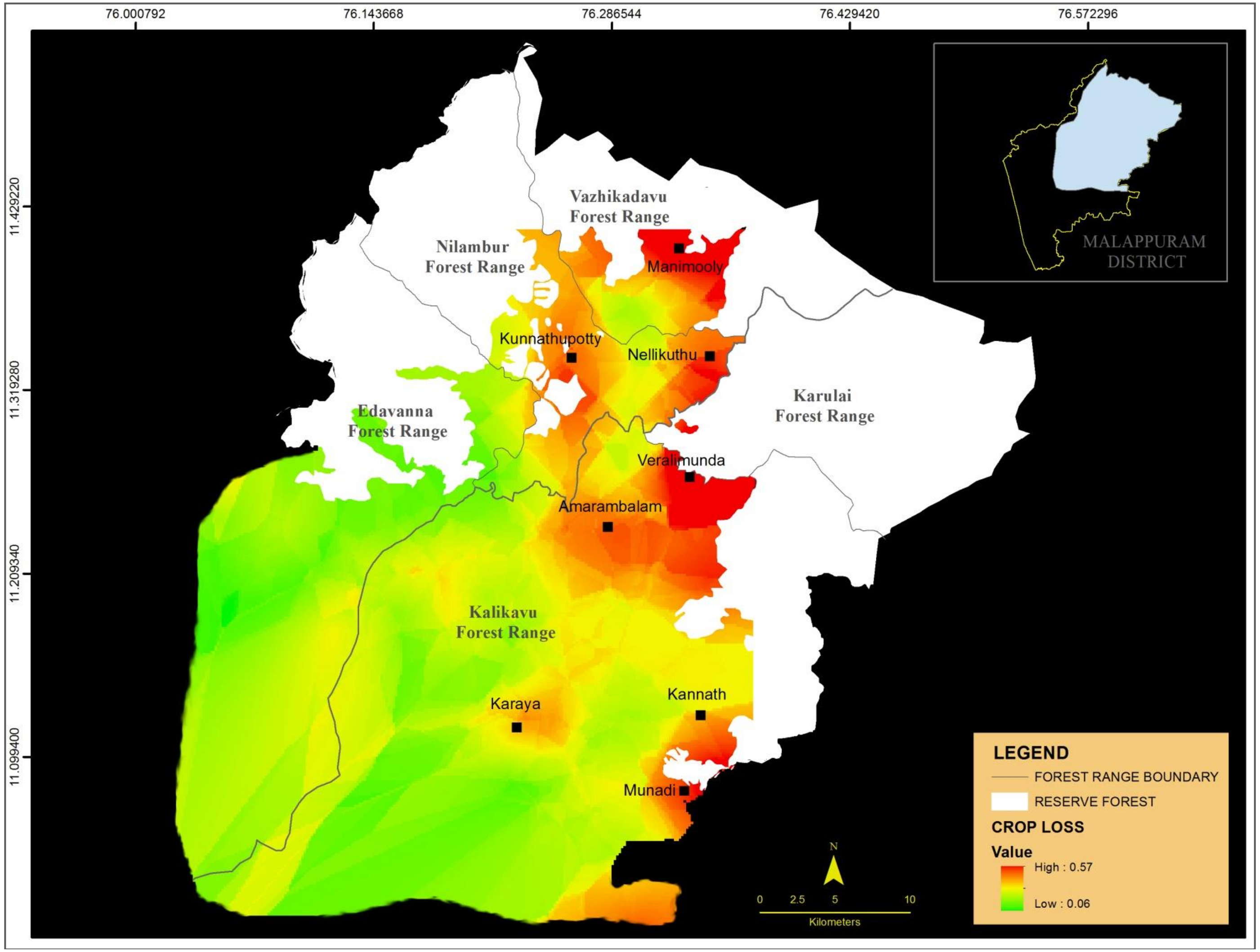



Fig. 42. Potential areas of crop damage in Malappuram District

cropland will adjust according to the behaviour and need of wild animals that will increase the effectiveness of mitigation measures. The median value of the crop loss recorded in many areas of the District even though the area was away from the Reserve Forest can be attributed to the wide distribution of the wild pig in the District. Crop loss due to wild pig was reported by the farmers far away from the Reserve Forest. A similar study conducted in the Thrissur District, also identified the extent of agriculture land, distance to Reserve Forest and age of the respondents as the three parameters influencing the crop damage (Jayson, 2013). Another study by Karanth *et al.* (2012) in the buffer areas of Kanha National Park (KNP) also revealed that the extent of agricultural land and distance to Reserve Forest as the two parameters for crop loss prediction. On the contrary to the above mentioned studies and general perception, the effect of distance from Reserve Forest on crop loss prediction was negligible in my study area and it is clear that in the Place like Karaya under Kalikavu Forest Range also showed high crop loss which was 15 Km away from the Reserve Forest (Fig. 42).

### 5.5.5. Livestock predation

Around 43.33 per cent of the respondents had livestock in their house, out of which 28.33 per cent depended on cattle, 12.33 per cent on goat and only 3 per cent on poultry. Livestock predation by wild animals was reported by 4.33 per cent of the respondents and the species involved were leopard (53.85%), wild dog (30.75%) and small Indian civet (15%). Leopard attack on cattle was reported from Kalikavu, Karulai and Vazhikadavu Forest Ranges. Two human-casualties by a vehicle colliding with wild pig were also reported in the questionnaire survey.

### 5.5.6. Socio-economic background

The primary source of income of the households surveyed were 61.67% agriculture, 18% daily wage, 12.67% others, 3.33% animal rearing and daily wage, 2.33% agriculture and animal rearing, 1.33% animal rearing and 0.67% others and agriculture. Most of the forest fringe areas of the district were occupied by the descendants of the migratory farmers of southern Kerala. They were mainly cultivating cash crops like Rubber, Arecanut, Cocoa and Nutmeg.

While considering the conservation perspective, 86 per cent of the respondents believed that conservation of wild animals is needed, along with proper care to keep them in their habitat and the rest 14 per cent remains neutral on this aspect (n=296). Whereas only 13.5 per cent opined that it as the joint responsibility of both people and government to implement measures to keep the intruding animals within the forest for protecting the crop against the activities of wild animals (n=296). The respondents (remaining 86.5 per cent) opined also expressed that the government is the only authority responsible for preventing the wild animals within the forest and giving protection for the cultivated crops of the farmers. Regarding the expected benefits from wildlife conservation, more than half of the respondents (52.4%) reported that they were not getting any benefit from wildlife and 47.6% believed that they have some benefits from wildlife. The awareness of wildlife laws and conservation issues was satisfactory (95.6%) among the respondent and only 0.3 per cent has excellent knowledge (n=296).

### 5.5.7. Discussion

More than fifty per cent of the respondents reported about forty–per cent of crop damage by wild animals in the District and among them 60% of the households depended on agriculture as their primary source of livelihood. Anything that cause damage to their agriculture crops will create huge impact on them. More than half (50%) of the respondents completed their high school education but the survey results indicated that only 3 per cent received any ex-gratia for their crop loss. Some kind of reluctance other than educational background is pulling back the people from giving application for ex-gratia. It is observed that submitting the application and availing of ex-gratia were restricted to certain people and they were repeatedly applying for it and availing the money. This finding is also supported by the observation of Rohini *et al.* (2016 b). The laborious procedure needed for submitting the application was the primary reason behind it. Delayed and low compensation will create increased attacks on wildlife by people (Wakoli and Sitati 2012). Wild pig was reported as the major crop-raiding species in the District as reported by Hassan *et al.* (2017) from Malaysia. In this study the majority (60%) of crop-raiding was reported during night hours. In the presence of hunting pressure and human activity during the day the wild pig become more nocturnal in their activity (Mayer and Brisbin 2009). Eighty six per cent of the respondents insisted that conservation of wild animals is the responsibility of the government which is similar to the findings of other studies from India and Sri-Lanka (Ogra, 2009; Fernando *et al.*, 2005). There is no significant correlation between the level of education and positive conservation attitude ($r_{s=}$ -0.031; $P > 0.595$). The result is consistent with many other studies (Gadd 2005; Groom and Harris 2008; Mir *et al.*, 2015). The conservation attitudes of the people in the Malappuram District was primarily determined by the negative attitudes developed by them due to the huge economic loss suffered due to crop damage by wild animals. The same result was reported by Panwar *et al.* (2014) from Mayureshwar Wildlife Sanctuary in India and Wang *et al.* (2006 b) from Bhutan. Gender, crop damage, livestock predation and total livestock holding were identified as the factors which influence the respondent's attitudes towards conservation in Kashmir Valley (Mir *et al.*, 2015). It is important to increase the awareness among the farmers about the ex-gratia paid by the Kerala Forest and Wildlife Department along with the smoothening of application procedures to improve the tolerance level of the people in the District which is discussed in many studies (Treves and Karanth 2003; Treves *et al.*, 2006; Naughton-Treves, 1998). Any kind of return or benefit from the protected area will create positive attitudes among the people towards the conservation (Infield, 1988; Alexander, 2000; Infield and Namara, 2001).

The timely and adequate ex-gratia provided to the affected people is a must to have for an immediate change in the negative attitude of the people towards the conservation. Awareness campaigns by Kerala Forest and Wildlife Department by participating representatives from

Vana Samrakhana Samithi (VSS), local politicians and farmers is necessary to ensure the involvement of farmers in the forest fringes in the development of mitigation strategy. It was found that the “first line of defence” of farmers does not exist now and this has happened because most of the farms in the forest fringes have been converted into rubber plantations and these farms are without any habitation and managed by the owners staying in the faraway places. The younger generation is not taking any interest in the “first line of defence” to prevent the wild animals from entering into the agriculture fields. There is a failure of traditional wisdom of defending the wild animals. A new setup or institution has to be built up in the Kerala Forest and Wildlife Department to provide the “first line of defence” in the fringe areas of the forest itself and to save the people from the fury of wild animals and also to conserve wild animals.

## 5.6. Evaluation of mitigation measures

### 5.6.1. Introduction

Many traditional control measures were used by the people to protect the crop from wildlife damage. Each method was effective against certain species. Apart from the traditional methods, new methods were also experimented to study their efficacy. Nine popular traditional methods were used by the farmers to deter wild animals from the cropland (Table 52). They can be classified into fences, watch and ward using humans and dogs, vocal instruments and light-producing systems.

Table 52. Traditional measures adopted by the marginal farmers for controlling the crop damage

| Sl. No. | Mitigation measures adopted | Forest Range | Targeted species |
|---|---|---|---|
| 1 | Watch and ward | All Forest Ranges | All crop-raiding species |
| 2 | Crackers | - do - | - do - |
| 3 | Sound with glass bottles and metallic objects | Kalikavu, Karulai, Vazhikadavu | Wild pig and Asian elephant |
| 4 | Domestic dogs | Kalikavu | Bonnet macaque and Hanuman langur |
| 5 | Trench | Kalikavu, Karulai , Vazhikadavu | Asian elephant |
| 6 | Cable wire | All Forest Ranges | Wild pig |
| 7 | Bright coloured clothes | Kalikavu, Nilambur | Wild pig and Indian peafowl |
| 8 | Spotlight | Vazhikadavu, Karulai | Asian elephant |
| 9 | Fences | | |
| | a. Stone wall | Karulai, Vazhikadavu | Asian elephant |
| | b. Barbed wire fence with concrete bar | All forest ranges | Wild pig and Indian crested porcupine |
| | c. Neem cake | Nilambur | Wild pig |
| | d. Bamboo fence | Nilambur, Edavanna | Wild pig and Indian crested porcupine |
| | e. Fish net | All Forest Ranges | Wild pig and Indian crested porcupine |
| | f. Crackers setup with stone | Karulai | Wild pig |
| | g. Electric fence | Kalikavu, Karulai, Nilambur, Edavanna | Asian elephant |

## 5.6.2. Popular traditional mitigation methods

### 1. X-ray sheet & Glass bottles

An X-ray sheet was kept in hanging position with the help of wooden poles and a plastic thread and a small thick glass bottle attached to the same thread just above the sheet. Two beer bottles were connected on either side of the small bottle from a wooden bar in a hanging position. When the wind strikes on the X-ray sheet, it will swing to either side and thereby the small bottle in the center will hit on the beer bottles which will produce a sound which deter the birds and animals from the farmlands (Plate 20a). More than one such set up can be seen in the same farmland. The method was recorded from Karulai Forest Range.

**2. Plastic cover fence**

Plastic covers tied in a rope and placed around the farmland in wooden poles above 1m height from the ground. The plastic covers hanging on the rope which move in the wind and produce sounds (Plate 20b). It was recorded as a short-term control measure in combination with others from all the five Forest Ranges.

**3. Fence using Bicycle tyre**

This fence was built around farmlands by joining together the abandoned bicycle tyre's (Plate 20c). It was mainly targeted against wild pig. The previous experience of the wild pigs from the iron wire trap illegally used in the District, which have a round shape at one end in which the pig's head will be trapped while trying to cross through it, created a fear in them towards the round shaped structures and this deterred the pigs from crossing the cycle tyre fences (n=13). It is a recently introduced effective short-term control measure in the Karulai and Kalikavu Forest Ranges.

a. X-ray sheet & glass bottle

b. Plastic cover fence


c. Bicycle-tyre fence

d. Cracker setup with stone

e. Machan (Watch and ward)

f. Fishnet fence

**PLATE 20: Control measures to prevent crop damage by wild animals**

### 4. Crackers setup with stone

This traditional method was used as a fence around the farmland to prevent the entry of wild pig and Indian crested porcupine. A box-like structure was made with wooden stumps and a stone was positioned at the center of the box by using plastic rope in a hanging position (Plate 20d). The stone has a flat undersurface which is tied with a cracker and another bigger stone was placed right below the hanging one. More than two such structures were there in the fence according to the size of the farmland. All of them were connected with iron wires. Once the pig tries to enter into the crop field, its feet will hit the wires therby stretching the wooden stumps apart, thus forcing a stone with the cracker to hit a flat surface below it. This will cause the bursting of cracker with blast sound that chase the wild pig away from the farmland and also inform the watchman. This method was prevalent in Karulai Forest Range.

### 5. Watch and ward

This method is commonly practiced in all the forest ranges of the Malappuram District to chase the animals from the farmland. The farmers constructed machans' (temporary night shelters) near the farmland or within it and either they employ someone for guarding the crop, or they guard themselves by spending their time in the machans' throughout the crop maturation period (Plate 20e).

### 6. Fish-net fence

Old fishnet was held around the farmland in 2 m height by using concrete or wooden poles to prevent the entry of wild pig, sambar and

Indian crested porcupine (Plate 20f). Proper maintenance is essential for the effectiveness of the fence because most frequently it was found destroyed by the Indian crested porcupine. It was a common preventive method in all the five forest Ranges.

### 7. Domestic Dogs

Trained dogs were employed to deter the wild animals from the farmland and they also indicated the presence of wild carnivores near cattle pens or human habitations (Plate 21a). Dogs along with the watch and ward were recorded as the only effective deterrent method against crop-raiding macaques.

### 8. Silver foil

Silver foil was placed around the farm at a height of 50 cm above the ground level in an iron wire with a gap of 0.5 m between them (Plate 21b). The reflection and noise produced in the light and wind respectively deterred the wild pig from the field. Farmers in the Kalikavu Forest Range were using this against wild pig and Indian crested porcupine.

### 9. Plastic bottles with water

The plastic bottles with water were kept along the bunds of the paddy field and also in front of the house to prevent the entry of wild pig and stray dogs (Plate 21c).

### 10. Neem-cake

Neem cake in powder form is good manure for the plantain cultivation. Its pungent smell is enough to protect the plantain from the wild pig attack. The farmers of Erumamunda under Nilambur Forest Division applied the neem cake around the plantain twice in a month which was an effective method to avoid the wild pigs from the plantain cultivation throughout their growth except for monsoon season. The market price of the neem cake was as a limiting factor for this practice.

### 11. Spotlight/Torchlight

Sport light or torchlight was recorded in Vazhikadavu and Karulai Forest Ranges as a common method against the Asian elephant. When the presence of Asian elephant was seen in the field, the farmers pointed the light towards them. In Mayilumpara of Karulai range, it was recorded that the elephants were aggressively advancing towards the source of light due to the repeated exposure. At Mayilumpara and Panichola under Karulai Forest Range where the elephant encounters were rampant, the farmers permanently made a setup with high voltage electric bulb to light up the field to deter the crop-raiding elephants.

### 12. Cable Wire

Cable wires were tightly held around the farmland in two or three rows with the support of concrete or wooden poles. The method was mainly to prevent the entry of Wild pig into farmlands. Wild pigs were very keen to avoid any kind of obstruction that they were confronted and the method was recorded in all the five Forest Ranges.

a. Guarding dog

b. Silver foil placed around the farm

c. Plastic bottles with water

d. Solar fence

e. Stone wall

f. Mesh net fence with green cloth

**PLATE 21: Control measures to prevent crop damage by wild animals**

### 13. Crackers

Crackers were burst to scare the wild animals and chase them away from the farmland and were employed in all the forest ranges of the District. All the watchers were keeping crackers with them during crop guarding and most often it was used in combination with other methods. It was ineffective against elephants as they were getting habituated to the method. Crackers were effectively used at Vettathoor in the Kalikavu Forest Range against the hanuman langurs and bonnet macaques.

Another notable mitigation measures against wild animals recorded in Malappuram district were solar fence, stone wall and mesh net fence with green cloth (Plate 21d to f).

## 5.6.3. Honey bee fence experiment

The natural fear of elephants to honey bees is using to deter the crop-raiding Asian elephants from the farmland by constructing the bio fence with honey bee boxes (Appendix III).

### 5.6.3.1. Honey bee fence at Mayilumpara

A total of 14 Asian elephant intrusions were recorded in the area, of which five times through the fenced area, two times by breaking the fence and in three occasions failed to cross the honey bee fence (Table 53). In all the other encounters, the elephants tried to avoid the honey bee fence by choosing a different path for entry. The encounters were recorded at night, which showed that the guarding bees were active even at night in the presence of elephants. The buzzing sounds of the bees itself kept the elephants away from the honey bee fence. With the previous experience of honey bee strikes from the forest, they avoided the honey bee fence. Seventy per cent of the encounters were made by solitary male elephant, locally called as “Ottakomban” (single tusker), which is a habituated crop raider in the area (Plate 22a & b). No elephant herd with more than four members was recorded from the area as crop raiders or intruders into the human habitats.

Table 53. Elephant encounters in the beehive fenced area

| Sl. No. | Date of encounter | Place of entry | Distance covered from the RF (km) | Crops damaged | Number of elephants | Time of attack |
|---|---|---|---|---|---|---|
| 1 | 29/03/2014 | Non fenced | 0.5 | Pineapple | 1 | 08.30 pm |
| 2 | 05/04/2014 | Fenced | 0.6 | Pineapple | 1 | 10.00 pm |
| 3 | 10/04/2014 | Non fenced | 2 | Pineapple, Plantain | 1 | 10.00 pm |
| 4 | 17/04/2014 | Non fenced | 1 | Jackfruit, Plantain | 1 | 03.30 am |
| 5 | 21/04/2014 | Non fenced | 3 | Jackfruit, Plantain | 1 | 02.00 am |
| 6 | 19/05/2014 | Fenced | 5 | Pineapple | 1 | 09.00 am |
| 7 | 23/05/2014 | Fenced | 0.01 | Nil | 2 | 03.30 am |
| 8 | 21/06/2014 | Non fenced | 2 | Pineapple | 1 | 09.00 pm |
| 9 | 28/07/2014 | Non fenced | 3 | Nil | 1 | 04.00 am |
| 10 | 10/09/2014 | Non fenced | 8 | Arecanut, Rubber | 3 | 03.00 am |
| 11 | 11/09/2014 | Non fenced | 6 | Arecanut, Rubber | 3 | 10.00 pm |
| 12 | 12/09/2014 | Non fenced | 3 | Arecanut, Rubber | 3 | 11.00 pm |
| 13 | 19/10/2014 | Fenced | 3 | Pineapple | 1 | 03.00 pm |
| 14 | 10/11/2014 | Fenced | 4 | Pineapple | 4 | 09.00 pm |

a. Habitual crop raider “Ottakamban” (“Single tusk”) at Karulai

b. Single tusker crossing compound wall at Chulliyodu

**PLATE 22: Habitual crop raider (”Ottakomban”) in settlement area (Karulai Forest Range)**

After three months of installation, beehive fence showed a wide range of acceptance among the farmers living in the forest fringe as it is practically applicable and economically beneficial. It is an integrated approach and the honey extracted provided additional revenue. Approximately 15 kgs of honey was extracted from eighteen beehives in the experimental site which generated an income of Rs. 3000/- (US$ 46) at a time (Nair and Jayson, 2016 b).

One disadvantage of the honey bee fence was that the bees has to be fed with artificial food for at least six months during the monsoon months starting from June to November if any income is expected by the sale of honey. Stealing the queen bee from the beehives by anti-social elements was another management problem and during the rainy months, constant attention was needed to provide artificial food at least in twenty days interval. In the current social scenario of the State, the maintenance of honey bee fences looks difficult.

#### 5.6.3.2. Beehive fence at Panichola

After the successful experience of beehive fence at Mayilumpara and collecting opinions from the fringe farmers and local politicians, Kerala Forest and Wildlife Department installed the beehive fence against Asian elephant at Panichola where the elephant encounters were rampant, on 15th June 2014. The place was three kilometer away from the Mayilumpara. The forest boundary of Panichola was with Rubber plantations of different ages which was inter cropped with teak trees along the sides of different passages through the rubber plantations. The 1 km straight walks through the passage lead to the first human settlement, coconut plantations and other cultivated crops. Only ten beehive boxes were used to prevent the elephant entry through three usual entry paths. The first set of 5 boxes were placed in the prescribed method in the usual path through which the elephants frequently entered into the rubber plantation by crossing the river Cherupuzha which shares boundary with Reserve Forest. The remaining five boxes were used to block two more usual entry paths in a set of two and three boxes.

Table 54. Elephant encounters recorded in the fenced area at Panichola

| Sl. No. | Date of encounter | Place of entry | Distance covered from the RF (km) | Crops damaged | Number of elephants | Time of attack |
|---|---|---|---|---|---|---|
| 1 | 18/06/2014 | Non fenced | 4 | Jack fruit | 1 | 10.00 am |
| 2 | 21/08/2014 | Fenced | 6 | Rubber, Plantain | 1 | 11.00 pm |
| 3 | 23/08/2014 | Non fenced | 6 | Rubber | 1 | 03 .00 am |
| 4 | 27/08/2014 | Non fenced | 7 | Arecanut, Coconut, Rubber | 1 | 11.00 pm |
| 5 | 03/09/2014 | Non fenced | 5 | Rubber, Teak | 3 | 04.00 am |
| 6 | 07/09/2014 | Non fenced | 8 | Rubber | 3 | 11.00 pm |
| 7 | 09/09/2014 | Non fenced | 8 | Rubber, Teak | 3 | 03.00 am |
| 8 | 16/11/2014 | Fenced | 6 | Rubber | 7 | 03.00 am |

During the six months of observation (June to November), eight elephant encounters were recorded from the place (Table 54). On two occasions, the elephants entered the rubber plantation by breaking the fence. Even though the elephant encounter reduced through the paths which were fenced with honey bee boxes the elephant intrusion in the area continued as before the fencing. The 1 km stretch of the rubber plantation along the forest boundary had eleven elephant entry paths and the elephants easily entered into the plantation through the paths which were left unblocked. Due to the lack of proper maintenance and replacement of the bee boxes in the fence by the authorities, the fence was entirely destroyed by the end of November 2014. This showed that without the cooperation of local people, honey bee fence might be a failure.

#### 5.6.3.3. Second phase of beehive fence (Mayilumpara)

An awareness class was conducted about the effectiveness and benefit of beehive fence with the participation of Forest Range Officer (Karulai), Sectional Forest Beat Officer (Karulai), Vana Samrakshana Samithi (VSS) members (Karulai), Panchayath member (Mayilumpara), Beekeeping farmer, fringe farmers (involved in the first phase) and other interested youngsters of Mayilumpara. As per the demand of farmers, the beehive-fence was installed again in the same place by increasing the number of beehive boxes from 19 to 30. Three local people who were interested in apiculture activities were selected as volunteers for the maintenance of the fence along with the direction of an experienced beekeeping farmer.

It was installed on July 2015 and was maintained up to January 2016 two more paths were blocked in addition to the six paths previously blocked.

Table 55. Elephant encounters recorded in the fenced area

| Sl. No. | Date of encounter | Place of entry | Distance covered from the RF (km) | Crops damaged | Number of elephants | Time of attack |
|---|---|---|---|---|---|---|
| 1 | 14/07/2015 | fenced | 3 | Jack fruit | 3 | 10.30 am |
| 2 | 08/08/2015 | Fenced | 5 | Rubber, Plantain | 1 | 11.00 pm |
| 3 | 27/08/2015 | Non fenced | 2 | Rubber | 1 | 03.30 am |

Compared to the previous experiment, the elephant encounters drastically reduced without changing the cropping pattern in the place. Three elephant intrusions were recorded in the experimental period and two of them through the fenced paths and on one occasion through the non-fenced path (Table 55). The effectiveness of the fence was again affected due to the anti social activities of the people, they disturbed the bees inside the box and also destroyed the boxes. We dismantled the fence by the end of January 2016 and completed the experiment.

**5.6.3.4. Beehive fence at Mayiladumpara (Thrissur)**

A workshop on human-wildlife conflict organized in the Kerala Forest Research Institute for the benefit of farmers from three adjacent Districts, namely Malappuram, Palakkad and Thrissur. In the workshop, the effectiveness of the beehive fence against the Asian elephants at Mayilumpara was described actively by the farmers from

Mayilumpara. A group of marginal farmers from Mayiladumpara in the fringe area of forests of Thrissur near the Peechi Dam with the help of Agricultural Technology Management Agency (ATMA) installed an advanced version of beehive fence on 2nd February 2016. The wooden poles were replaced by iron poles concreted on the ground, aluminum wires were used to connect the poles and iron hooks were used to hang the beehive box on the wire (Plate 23a). A cross-connection of Aluminum wires also established to assure minimum damage for the fence on elephant intrusion. A total of 200 beehive boxes used to block 2 km area.

No elephant intrusions were recorded through the fenced area after the instalment of beehive fence but exactly two months after the establishment of beehive fence, Kerala Forest and Wildlife Department installed a 2 km stretch of solar fence in the same area close to the beehive fence. So the combination of these two fences effectively stopped the elephant intrusion in the area. The villagers participated in the program and they formed a society called “Mythri Bee Society”. The society successfully managed the production and sale of the honey extracted from the fence.

#### 5.6.3.5. Limitations of the honey bee fence

##### 5.6.3.5.1. Greater banded hornet (*Vespa tropica haematodes* Bequard, 1936)

The wasps were found hovering over the hives during the months of September-December. They were predating on the honey bees in the hives and thereby seriously affecting the health of the honey bee colony (Plate 23b). The wasp has a bright yellow band around its abdomen and has an average size 27 mm. On search, their nest was observed on a tree in the peripheral forest. The adult wasps were very aggressive and if disturbed sting badly.

#### 5.6.3.5.2. Direct sunlight

Exposure to the direct sunlight for a long duration caused the evacuation of the bee boxes in the fence. In the first trail of experiments at Mayilumpara, we used, the transparent plastic sheets over the hives to give protection from the rain but it failed to protect the beehive boxes from over exposure to direct sunlight and hence three boxes found evacuated by the bees.

#### 5.6.3.5.3. Social issues

The major problem that we faced during our experimental trials at Mayilumpara was the theft of queen bees from the hives. There was also the targeted extraction of honey combs by the anti social elements without considering the purpose of the fence.

### 5.6.4. Yellow colored cloth

Yellow colored cloth is an effective mitigation measure to deter the crop-raiding animals like wild pig and Indian crested porcupine**.** The innovative method was observed as the traditional practice by the


a. Beehive fence erected at Mayiladumpara


b. Wasp (*Vespa tropica haematodes*) on the beehive box

**PLATE 23: Beehive fence experiment**

farmers in the Kalikavu Forest Range of Nilambur South Forest Division. The bright color of the cloth was easily detected by the crop-raiding animals in the dark hours and they avoided such areas. The high percentage (66.67) of encounter by wild animal was recorded from the unprotected area, where this control measure was not employed and the encounter rate was less (16.67%) in the area which was protected by the yellow colored cloth.

### 5.6.5. Bio-repellent (Trump guard)

The field trials showed that the natural repellent "trump guard" was an effective control measure to deter the crop-raiding wild pig. Even though the presence of wild pig was recorded from the nearby areas, only two encounters were recorded in the sample plots of the Nilambur Forest Range. No animal encounter was recorded from the sample plots of all the other four Forest Ranges. The particular smell of the repellent kept the wild pigs away from the crop field and it was noticed that the proper application of the repellent in the field twice in a week was very essential to keep it active against the crop raiders.

GCMS analysis of bio-repellant "Trump guard" extracted in chloroform was carried out in the Kerala Forest Research Institute, Peechi, Thrissur and found to have 22 volatile compounds. Most of the compounds identified were natural products. None of the volatile pesticides, herbicides or other environmental hazardous chemicals were detected in GCMS analysis. Major peak was obtained at Rt. 44.919 which was identified as Stigmast-5-en-3-ol which reduce glucose uptake.

### 5.6.6. Discussion

It is important to develop and popularize the low cost, effective control measures to reduce the human-wildlife conflict. A number of innovative mitigation methods were experimented in African countries against African elephants and among these Chilli-fence was found useful to prevent crop-raiding elephants, (Parker and Osborn, 2006; Osei-Owusu and Bakker, 2008). The mixture of used diesel engine oil and chili-powder was tested against Asian elephants in the tropical monsoon climate of Kerala and found that it can be used as a short-term control measure (Jayson, 2013). The method was also found effective in Assam to deter Asian elephants from the sugarcane fields (Baishya, *et al.*, 2012). In all the cases the smell of the chili was determined as the deterring agent. The use of tobacco powder along with chilli to give a more intense smell was tested in three different States of India and reported that it is useful in low monsoon season (Chelliah *et al.*, 2010).

Beehive fence proved as another successful mitigation measure against African Elephants in multiple locations in Kenya (King *et al.*, 2009; King *et al.*, 2011; King *et al.*, 2017). In my trials at Mayilumpara, the bee-hive fence proved its efficacy to deter the Asian elephant from farmlands. The added advantage of the bee-hive fence was the sustainable income generation from the honey harvesting. In Mayiladumpara, the local farmers practiced apiculture activity and benefitted with the income by marketing the honey extracted from the fence through the society formed by them. Kerala Forest and Wildlife

Department introduced the solar fencing next to the beehive-fence in the same stretch and the complete stoppage of elephant encounters in the area recorded during the period was due to the combined effect of both the fence.

In this study, the yellow colored cloth was identified as the cheapest effective measure to deter the wild pig from the cropland. Even though the effect of colour was not studied, it was noticed that, the yellow cloured cloth was effective against the wild pig than the use of cloths with dull colours. Previous studies from Kerala reported the effectiveness of plastic sheets with yellow and white coloures to prevent the entry of wild pig in to the cropland (Gopakumar *et al.*, 2012; Jayson, 2013).

Thirteen popular indigenous preventive measures were identified in this study which is similar to the report by Jayson (1999) from Marayur Forest Range, Idukki however the methods like neem cake, silver foil and bicycle tyre fence were not previously reported in Kerala. Traditionally used methods were found effective as the short term control measure against the wild animals in the District. Popularization and creating awareness through communication about such methods to reach every farmer in the District was carried out to improve its effectiveness. Fifteen traditional mitigation measures used to deter the wild animals in Kerala. The efficacy of bar soap to deter the Sambar deer was evaluated which showed that it can be used for short periods (15 days) as deterrent to Sambar and as the period increases the animal became conditioned and learned to avoid the soap (Jayson, 1999).

Solar fencing was recognized as one of the best methods to prevent wild animals from the cropland. High voltage current produced by the energizer attached to the solar panel passed through the iron wire as a pulsating manner, which can deter the animals without any harm to their life (Webb *et al.*, 2009). The effectiveness of the solar fence was reported in many studies around the world (Blair *et al.*, 1979; Angst, 2001; Desai and Riddle, 2015; Hoare, 2003; Fernando *et al.*, 2008).

A study from Kenya revealed that the selection of fence location in relation to landscape factors, maintenance of non-electrified fences and the proximity of the fence to high elephant concentration are the significant factors that determine the performance of electric fence (Kioko, *et al.*, 2008). The failure of the electric fence installed by Kerala Forest and Wildlife Department in the Malappuram District was observed on many occasions as the Asian elephants intruded into the crop land through the fenced area (n=8) (Plate 24a & b). The electric fence installed under private ownership showed higher performance than the government-owned one (Nath and Sukumar, 1998). The under performance of the government installed electric fences was primarily due to the lack of maintenance and insufficient support from the local communities. The Forest Department has to ensure the local participation and scientific approach for the establishment of solar fencing to get maximum effectiveness of the invested resources. The solar fences jointly maintained by Forest Department and local people were reported in many areas (Nath and Sukumar, 1998).

a. Solar electric fence damaged by Asian elephant at Karuvarakundu (Kalikavu Forest Range)

b. Elephant crossed through solar fence due to lack of maintenance at Anamari (Vazhikadavu Forest Range)

**PLATE 24: Damage to solar electric fence**

## 5.7. Media coverage of human-wildlife conflict

Media has an important role in educating the threat of human-wildlife conflict on farmers. Hence, it is important to analyse the news items regarding the human-wildlife conflict published in the media including the local newspapers. The presentation of the news has a great influence on the attitudes of the readers towards the issue. A total of 223 news items were collected from the print media during the study period. Reports published during the year of 2013 was 2.5±3.29 reports/month, in 2014 it was 8.83±4.15 reports/month, in 2015 it was 5.33±3.63 reports/month, and in 2016 it was 1.93±1.83 (ANOVA, F= 10.792; $P < 0.001$).

Table 56. News items published from each range (n=223)

| Sl. No. | Forest Division | Forest Range | No. of news items published |
|---|---|---|---|
| 1 | Nilambur South | Kalikavu | 94 |
| | | Karulai | 64 |
| 2 | Nilambur North | Vazhikadavu | 50 |
| | | Nilambur | 11 |
| | | Edavanna | 4 |

The focus of news items were as follows, Elephant (129), leopard (33), wild pig (21), monkey (9), unidentified animal (3), and other animals (Snakes, porcupine, barn owl, deer, jungle cat, slender lories, gaur, small Indian civet, palm civet and wild dog) (18). The number of news about the pattern of the land use changes close to forest was ten.

The most number of news items related to human-wildlife conflict issues were published from Kalikavu Forest Range followed by Karulai, Vazhikadavu, Nilambur and Edavanna (Table 56 & Fig. 43).

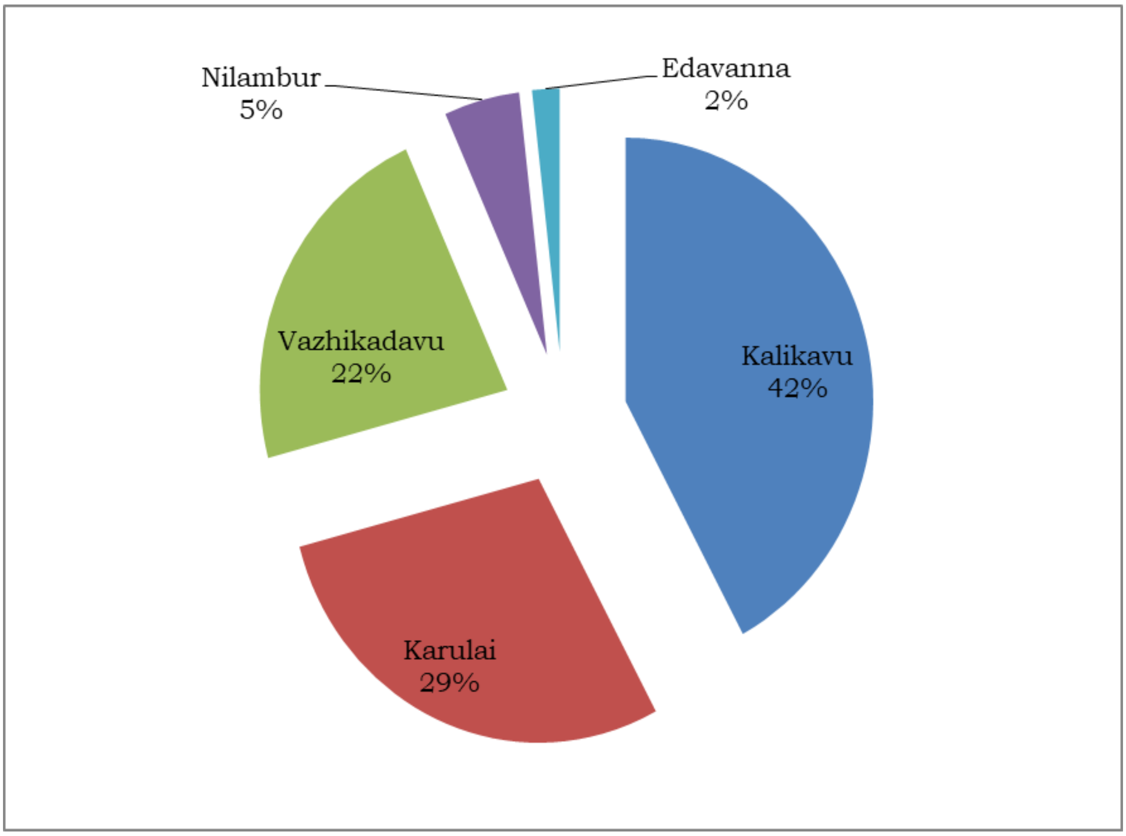



Fig. 43. Range wise details of news items published on human-wildlife conflict

A major portion of the news items was regarding crop-raiding incidences of wild animals (51%). Sixteen per cent dealt with the sighting of carnivores (mainly leopards in the human habituation), 5% news were on human casualties (wild pig, elephant, gaur), 4% reported about mitigation measures, 3% dealt with livestock predation by leopard, wild dog and unidentified animals, 3% reported wildlife poaching incidents, 2% reported wild animal-vehicle collision, 9% reported on the dead bodies of animals (elephant, monkey, deer), 5% reported house hold damage by wild animal and 2% reported rescue missions (Fig. 44).

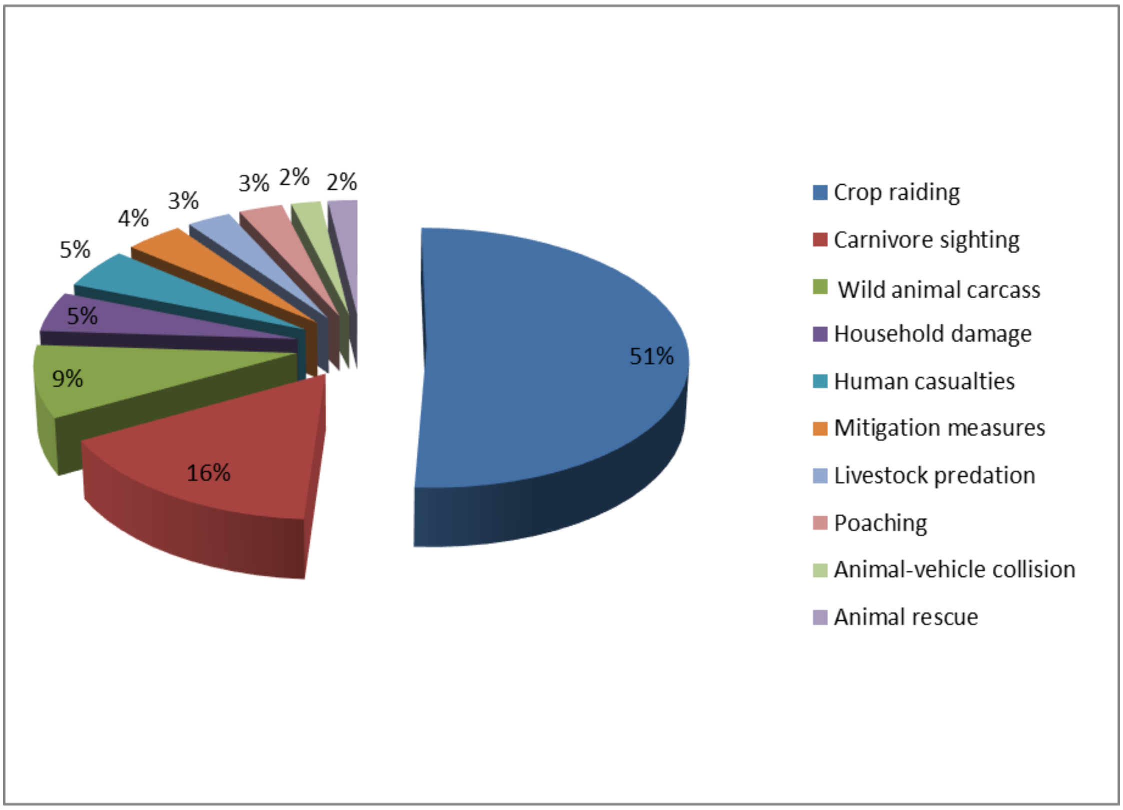



Fig. 44. Content of news items published during the study period (2013-2016) (n=171)

**Case study- News on Civet cat**

A news about a trapped civet was published in the leading local newspaper "Mathrubhoomi". The news was about on the civet which was trapped at the place called Padinjattumuri under Kalikavu forest Range on 2-12-2014. A trap was set due to the demand of people by sighting an unidentified animal in the area. Then trapped animal was locally identified as the Malabar civet (*Viverra civettina*) which is endemic to the Western Ghats of India and listed as critically endangered by IUCN as its population size is estimated to number fewer than 250 individuals, with no subpopulations greater than 50 individuals. In the report details of the Malabar civet including the practice of trading on it for the use of civet musk and civet oil was mentioned. We visited the area and collected the data to confirm that whether it is Malabar civet or not. We had a discussion with forest officials in the Karuvarakundu forest station and they provided the photographs of the trapped animal (Plate 25). After detailed examination, it was identified as a small Indian civet (*Viverricula indica*) which is the least concern in IUCN red list and commonly sighted in the area. The problem with this kind of reporting is that the locals were getting attracted towards the trading aspects of Malabar civet and thereby they may start focusing on the animal erroneously understanding it as Malabar civet and that may challenge the peaceful existence of the species. It is essential to show great responsibility from the media persons when dealing with wildlife reporting. In a District like Malappuram, it is crucial to develop a particular wing in all responsible print and visual media by including the persons with expertise in science reporting to deal with the problems related to wildlife and birds.

### 5.7.1. Discussion

Media analysis is defined as a systematic method to study mass media (Macnamara, 2005). It is the analysis of what is contained in a message (Prasad, 2008). The review of media is a valuable tool to realize

**PLATE 25: Small Indian civet (*Viverricula indica*) trapped at Padijattumuri**

the human dimensions of a conflict issue because media has a great influence on attitudes and affective responses of an audience (Gore *et al.*, 2005; Gore and Knuth, 2009). All the highly circulated local dailies of the Malappuram District have a particular interest to report the news items focused on Asian elephants and leopard. While analyzing the case of leopard, it was found that publishing anything about the attractive carnivore, especially about the sighting of the animal was an easy process without any proper confirmation and background work. Asian elephant was the other animal that has extra hype in the media most of the time related to the crop-raiding issues. Management and conservation programmes involving large, allegedly dangerous mammals are likely to encounter an adverse press reaction (Goulding and Roper, 2002). The news items about these animals were unknowingly creating a strong negative attitude among the readers of the Malappuram District most of whom have no direct experience with the animals. The framing of the news item influences the perception of the readers, depending on the characteristic of the audience and also how they process mass media messages (Scheufele and Tewksbury, 2007).

A review of Redpath *et al.* (2015) revealed that the human-wildlife conflict is focused on the conflict between two schools of thoughts, one who supported the measure to conserve wildlife and the other ones who were advocating the prioritization of human activities and livelihoods. While analyzing the content of news items regarding the wildlife in the present study, the prevailing trend was in support of human activities and livelihood. On the other side, for achieving this purpose over blaming of wild animals was also noticed. So it was a major hindrance against positive conservation attitudes of the locals which is very important for the successful implementation of management planning.

The use of civet-musk is said to have been widespread within this species' range during 1965-1970 (Ashraf *et al.*, 1993). In the past, this species might have been used to collect civet oil, although there are no records to authenticate this claim. Small Indian Civet is still illegally 'farmed' and kept in captivity to extract civet, and any remaining Malabar Civets are likely to be at risk for the same reason. As mentioned in the case study, the exploitation of animals can happen due to the irresponsible reporting of news highlighting the commercial benefit of the animals. The study of Bhatia *et al.* (2013) revealed that the media outlets seem attentive to human-leopard conflict and they were capable of correcting misperceptions and facilitating mitigation and effective management. On this background, they suggested that the mutual understanding between the conservation professionals who were well aware of the cultural and linguistic differences in reporting within the country and the mass media could be a vital component of managing human-wildlife conflict.

Chapter six

# Conclusions

# 6. CONCLUSIONS

**Vegetation**

1. The tree species *Xylia xylocarpa, Terminalia bellirica, Terminalia paniculata, Grewia tilIifolia, Hydnocarpus pentandra, Persea macrantha, Kydia calycina* were the dominant species recorded in the forest.

2. The abundance, density and diversity of the tree species within the forest were comparable with any other undisturbed forest to support a variety of wild animals.

**Crop damage**

3. The crop damaging animal species identified in the District were Asian elephant (*Elephas maximus*), Wild pig (*Sus scrofa*), Bonnet macaque (*Macaca radiata*) Black-footed gray langur (*Semnopithecus hypoleucos*) and Indian crested porcupine (*Hystrix indica*). Damage by Black-footed gray langur is a new report of Kerala.

4. Coconut (*Cocos nucifera*), Arecanut (*Areca catechu*), rubber (*Hevea brasiliensis*), jack tree (*Artocarpus heterophyllus*), plantain (*Musa paradisiaca*), paddy (*Oryza sativa*) and tapioca (*Manihot esculenta*) are the crop species damaged by wild animals. Damage to rubber, nutmeg and cocoa by Asian elephant was a new report from India.

5. The highest crop damage by Asian elephant was recorded during the monsoon season. Elephants damaged crops worth Rs. 22,62822/- (US$ 32,051) per annum for the crops other than rubber and for rubber, it was Rs. 28,59464/- per annum (US$

39,938). The highest number of incidents was recorded from Moothedanm Grama Panchayath.

6. Arecanut cultivation in the immediate fringe of the forest was the major attractant for Asian elephant. The practice of pineapple cultivation in the rubber plantation was identified as one of the major reasons for the damage of rubber plantation by Asian elephant in Malappuram District.

7. The intrusion of elephant up to 6 km away from the forest was due to the presence of vast areas of rubber plantation sharing the boundary of forest, which were giving enough protection for the movement of elephant without getting noticed by the people.

8. Crop damage by wild pig was recorded from all the five Forest Ranges and the mean economic loss was estimated as Rs. 34,460/- per ha per annum. The highest damage was recorded from Nilambur Forest Range followed by Kalikavu, Karulai, Vazhikadavu and Edavanna.

9. The presence of Indian crested porcupine was recorded from all the forest ranges except Nilambur Range. The mean economic loss was estimated as Rs.1322/- per ha/annum and the highest damage was recorded from Edavanna Forest Range followed by Karulai, Vazhikadavu and Kalikavu.

10. The debarking of rubber trees over 15 years of age in the basal portion by the Indian Crested porcupine was newly reported in India. The debarking behaviour on coconut palm and the consumption of newly formed bamboo clumps by Indian crested porcupine were also recorded.

11. Bonnet macaque caused an economic loss of Rs.11914/- per ha/annum in Kalikavu Forest Range followed by Rs.877/- per ha/annum in Edavanna Forest Range. The highest loss of coconuts (Eight nuts/tree) due to bonnet macaque was recorded from the Kalikavu Forest Range followed by Edavanna.

12. Black-footed gray langur caused an economic loss of Rs.4412/- per annum in the Kalikavu Forest Range which is a first report in India.

**Human casualties and cattle-lifting**

13. Five human deaths and three human injuries due to Asian elephants and forty six Asian elephant deaths were recorded during the years from 2013-2016.

14. Seventy-one per cent of the elephants died in the District were male and most of the elephant death cases were detected in and around the farmland and occurred during the monsoon season.

15. A total of 19 human-wild pig encounters were recorded from the study area and 8 of them were due to the collision with vehicles (2 autos and 6 motorbikes). The number of victims was twenty six including three women.

16. The wild pig rabies was reported for the first time in India from Pathippara under Karulai Forest Range.

17. Rubber plantations in the District were recognized as secondary habitat for wild pigs and Asian elephants and the plantations had a significant contribution towards the incidents of human-wildlife interactions.

18. Leopard and Dhole were the main species involved in the attack on livestock. Grazing fields close to forest land and the evening hours of grazing were the main factors influencing the attack of carnivores.

**Conservation attitude**

19. Forty per cent crop damage were reported by 52.1 per cent of the respondents. Most of the respondents (68.3%) were unaware of the ex-gratia paid by the Kerala Forest and Wildlife Department for the crop loss and only 3 per cent received any compensation for the crop loss.

20. Despite educational background, people of Malappuram District showed some reluctance for applying for ex-gratia and was observed that submission of the application and availing of ex-gratia was restricted to some people who were repeatedly applying for it.

21. Only 13 per cent of the people opined that it is the joint responsibility of the people and government to implement and maintain the mitigation measures to keep intruding animals within the forest.

**Potential areas of crop damage**

22. The prediction using GIS showed that all the forest ranges except Edavanna Range were highly susceptible to crop loss due to wild animals.

23. Elevation, duration of stay, number of animal and number of cultivated crops were identified as the influencing factors for crop damage by wild animals around the Reserve Forest of Malappuram District.

24. The major places having high crop loss were Manimooly from Vazhikadavu Range, Veralimunda from Karulai Range and Munadi from Kalikave Range.

**Control measures**

25. Thirteen indigenous control measures were identified which are used by people to prevent crop damage by wild animals.

26. Beehive fence is an effective control measure against crop-raiding Asian elephants. Participation of the people in the maintenance of beehive fence can be assured as it has a monetary benefit in the form of honey harvested from the beehive boxes.

27. Yellow colored cloth is an effective mitigation measure to deter the crop-raiding animals like wild pig and Indian crested porcupine.

# Chapter seven

# Recommendations

# 7. RECOMMENDATIONS

1. As the crop-raiding by elephant was highest in the rainy season (July- October) maximum efforts should be taken to strengthen the remedial measures in the monsoon season to avoid the entry of elephants into the non forest land. This should be by forming a new institution in the Kerala Forest and Wildlife Department for implementing the first line defense in the fringe areas with the support of local people.
2. Focus of crop prevention methods should be in the areas of Arecanut cultivation intercropped with plantains.
3. Farmers should be advised to avoid the cultivation of crops like plantain, pineapple and jack fruit in the boundary of forest which act as a major attractant for the elephants.
4. Radio collaring of the habitual crop raider (Ottakomban), which is responsible for around 40 per cent of the crop loss by elephant in the study area is recommended which will help in proper monitoring of its movement within and outside the forest areas.
5. Removal of pineapple cultivations from the rubber plantations is a must to reduce the damage to the highly paid cash crop in the forest fringes.
6. Care should be taken to avoid collision with a wild pig while riding the vehicles in the early morning and late evening, primarily through the road edged by rubber plantations. Caution boards are suggested to be placed on the roads edged by rubber plantations in the Kalikavu Forest Range.

7. Presence of wild pig outside the forest areas should be identified and removed.

8. Garbage management is must in all the panchayaths particularly the chicken and other slaughter waste, so that pigs coming closer to human habitations as well as their interaction with free-ranging dogs can be avoided.

9. The preventive measures like coloured cloth, fish net fence, fence with cycle tyres, glass bottles with X-ray sheets produced sound in the breeze. Plastic covers hanging on the rope, stones with crackers are some of the traditionally used mitigation measures against wild pig observed in the field. A combination of these measures should be used to increase the effectiveness.

10. Population estimation of wild pig should be conducted regularly and measures should be taken to restrict their population according to the carrying capacity of the forest.

11. The major focus of management should be directed towards wild pig as it is a menace to the farmers and reported in most of the places in Malappuram District.

12. The use of GIS as a tool by incorporating the local knowledge with technical expertise can provide an effective way to map the extent and severity of the crop damage due to wild animals which in turn will help in the mitigation of human-wildlife interactions for a peaceful co-existence of the people and wildlife.

13. Awareness programs and meetings should be conducted by the respective forest ranges at least twice in six months with the

participation of Forest officials and farmers in the District to increase the communication between them and to encourage a participatory approach in the mitigation of crop-raiding animals.

14. The farmers were not showing interest to apply for the compensation for damage due to the wild animals. Kerala Forest and Wildlife Department should make sure to provide adequate and timely ex-gratia for the affected people as an immediate support.

15. Beehive fence is a low cost and more dependable mitigation measure for the farmers in the fringe areas of the forest which can yield economic benefit too. Popularization of this method can be practiced by the Kerala Forest and Wildlife Department and other Government organizations with the cooperation of people.

16. Cattle grazing in the forest fringe areas during the evening hours should be avoided and also the cattle should be kept inside the closed pens to reduce the cattle lifting incidences by carnivores in the villages sharing the boundary with forest.

17. Selected locations where continuous watch and ward monitoring/ electric fence needed to prevent the entry of elephant into the human settlements and crop field are givenbelow.

    a) **Panichola**: This place is in the Karulai Forest Range in which the elephant intrusions were rampant. A 4 km stretch of fence is needed along the sides of Cherupuzha River and Cheranghathodu.

b) **Mayilumpara-Unnikulam**: A 6 km stretch of defence mechanism is needed in this location where rubber plantations share the boundary with the reserve forest through which elephants intrude into the croplands.

c) **Munadi**: In this location, agricultural areas directly share the boundary with the Reserve Forest. The crops cultivated are arecanut, coconut and plantain which are very attractive to elephants and thereby the frequency of elephant encounters was high. A stretch of 4 km defence is essential to keep the elephants within the forest.

d) **Chenappady:** This place is in the Kalikavu Forest range and also within the Pullanghodu rubber estate. The estate shares its boundary with the reserve forest. A stretch of 7 km should be kept under watch & ward to restrict the entry of elephants into the agriculture fields.

# Chapter eight
# References

# 8. REFERENCES


Abideen, M. Z. (2015). Working plan of Nilambur South Forest Division (2014-2015 to 2023-24). Forest and Wildlife Department, Government of Kerala, 396 pp.

Acharya, K.P., Paudel, P.K., Jnawali, S.R., Neupane, P.R. and Kohl, M. (2017). Can forest fragmentation and configuration work as indicator of human-wildlife conflict? Evidences from human death and injury by wildlife attacks in Nepal. *Ecological Indicators*, 80: 74-83.

Administration Report 2015-16. Kerala Forest and Wildlife Department, 106 pp.

Ahmad, A. and Chaudhry, M.I. (1977). Studies on habits, habitat and damage of porcupines *Hystrix Indica*, Rodentia, Mammalia*. Pakistan Journal of Forestry*, 27: 147-150.

Ahmed, B.H.M. (1991). Man and wild pigs (*Sus cristatus*) interaction from the Western Ghats of south Maharashtra. Ph.D. thesis, Shivaji University. Kohlapur.

Akram, F., Ilyas, O., Haleem, A. (2017). Food and feeding habits of Indian crested porcupine in Pench Tiger Reserve, Madhy Pradesh, India. *Ambient Science*, 04(1): DOI:1021276/ambi.2017.04.ra02.

Alexander, S.E. (2000). Resident attitudes towards conservation and black howler monkeys in Belize: The Community Baboon Sanctuary. *Environmental Conservation*, 27: 341-350.

Amici, A., Serrani, F., Rossi, C.M. and Primi, R. (2012). Increase in crop damage caused by wild boar (*Sus scrofa* L.): The “refuge effect”. *Agronomy for Sustainable Development*, 32(3): 683-692, DOI 10.1007/s13593-011-0057-6.

Anand, S. and Radhakrishna, S. (2017). Investigating trends in human-wildlife conflict: Is conflict escalation real or imagined. *Journal of Asia-Pacific Biodiversity*, 10: 154-161.

Anand, S., Binoy, V.V. and Radhakrishna, S. (2018). The monkey is not always a God: Attitudinal differences towards crop-raiding macaques and why it matters for conflict mitigation. *Ambio*, 47(6): 711-720.

Angst, C. (2001). Electric fencing of fallow deer enclosures in Switzerland - a predator proof method. *Carnivore Damage Prevention News,* 3: 8-9.

Apollonio, M., Anderson, R. and Putman R. (2010). European ungulates and their management in the 21st century. Cambridge University Press, Cambridge, 604 pp.

Appayya, M.K. (1995). Elephants in Karnataka (India): A status report. *In*: Daniel JC, Datye HS (eds) A week with elephants. Bombay Natural History Society and Oxford University Press, Bombay, 88–93 pp.

Ashraf, N.V.K., Kumar, A. and Johnsingh, A.J.T. (1993). Two endemic viverrids of the Western Ghats, India. *Oryx*, 27: 109–114.

Athreya, V., Odden, M., Linnell, J.D.C. and Karanth, K.U. (2011). Translocation as a tool for mitigating conflict with leopards in human-dominated landscapes of India. *Conservation Biology*, 25(1): 133-141.

Attia, T.S.N., Martin, T.N., Forbuzie, T.P., Angwafo, T.E. and Chuo, M.D. (2018). Human-wildlife conflict: Causes consequences and management strategies in Mount Cameroon national park south west region, Cameroon. *International Journal of Forest, Animal and Fisheries Research,* 2(2): 2456-8791.

Bailey, T.N. (1993). The African Leopard: Ecology and behaviour of a solitary felid. Columbia University Press, New York, 429 pp.

Baishya, H.K., Dey, S., Sarmah, A., Sharma, A., Gogoi, S., Aziz, T., Ghose, D. and Williams, A.C. (2012). Use of chilli fences to deter Asian elephants- A pilot study. *Gajah*, 36: 11-13.

Bapureddy, G., Santhosh, K., Jayakumar, S. and Kumara, H.N. (2015). Estimate of primate density using distance sampling in the evergreen forests of the central Western Ghats, India. *Current Science*, 108(1): 118-123.

Barlow, A.C.D., Greenwood, C.J., Ahmad, I.Q. and Smith, J.L.D. (2010). Use of an action selection frame work for human-carnivore conflict in the Bangladesh Sundarbans. *Conservation Biology*, 1-10.

Barnes, R.F.W. (1996). The conflict between humans and elephants in central African forests. *Mammal Review*, 26: 67–80.

Barua, M., Bhagwat, S.A. and Jadhav. S. (2013). The hidden dimensions of human-wildlife conflict: Health impacts, opportunity and transaction costs. *Biological Conservation*, 157: 309-316.

Baxter, R. and Hansson, L. (2008). Bark consumption by small rodents in the northern and southern hemispheres. Mammal Review, https://doi.org/10.1046/j.1365-2907.2001.00078.x

Bayani, A., Tiwade, D., Dongre, A., Dongre, A.P., Phatak, R. and Watve, M. (2016). Assessment of crop damage by protected wild mammalian herbivores on the western boundary of Tadoba-Andhari-Tiger Reserve (TATR), Central India. *PLoS ONE*, 11(4): 1-18.

Beisner, E.A., Heagerty, A., Seil, S.K., Balasubramaniam, K.N., Atwill, E.R., Gupta, B.K., Tyagi, P.C., Chauhan, N.P.S., Bonal, B.S., Sinha, P.R. and McCowan, B. (2015). Human-wildlife conflict: Proximate predictors of aggression between humans and rhesus macaques in India. *American Journal of Physical Anthropology*, 156(2): 286-94.

Ben-Shahar, R. and Macdonald, D.W. (2002). The role of soil factors and leaf protein in the utilization of mopane plants by elephants in Northern Botswana. *BMC Ecology*, 2(3): 1-6.

Berliani, K., Alikodra, H.S., Masy'ud, B. and Kusrini, M.D. (2016). Susceptibility of cultivated plants to Sumatran elephant (*Elephas maximus sumatranus*) in the human-elephant conflict area in Aceh province. *Jurnal Manajemen Hutan Tropika*, 22(1): 65-74.

Bhatia, S., Athreya, V., Grenyer, R. and Macdonald, D.W. (2013). Understanding the role of representations of human-leopard conflict in Mumbai through media content analysis. *Conservation Biology*, 27: 588-594.

Bhattarai, B.R. and Fischer, K. (2014). Human-tiger (*Panthera tigris*) conflict and its perception in Bardia National Park, Nepal. *Oryx*, 1-7.

Bhima, R. (1998). Elephant status and conflicts with humans on the western bank of Liwonde National Park, Malawi. *Pachyderm*, 25:74-80.

Bieber, C. and Ruf, T. (2005). Population dynamics in wild boar *Sus scrofa*: Ecology and elasticity of growth rate and implications for the management of pulsed resource consumers. *Journal of Applied Ecology*, 42(6): 1203-1213.

Biru, Y. and Bekele, A. (2012). Food habits of African elephant (*Loxodonta africana*) in Babile Elephant Sanctuary, Ethiopia. *Tropical Ecology*, 53(1): 43-52.

Blair, J. A. S., Boon, G. G. and Noor, N. M. (1979). Conservation or cultivation: The confrontation between the Asian elephant and land development in Peninsular Malaysia. *Abstract of Land Development Digest*, 2: 25-58.

Brooks, J.E., Ahmed, E. and Hussain, I. (1988). Characteristics of damage by vertebrate pests to groundnut in Pakistan. *Proc.13th Vert. Pest Conf., Univer. California, Davis,* 129-133 pp.

Bulte, E. and Rondeau, D. (2007). Compensation for wildlife damages: Habitat conversion, species preservation and local welfare. *Journal of Environmental Economics and Management*, 54: 311-322.

Burnham, K.P. and Anderson, D. (2002). Model selection and multimodel inference. A practical information theoretic approach. Springer Verlag, New York. 454 pp.

Cahill, S. and Llimona, F. (2004). Demographics of a wild boar *Sus scrofa* Linnaeus, 1758 population in a metropolitan park in Barcelona. *Galemys*,16: 37–52.

Cahill, S., Llimona, F., Cabaneros, L. and Calomardo, F. (2012). Characteristics wild boar (*Sus scrofa*) habituation to urban areas in the Collserola Natural Park (Barcelona) and comparison with other locations. *Animal Biodiversity and Conservation*, 35(2): 221-233.

Cai, J., Jiang, Z., Zeng, Y., Li, C. and Bravery, B.D. (2008). Factors affecting crop damage by wild boar and methods of mitigation in a Giant Panda Reserve. *European Journal of Wildlife Research*, 54: 723-728.

Chakravarthy, A.K. and Girish, A.C. (2007). Feeding ecology of Indian porcupine (*Hystrix indica* Kerr) in coconut (*Cocos nucifera* L) plantations of the Western Ghats of Karnataka. *Journal of the Bombay Natural History Society,* 104(1): 40-44.

Chakravarthy, A.K., Girish, A.C. and Sridhara, S. (2006). Pest status of the Indian crested porcupine, *Hystrix indica. In*: Vertebrate pests in agriculture: The Indian scenario (Ed. Shakunthala Sridhara), Jodhur Publishers, India, 287-300 pp.

Chauhan, N.P.S. and Sawarkar, V.B. (1989). Problem of over-abundant populations of "Nilgai" and blackbuck" in Haryana and Madhya Pradesh and their management. *Indian Forester*, 115(7):488-493.

Chauhan, N.P.S., Barwal, K.S. and Kumar, D. (2009). Human-wild pig conflict in selected states in India and mitigation strategies. *Acta Silvatica & Lignaria Hungarica*, 5:189-197.

Chelliah, K., Kannan, G., Kundu, S., Abilash, N., Madhusudan, A., Baskaran, N. and Sukumar, R. (2010). Testing the efficacy of Chilli-tobacco rope fence as a deterrent against crop-raiding elephants. *Current Science*, 99: 1239-1243.

Chen, S., Yi, Z.F., Arceiz, A.C., Chen, M.Y. and Webb, E.L. (2013). Developing a spatially explicit, sustainable and risk- based insurance scheme to mitigate human-wildlife conflict. *Biological Conservation*, 168: 31-39.

Chen, Y., Marino, J., Chen, Y., Tao, Q., Sullivan, C.D., Shi, K. and Macdonald, D.W. (2016). Predicting hotspots of human-elephant conflict to inform mitigation strategies in Xishuangbanna, Southwest China. *PLoS ONE*, 11: 1-15.

Chhangani, A.K. and Mohnot, S.M. (2004). Crop-raiding by wild boar (*Sus scrofa*) in and around Aravalli, and its management in Rajasthan, India. *Tiger paper*, 31(2): 1-5.

Chiyo, P.I., Lee, P.C., Moss, C.J., Archie, E.A., Hollister-Smith, J.A. and Alberts, S.C. (2011). No risk no gain: Effects of crop-raiding and genetic diversity on body size in male elephants. *Behavioural Ecology*, 22: 552-558.

Choden, D. and Namgay, K. (1996). Report on the findings and recommendations of the wild boar survey: Project for assessment of crop damage by the wild boar. National Plant Protection Center, Ministry of Agriculture, Royal Government of Bhutan, Thimphu, Bhutan.

Chong, D.K.F. and Dayang Norwana, A.A.B. (2005). Guidelines on the better management practices for the mitigation and management of human-elephant conflict in and around oil palm plantations in Indonesia and Malaysia. WWF Malaysia report, Pataling Jaya, Malaysia.

Choquenot, D., Mcllroy, J. and Korn, T. (1996). Managing vertebrate pests: Feral pigs. Bureau of Resource Sciences, Australian Government Publishing Service, Canberra, 1-171 pp.

Choudhury, A. (2004). Human-elephant conflict in Northeast India. *Human Dimensions of Wildlife*, 9: 261-270. DOI: 10.1080/10871200490505693.

Christopher, G. (1998). Studies on man-wildlife interactions in Peppara Wildlife Sanctuary and adjacent areas, Trivandrum District, Kerala. Ph.D. Thesis. FRI (Deemed) University, Dehra Dun, 204 pp.

Compose-Arceiz, A., Takatsuki, S., Ekanayaka, S.K.K. and Hasegawa, T. (2009). The human-elephant conflict in southeastern Sri Lanka: Type of damage, seasonal patterns, and sexual differences in the raiding behaviour of elephants. *Gajah*, 31, 5-14.

Conover, M.R. (2002). Resolving human-wildlife conflicts: The science of wildlife management. Lewis Publishers. 418 pp.

Cottam, G. and Curtis, J.T. (1956). The use of distance measures in phytosociological sampling. *Ecology*, 37(3): 451-460.

d'Huart, J.P. (1991). Habitat utilization of old world wild pigs. In: Barrett RG, Spitz F (eds) Biology of suidae, IRGM, Grenoble, 30-48 pp.

Dahlgren, R.B., Wywialowski, A., Bubolz, T.A. and Wright, V.L. (1977). Influence of knowledge of wildlife management principles on behaviour and attitudes toward resource issues. *Transactions of North American Wildlife and Natural Resources Conference*, 42: 145-155.

Daily, D.C., Indu, K. and Vijayan. (2014). A case of rabies in a wild pig. *Indian Journal of Scientific Research and Technology*, (5):23-24.

Daniel, J.C. (1996). The leopard in India - A natural history. Natraj Publishers, Dehradun, 228 pp.

Daniel, J.C., Desai, A.A, Kumar, A. and Sakthivel, C. (2008). Evaluating population enumeration methods and human elephant conflict mitigation methods in Mudumalai Tiger Reserve, Tamil Nadu, India. Bombay Natural History Society, Mumbai, 56-57 pp.

Daniel, J.C., Desai, A.A., Sivaganesan, N., Datye, H.S., Rameshkumar, S., Baskaran, N., Balasubramanian, M. and Swaminathan, S. (1995). Ecology of the Asian elephant. Final Report 1987-1994. Bombay Natural History Society, Bombay.

Dar, N.I., Minhas, R.A., Zaman, Q. and Linkie, M. (2009). Predicting the patterns, perceptions, and causes of human-carnivore conflict in and around Machiara National Park, Pakistan. *Biological Conservation*, 142: 2076-2082.

Deb, S., Debnath, M.K., Chakraborty, S., Weindorf, D.C., Kumar, D., Deb, D. and Choudhury, A. (2018). Anthropogenic impacts on forest land use and land cover change: Modeling future possibilities in the Himalayan Terai. *Anthropocene*, 21: 32-41.

Dela, J.D.S. (2011). Impact of monkey-human relationships and habitat change on *Semnopithecus vetulus nestor* in human modified habitats. *Journal of the National Science Foundation of Sri Lanka*, 39(4): 365-382.

Desai, A. A. and Krishnamurthy, V. (1992). Elephants in Meghalaya State, India: status conservation and conflict with agriculture. *In*:. The Asian Elephant (ed.) Silas, E. G. Krishnan, N. M. and Nirmalan, G. Kerala Agricultural University, Trichur, India 9-13 pp.

Desai, A.A. and Riddle, H.S. (2015). Human-elephant conflict in Asia. Technical Report, U.S Fish and Wildlife Service and Asian Elephant Support, 92 pp.

Dexter, N. (1998). The influence of pasture distribution and temperature on habitat selection by feral pigs in a semi-arid environment. *Wildlife Research*, 25: 547-559.

Dickman, A.J. (2010). Complexities of conflict: The importance of considering social factors for effectively resolving human-wildlife conflict. *Animal Conservation*, 13: 458-466.

Duffus, D.A. and Dearden, P. (1990). Non-consumptive wildlife oriented. Recreation: A conceptual Frame Work. *Biological conservation*, 53: 213-231.

Easa, P.S. and Jayaraman, K. (1998). Population estimation of major mammals in the forests of Kerala- 1997. KFRI Consultancy Report. Kerala Forest Research Institute, Peechi, 80 pp.

Easa, P.S. and Sankar, S. (2001). Study on man-wildlife interaction in Wayanad Wildlife Sanctuary. KFRI Research Report 166. Kerala Forest Research Institute, Peechi, 190 pp.

Easa, P.S., Sivaram, M. and Jayson, E.A. (2002). Population estimation of major mammals in the forests of Kerala - 2002. KFRI Consultancy Report No. 9. Kerala Forest Research Institute, Peechi, 88 pp.

Ekanayaka, S. K. K., Campos-Arceiz, A., Rupasinghe, M., Pastorini, J. and Fernando, P. (2011). Patterns of crop-raiding by Asian elephants in a human-dominated landscape in southeastern Sri Lanka. *Gajah*, 34: 20-25.

Enari, H. and Suzuki, T. (2010). Risk of agricultural and property damage associated with the recovery of Japanese monkey populations. *Landscape and Urban Planning*, 97: 83-91.

Erkinaro, E., Kalevi, H., Lindgren, E. and Sulkava, S. (1982). Occurrence and spread of wild pigs (*Sus scrofa*) in the eastern Finno Scandia. *Memoranda*, 58:39-47.

Fadeev, E.V. (1975). The ecology of the wild pigs in the central Russian SPSR. *Biol. Poelroned*, 28: 20-28.

Fattorini, N. and Pokheral, C.P. (2012). Activity and habitat selection of the Indian crested porcupine. *Ethology Ecology and Evolution*, 24:377-387.

Feichtner, B. (1998). Causes of fluctuations in the hunting kill of wild boar in the Saarland. *Zeitschrift für Jagdwissenschaft*, 44(3): 140-150

Fernando, P., Kumar, M.A., Williams, A.C., Wickramanayake, E., Aziz, T. and Singh, S.M. (2008). Review of human-elephant conflict mitigation measures practised in South Asia. WWF-World Wide Fund for Nature, AREAS Technical Support Document submitted to World Bank. 50 pp.

Fernando, P., Wikramanayake, E., Weerakoon, D., Jayasinghe, L.K.A., Gunawardene, M. and Janaka, H.K. (2005). Perceptions and patters of human-elephant conflict in old and new settlements in Sri-Lanka: insights for mitigation and management. *Biodiversity and Conservation*, 14: 2465-2481.

Gadd, M.E. (2005). Conservation outside parks: Attitudes of local people in Laikipia, Kenya. *Environmental Conservation*, 32: 50-63.

Gandiwa, E., Gandiwa, P. and Muboko, N. (2012). Living with wildlife and associated areas Northern Gonarezhou National Park, Zimbabwe. *Journal of Sustainable Development in Africa*, 14(6): 252-260.

Ganguly, I., Chauhan, N.S. and Verma, P. (2018). Assessment of human-macaque conflict and possible mitigation strategies in and around Asola-Bhatti Wildlife Sanctuary, Delhi NCR. *Environment and Ecology*, 36(3): 823-827.

Gee, E. P. (1964). Wildlife of India, Coliins, London: 1-192 pp.

Genov, P. (1981). The distribution of wild boar (*Sus scrofa* L.) in Eurasia and its adaptation to feeding conditions. *Zeitschrift für Jagdwissenschaft*, 27(4): 221-231.

Ghimirey, Y., Acharya, R. and Pokhrel, B.M. (2018). Human-Assamese macaque conflict in Makalu-Barun National Park buffer zone, Nepal. Friends of Nature. *The Himalayan Naturalist*, 1(1): 3-7.

Gilbert-Norton, L., Wilson, R., Stevens, J.R. and Beard, K. (2010). A meta-analytic review of corridor effectiveness. *Conservation Biology*, 24(3): 660-668.

Gillingham, S. and Lee, P.C. (2003). 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(3): 316–325.

Gopakumar, S., Santhoshkumar, A.V. and Kunhamu, T.K. (2012). Wild boars: Is elimination the day forward. *Current Science*, 102: 14-15.

Gore, M.L. and Knuth, B.A. (2009). Mass media effect on operating environment of wildlife-related risk-communication campaign. *The Journal of Wildlife Management*, 73: 1407-1413.

Gore, M.L., Siemer, W.F., Shanahan, J.E., Schuefele, D. and Decker, D.J. (2005). Effect on risk perception of media coverage of a black bear-related human fatality. *Wildlife Society Bulletin*, 33: 507-516.

Goulding, M.J. and Roper, T.J. (2002). Press response to the presence of free-living wild boar (*Sus scrofa*) in southern Engalnd. *Mammal Review*, 32: 272-282.

Govind, S.K. and Jayson, E.A. (2014). Economic loss to the farmers due to wild animals in Thrissur District, Kerala, India. *In*: Proceedings of the National Conference on Modern Trends in Zoological Research. Department of Zoology, St. Aloysius College, Elthuruth, Thrissur, Kerala, India. 220-223 pp.

Govind, S.K. and Jayson, E.A. (2018). Coconut (*Cocos nucifera*) damage by wild pig (*Sus scrofa*) and Indian crested porcupine (*Hystrix Indica*) in Central Kerala, India. *Current Science*, 115(1): 9-10.

Graham, M.D. and 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(1): 76-82.

Greaves, J.H. and Khan, A.A. (1978). The status and control of porcupines, genus *Hystrix* as forest pests. *The Commonwealth Forestry Review*, 57: 25-32.

Groom, R. and Harris, S. (2008). Conservation on community lands: The importance of equitable revenue sharing. *Environmental Conservation*, 35: 242-251.

Gross, E.M., Lahkar, B.P., Subedi, N., Nyirenda, V.R., Lichtenfeld, L.L. and Jakoby, O. (2018). Seasonality, crop type and crop phenology influence crop damage by wild herbivores in Africa and Asia. *Biodiversity and Conservation*, doi.org/10.1007/s10531-018-1523-0.

Groves, C.P. (1991). Suid and dicotylid systematic today. *In*: Barrett RG, Spitz F (eds) Biology of suidae, IRGM, Grenoble, 20-30 pp.

Gubbi, S. (2012). Patterns and correlates of human-elephant conflict around a South Indian Reserve. *Biological Conservation*, 148: 88-95.

Gubbi, S., Swaminath M.H., Poornesha H.C., Bhat, R. and Raghunath R. (2014). An elephantine challenge: Human-elephant conflict distribution in the largest Asian elephant population. *Biodiversity and Conservation*, 23(3): 633-647.

Gunaratne, L.H.P. and Premarathne, P.K. (2006). The effectiveness of electric fencing in mitigating human-elephant conflict in Sri-Lanka. Economy and environmental program for Southeast Asia, RP.No. 2005-RR1, 68 pp.

Habib, A., Nazir, I., Fazili, M.F. and Bhat, B.A. (2015). Human-wildlife conflict-causes, consequences and mitigation measures with special reference to Kashmir. *The Journal of Zoology Studies*, 2(1): 26-30.

Hafeez, S., Khan, G. S., Ashfaq, M. and Khan, Z. H. (2011). Food habits of the Indian crested porcupine *(Hystrix indica*) in Faisalabad, Pakistan. *Pakistan Journal of Agricultural Sciences*, 48(3):205-210.

Haikonen, H.B.A. and Summala, H. (2001). Deer-vehicle crashes: Extensive peak at 1 hour after sunset. *American Journal of Preventive Medicine*, 21(3): 209-213.

Hassan, S., Hambali, K., Shaharuddin, W.Y.W. and Amir, A. (2017). Human-wildlife conflict: A case study of local perceptions in Jeli, Kelantan, Malaysia. *Malayan Nature Journal*, 69(2): 113-125.

Herrero, J., García-Serrano, A., Couto, S., Ortuno, V.M. and Garcia-Gonzalez, R. (2006). Diet of wild boar *Sus scrofa* L. and crop damage in an intensive agro ecosystem. *European Journal of Wildlife Research*, 52: 245–250.

Hill, C.M. (2004). Farmers' Perspectives of conflict at the wildlife agriculture boundary: Some lessons learned from African subsistence farmer. *Human Dimensions of Wildlife*, 9: 279-286.

Hoare, R.E. (1999). Determinants of human-elephant conflict in a land-use mosaic. *Journal of Applied Ecology*, 36: 689-700.

Hoare, R.E. (2000). African elephants and humans in conflict: The outlook for co-existence. *Oryx*, 34: 34-38.

Hoare, R.E. (2001). A dicision support system for managing human-elephant conflict situation in Africa. IUCN African Elephant Specialist Group, 105 pp

Hoare, R.E. (2003). Fencing and other barriers against problem elephants. AFESG Technical Brief Series, 10 pp.

Hoare, R.E. and Du Toit, J.T. (1999). Coexistence between people and elephants in African Savannas. *Conservation Biology,* 13: 633-639.

Holbrook, M.R. (2012). Kyasanur Forest Disease. *Antiviral Research*, 96: 353-362.

Honda, T. and Sugita, M. (2007). Environmental factors affecting damage by wild boars (*Sus scrofa*) to rice fields in Yamanashi Prefecture, central Japan. *Mammal Study*, 32: 173-176.

Howe, T.D., Singer, F.J. and Ackerman, B.B. (1981). Forage relationships of European wild boar invading northern hardwood forest. *Journal of Wildlife Management*, 3: 748-754.

Imam, E. (1991). Translocation: A proposal for the conservation and management of rhesus monkey in Aligarh District. *Zoos Print*, 8: 3-4.

Imam, E., and Malik, I. (1997). Translocation of Monkeys from National Zoological Park, New Delhi to Tughlaqabad Fort, South Delhi. A report submitted by Vatavaran to National Zoological Park, New Delhi.

Imam, E., Malik, I. and Yahya, H.S.A. (2001). Translocation of Rehesus macaques from Air Force Station, Gurgaon (Haryana) to the natural forest of Firozpur –Jhirka, Haryana, India. *Journal of the Bombay Natural History Society*, 98(3): 355-359.

Infield, M. (1988). Attitudes of a rural community towards conservation and a local conservation area in Natal, South Africa. *Biological Conservation*, 45: 21-46.

Infield, M. and Namara, A. (2001). Community attitudes and behaviour towards conservation: An assessment of a community conservation programme around Lake Mburo National Park, Uganda. *Oryx*, 35 (1): 48-60.

Jackson, R. (1998). People-wildlife conflict management in the Qomolangma Nature Preserve, Tibet. Tibet's Biodiversity: Conservation and Management. Conference proceedings, 40-46 pp.

Jakubas, D., Rys, M. and Lazarus, M. (2018). Factors affecting wildlife-vehicle collision on the express way in suburban area in northern Poland. *North-Western Journal of Zoology*, 14 (1): 107-116.

Jayson, E. A. (2013). Assessment of crop damage by wild animalas in Trichur District, Kerala, KFRI Research Report No.491. Kerala Forest Research Institute, Peechi, 57 pp.

Jayson, E.A. (1998). Studies on man-wildlife conflict in Peppara Wildlife Sanctuary and adjacent areas. KFRI Research Report No.140, Kerala Forest Research Institute, Peechi, 71 pp.

Jayson, E.A. (1999). Studies on crop damage by wild animals in Kerala and evaluation of control measures. KFRI Research Report, 169. Kerala Forest Research Institute, Peechi, 48 pp.

Jayson, E.A. and Christopher, G. (2008). Human-elephant conflict in the southern Western Ghats: A case study from Peppara wildlife sanctuary, Kerala, India: *Indian Forester*. 1309-1325.

Jayson, E.A. and Padmanabhan, P. (2002). Evaluation of problems of captive/natural population of crocodile in Neyyar Wildlife Sanctuary and suggestions for their management with special emphasis on reduction of human-animal conflict. KFRI Research Report 237. Kerala Forest Research Institute, Peechi, 96 pp.

Jeyasingh, P.D. (1999). Crop depredation by the Indian wild pig (*Sus scrofa cristatus*) at fenced and unfenced areas on the eastern boundary of the Kalakad-Mundanthurai Tiger Reserve. M.S. Thesis Pondicherry University, Pondicherry, India. 46 pp.

John, J.K., Kattoor, J.J., Nair, A.R., Bharathan, A.P., Valsala, R. and Sadanandan, G.V. (2014). Kyasanur forest disease: a status update. *Advances in Animal and Veterinary Sciences*, 2: 239-336.

Johnsingh, A., Panwar, H. and Rodgers, W. (1991). Ecology and conservation of large felids in India. In N. Maruyama *et al.*, editor, Wildlife conservation: present trends and perspectives for the 21 century. Proc. Intl. Symposium on Wildlife Conservation in Tsukuba and Yokohama, 21-25 August 1990, 160-166 pp.

Joju, C. T. (2015). Working plan for Nilambur North Forest Division (2015-16 to 2024-25), Forest and wildlife department, Government of Kerala, 559 pp.

Joshi, A., Vaidyanathan, S., Mondol, S., Edgaonkar, A. and Ramakrishnan, U. (2013). Connectivity of tiger (*Panthera tigris*) Populations in the human influenced forest mosaic of central India. *PLoS ONE*, 8(11):1-11.

Joshi, R. and Singh, R. (2008). Feeding behaviour of wild Asian elephants (*Elephas maximus*) in the Rajaji National Park. *The Journal of American Science*, 4(2): 34-48.

Kabir, M., Waseem, M., Ahmad, S., Goursi, U.H. and Awan, M.N. (2017). Livestock depredation by leopard, an alarming intimidation for its conservation in Pir Lasoora National Park Nakial, Azad Jammu and Kashmir. *International Journal of Conservation Science*, 8(2): 295-302.

Kakkoth, S. (2001). Nilambur Valley: A study in interrelationship between habitat, economy, society and culture. Ph.D Thesis, center for anthropological studies, University of Calicut, 37-50 pp.

Kala, C.P. and Kothari, K.K. (2013). Live stock predation by common leopard in Binsar Wildlife Sanctuary, India: Human-wildlife conflict and conservation issues. *Human-Wildlife Interactions*, 7(2): 325-333.

Kangwana, K. (1995). Human-elephant conflict: challenges ahead. *Pachyderm*, 19: 11-14.

Karanth, K.K. and Kudalkar, S. (2017). History, location and species matter: Insight for human-wildlife conflict mitigation from India. *Human Dimensions of Wildlife*, DOI: 10.1080/10871209.2017.1334106.

Karanth, K.K., Gopalaswamy, A.M., Defries, R. and Ballal, N. (2012). Assessing patterns of human-wildlife conflicts and compensation around a central Indian Protected Area. *PLoS ONE*, 7: 1-13.

Karanth, K.K., Gopalaswamy, A.M., Prasad, P.K and Dasgupta, S. (2013). Patterns of human–wildlife conflicts and compensation: Insights from Western Ghats protected areas. *Biological Conservation*, 166, 175–185.

Karimi, R.R. (2009). An assessment of perceived crop damage in a Tanzanian village impacted by human-elephant conflict and an investigation of deterrent properties of African elephants (*Loxodonta africana*) exudates using bioassays. Electronic Theses and Dissertation, 740, 90 pp.

Keuling, O., Stier, N. and Roth, M. (2009). Commuting, shifting or remaining? Different spatial utilisation patterns of wild boar *Sus scrofa* L. in forest and field crops during summer. *Mammalian Biology*, 74: 145–152.

Kgathi, D.L., Mmopelwa, G., Mashabe, B. and Mosepele, K. (2012). Livestock predation, house hold adaptation and compensation policy: a case study of Shorobe village in Northern Botswana. *Agricultural Economics Association of South Africa*, 52(2): 22-37.

Khalil, S. U. R. and Hussain, T. (2008). Common leopard predation on livestock, an assessment of local predation in the Gallies Forest division, District Abbotabad. Leopard conservation project WWF-Pakistan, 33 pp.

Khan, A. A. (2010). Bio-economic impacts of vertebrate pests on crops with special reference to rodent pests in Pakistan and other countries. VPCI/SARC, PARC, Karachi. 35 pp.

Khan, A.A., Ahmad, S., Hussain, I. and Munir, S. (2000). Deterioration impact of Indian crested porcupine (*Hystrix indica*) on forestry and agricultural systems in Pakistan. *International Biodeterioration & Biodegradation*, 45: 143-149.

Khan, A.A., Mian, A. and Hussain, R. (2014). Deterioration Impact of Indian crested porcupine, on Irrigated Forest Plantations in Punjab, Pakistan. *Pakistan Journal of Zoology*, 46(6): 1691-1696.

Khan, M.A.R. (1986). The status and distribution of the cats in Bangladesh. Cats of the world: Biology, conservation and management. National Wildlife Federation, Washington, D.C., 43-49 pp.

King, L.E. (2013). Elephants and bees: Could honey bees be effective deterrents for Asia's crop-raiding elephants?. *Sanctuary Asia*. 61-65.

King, L.E., Douglas-Hamilton, I. and Vollrath, F. (2011). Beehive fences as effective deterrents for crop-raiding elephants: field trials in northern Kenya. *African Journal of Ecology*, 49: 431–439.

King, L.E., Lala, F., Nzumu, H., Mwambingu, E. and Douglas-Hamilton I. (2017). Beehive fences as a multidimensional conflict-mitigation tool for farmers coexisting with elephants. *Conservation Biology*, 31:743–752.

King, L.E., Lawrence, A., Douglas-Hamilton, I. and Vollrath, F. (2009). Beehive fence deters crop-raiding elephants. *African Journal of Ecology*, 47: 131-137.

King, L.E., Pardo, M., Weerathunga, S., Kumara, T.V., Jayasena, N., Soltis, J. and de-Silva, S. (2018). Wild Sri Lankan elephants retreat from the sound of disturbed Asian honey bees. *Current Biology*, 28:51-65.

Kioko, J., Muruthi, P., Omondi, P. and 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.

Kumar, M.A., Mudappa, D. and Raman, T.R.S. (2010). Asian elephant (*Elephas maximus*) habitat use and ranging in fragmented rain forest and plantations in the Anamalai hills, India. *Tropical Conservation Science*, 3(2): 143-158.

Kumar, S. and Rahmani, A.R. (2000). Livestock Depredation by wolves in the Great Indian Bustard Sanctuary, Nannaj (Maharastra), India. *Journal of the Bombay Natural History Society*, 97(3): 340-348.

Lagos, L., Picos, J. and Valero, E. (2012). Temporal pattern of wild ungulate-related traffic accidents in northwest Spain. *European Journal of Wildlife Research*, 58: 661–668.

Lahm, S.A. (1996). A national-wide survey of crop-raiding by elephants and other species in Gabon. *Pachyderm*, 21: 69-77.

Lamichhane, B.R., Persoon, G.A., Leirs, H., Musters, C.J.M., Subedi, N., Gairhe, K.P., Pokheral, C.P., Poudel, S., Mishra, R., Dhakal. M., Smith, J.L.D. and de-longh, H.H. (2017). Are conflict-causing tigers different? Another perspective for understanding human-tiger conflict in Chitwan National Park, Nepal. *Global Ecology and Conservation*, 11: 177-187.

Lim, B.L. (2016). The porcupines, the common bamboo rat, squirrels and the tree shrew as secondary pests of agriculture in Malaysia. *UTAR Agriculture Science Journal*, 2(2): 33-42.

Linkie, M., Dinata, Y., Nofrianto, A. and Leader-Williams, N. (2007). Patterns and perceptions of wildlife crop-raiding in and around Kerinci Seblat National Park, Sumatra. *Animal Conservation*, 10: 127-135.

Lombardini, M., Meriggi, A. and Fozzi, A. (2016). Factors influencing wild boar damage to agricultural crops in Sardinia (Italy). *Current Zoology*, 1-8, doi: 10.1093/cz/zow099.

Lute, M.L., Navarrete, C.D., Nelson, M.P. and Gore, M.L. (2016). Moral dimensions of human-wildlife conflict. *Conservation Biology*, 0: 1-12, DOI: 10.1111/cobi.12731.

Macnamara, J. (2005). Media content analysis: Its uses and benefits and best practice methodology. *Asia Pacific Public Relations Journal*, 6(1): 1-34.

Madden, F. (2004). Can traditions of tolerance help minimize conflict? An exploration of cultural factors supporting human-wildlife coexistence. *Policy matters*, 13: 234-241.

Madhusudan, M.D. (2003). Living amidst large wildlife: Livestock and crop depredation by large mammals in the interior villages of Bahadra Tiger Reserve, South India. *Environmental Management*, 31(4): 466-475.

Madhusudan, M.D. and Mishra, C. (2003). Why big, fierce animals are threatened: conserving large mammals in densely populated landscapes. In V. K. Saberwal, and M. Rangajaran (Eds.), Battles over nature: science and the politics of wildlife conservation, Delhi, India, 31-55 pp.

Maikhuri, R.K., Nautiyal, S., Rao, K.S. and Saxena, K.G. (2001). Conservation policy-people conflicts: a case study from Nanda Devi Biodiversity Reserve (A World Heritage Site, India). *Forest Policy Economics*, 2: 355–365.

Manral, U., Sengupta, S., Hussain, S.A., Rana, S. and Badola, R. (2016). Human-wildlife conflict in India: A review of economic implication of loss and preventive measures. *Indian Forester*, 142(10): 928-940.

Mary, R.A.A. and Karthikeyan, A. (2016). An efficient warning system for human-elephant conflict. *International Journal of Scientific Research in Science, Engineering and Technology*, 2(2): 344-349.

Massei, G. and Cowan, D. (2014). Fertility control to mitigate human-wildlife conflicts: a review. *Wildlife Research*, doi.org/10.1071/WRI3141.

Massei, G., Roy S. and Bunting, R. (2011). Too many hogs? A review of methods to mitigate impact by wild boar and feral hogs. *Human-Wildlife Interactions*, 5: 79–99.

Mayer, J.J. (2013). Wild pig attacks on humans. Wildlife Damage Management Conferences. Proceedings Savannah River National Laboratory, 17-35 pp.

Mayer, J.J. and Brisbin, Jr. I.L. (2009). Wild pigs: Biology, damage, control techniques and management SRNLRP-2009-00869. Savannah River National Laboratory. 400 pp.

Mayer, J.J. and Johns, P.E. (2007). Characterization of wild pig-vehicle collisions. Proceedings of the wildlife damage management conference, 12: 175-187.

Mckay, G.M. (1973). Behaviour and ecology of the Asiatic elephant in southeastern Cylon. Smithsonian contributions to zoology, Smithonian Institution Press, City of Washington, No.125, 67-69 pp.

McLennan, M.R., Spagnoletti, N. and Hockings, K.J. (2017). The implications of primate behavioural flexibility for sustainable human-primate coexistence in anthropogenic habitats. *International Journal of Primatology*, DOI 10.1007/s10764-017-9962-0.

Mclntyre, E.G. (1972). Barkstripping- A natural phenomenon. *J.R. Scottish For. Soc.,* 26: 43-50.

Messmer, T.A. (2000). The emergence of human-wildlife conflict management: Turning challenges into opportunities. *International Biodeterioration & Biodegradation*, 45, 97-102.

Mian, A., Khan, A.A. and Hussain, R. (2007). Biology and management of porcupine, *Hystrix indica* in Central Punjab, Pakistan. Final Progress Rep. (2003-2007,unpublished). ALP project, development of zoology¸ University of Arid Agriculture, Rawalpindi, 129 pp.

Milind, W., Kajol, P., Abhijeet, B. and Pramod, P. (2016). A theoretical model of community operated compensation scheme for crop damage by wild herbivores. *Global Ecology and Conservation,* 5: 58-70.

Mir, Z.R., Noor, A., Habib, B. and Veeraswami, G.G. (2015). Attitudes of local people toward wildlife conservation: A case study from the Kashmir Valley. *Mountain Research and Development*, 35(4): 392-400.

Mishra, C. (1997). Livestock depredation by large carnivores in the Indian trans-Himalaya: Conflict perceptions and conservation prospects. *Environmental Conservation,* 24: 338–343.

Mishra, J. (1971). An assessment of annual damage to crop by elephants in Palamau, District, Bihar. *Journal of the Bombay natural History Society*, 68: 307-310.

Monroe, M.W. and England, L.D. (1978). Elephants and Agriculture in Malaysia, Kuala Lumpur. Department of Wildlife and National Parks, Kuala Lmpur.

Mourya, D.T., Yadav, P.D. and Patil, D.Y. (2014). Highly infectious tick-borne viral diseases: Kyasanur forest disease and crimean-congo haemorrhagic fever in India. *WHO South East Asia Journal of Public Health,* 3: 8-21.

Murhekar, M.V., Kasabi, G.S., Mehendale, S.M., Mourya, D.T., Yadav, P.D. and Tandale, B.V. (2015). On the transmission pattern Kyasanur Forest Disease (KFD) in India. *Infectious Diseases of Poverty*, 4:37.

Nair, R.P. and Jayson, E.A. (2016 a). Wild pig rabies- A case study from Pathippara, Malappuram, Kerala. *International journal of Research in Medical and Basic Sciences* 2: 1-5.

Nair, R.P. and Jayson, E.A. (2016 b). Effectiveness of beehive fences to deter crop-raiding Asian elephants in Kerala, India. I*nternational Research Journal of Nature and Applied Sciences*, 3: 14-19.

Nath, C.D. and Sukumar, R. (1998). Elephant-human conflict in Kodagu, southern India: Distribution patterns, people's perceptions and mitigation methods. Asian Elephant Conservation Centre, Bangalore, India, 62 pp.

Nath, N.K., Dutta, S.K., Das, J.P. and Lahkar, B.P. (2015). A quantification of damage and assessment of economic loss due to crop-raiding by Asian elephant *Elephas maximus*, (Mammalia: Proboscidea: Elephantidae): A case study of Manas National Park, Assam, India. *Journal of Threatened Taxa,* 7(2): 6853-6863.

Naughton-Treves, L. (1998). Predicting pattern of crop damage by wildlife around Kibale National Park, Uganda. *Conservation Biology*, 12 (1): 156-168.

Naughton-Treves, L. (1999). Whose animals? A history of property rights to wildlife in Toro, Western Uganda. *Land Degradation & Development*, 10: 311-328.

Nelson, A., Bidwell, P. and Sillero-Zuberi, C. (2003). A review of human-elephant conflict management strategies, People and wildlife initiative, Wildlife Conservation Research Unit. Oxford University, 25 pp.

Neupane, D., Kunwar, S., Bohara, A.K., Risch, T.S. and Johnson, R.L. (2017). Willingness to pay for mitigating human-elephant conflict by residents of Nepal. *Journal of Nature Conservation*, 36: 65-76.

Newton, P.N. (1987). The social organization of forest hanuman langur (*Presbytis entellus*). *International Journal of Primatology*, 8: 199-232.

Ngama, S., Korte, L., Bindelle, J., Vermeulen, C. and Poulsen, J.R. (2016). How bees deter elephants: Beehive trails with forest elephants (*Loxodonta Africana cyclotis*) in Gabon. *PLoS ONE,* 11(15): 1-12.

Nijman, V. and Nekaris, K.A. (2010). Testing a model for predicting primate crop-raiding using crop and farm specific risk values. *Applied Animal Behaviour Science*, 127: 125-129.

Nowell, K. and Jackson, P. (1996). Wild cats: Status survey and conservation action plan. IUCN/SSC Cat Specialist Group. IUCN, Gland, 382 pp.

Nyerges, A.E. (1992). The ecology of wealth in people: Agriculture, Settlement, and society on the perpetual frontier. *American Anthropologist*, 94(4): 860-881.

Nyhus, P.J., Fischer, H., Madden, F. and Osofsky, S. (2003). Taking the bite out of wildlife damage: The challenges of wildlife compensation schemes. *Conservation in Practice*, 4: 37-40.

Nyhus, P.J., Tilson, R. and Suminato, R.T. (2000). Crop-raiding elephants and conservation implications at Way Kambas National Park, Sumatra, Indonesia. *Oryx*, 34: 262–274.

Nyirenda, V.R., Myburgh, W.J., Reilly, B.K., Phiri, A.I. and Chabwela, H.N. (2013). Wildlife crop damage valuation and conservation: Conflicting perception by local farmers in the Luangwa Valley, eastern Zambia. *International Journal of Biodiversity and Conservation*, 5(11): 741-750.

Odden, M., Athreya, V., Rattan, S. and Linnell, J.D.C. (2014). Adaptable neighbours: Movement patterns of GPS-collared leopards in human dominated landscapes in India. *PLoS ONE*, 9(11): 1-9.

Ogada, M.O., Woodroffe, R., Oguge, N.O. and Frank, L.G. (2003). Limiting depredation by African carnivores: The role of livestock husbandry. *Conservation Biology*, 17(6): 1521-1530.

Ogra, M. (2009). Attitudes toward resolution of human–wildlife conflict among forest-dependent agriculturalists near Rajaji National Park, India. *Human Ecology*, 37(2): 161-177.

Ogra, M. and Badola, R. (2008). Compensating human-wildlife conflict in protected area communities: Ground-level perspectives from Uttarakhand, India. *Human Ecology*, 36: 717-729.

Olivier, R.C.D. (1978). On the ecology of the Asian elephant. Ph.D. Thesis, University of Cambridge, UK.

Osborn, F.V. and Parker, G.E. (2003). Towards an integrated approach for reducing the conflict between elephants and people: A review of current research. *Oryx*, 37(1): 1-5.

Osei-Owusu, Y. and Bakker, L. (2008). Human-wildlife conflict: Elephant technical manual. Wildlife management working paper (11). Food and Agriculture Organization of the United Nations, Rome. 45 pp.

Panwar, N., Khan, J.A. and Gavali, R.S. (2014). Attitude and perceptions of local people towards a conservation based approach for poverty alleviation in a semiarid region Wildlife Sanctuary , India, *The Journal of Ecology*, 109: 414-424.

Parisara Envis Newsletter (2015). Human wildlife conflict-need for calm coexistence. Karnataka ENVIS Centre, Environmental Management and Policy Research Institute, 37 pp.

Parker, G.E. and Osborn, F.V. (2006). Investigating the potential for Chilli *Capsicum spp*. to reduce human-wildlife conflict in Zimbabwe. *Oryx*, 40(3): 343-346.

Parker, G.V. and Osborn, F.V. (2001). Dual season crop damage by elephants in the Eastern Zambezi Valley, Zimbabwe. *Pachyderm*, 30: 49-56.

Patterson, B.D., Kasiki, S.M., Selempo, E. and Kays, R.W. (2004). Livestock predation by lions (*Panthera leo*) and other carnivores on ranches neighboring Tsavo National Parks, Kenya. *Biological Conservation*, 119: 507-516.

Paudel, P.K. (2016). Conflict due to Assamese macaques (*Macaca assamensis* McClelland 1840) and crop protection strategies in Kali-gandaki River Basin, Western Nepal. *Our nature*, 14(1): 107-114.

Pimentel, D., Zuniga, R. and Morrison, D. (2005). Update on the environmental and economic costs associated with alien-invasive species in the United States. *Ecological Economics,* 52: 273–288.

Podgorski, T., Bas, G., Jedrzejewska, B., Sonnichsen, L., Sniezko, S., Jedrzeejewski, W. and Okarma, H. (2013). Spatio-temporal behavioral plasticity of wild boar (*Sus scrofa*) under contrasting conditions of human pressure: Primeval forest and metropolitan area. *Journal of Mammalogy*, 94(1): 109-119.

Poudyal, N.C., Caplenor, C., Joshi, O., Maldonado, C., Muller, L.I. and Yoest, C. (2017). Characterizing the economic value and impacts of wild pig damage on a rural economy. *Human Dimensions of Wildlife*, 22(6): 538-549.

Pozo, R.A., Coulson, T., McCulloch, G., Stronza, A.L. and Songhurst, A.C. (2017). Determining baselines for human-elephant conflict: A matter of time. *PLoS ONE*, 12(6): 1-17.

Pozo, R.A., Cusack, J.J., McCulloch, G., Stronza, A., Songhurst, A. and Coulson, T. (2018). Elephant space-use is not a good predictor of crop damage. *Biological Conservation*, 228: 241-251.

Prakash, I. (1971). Breeding season and litter size of the Indian desert rodents. *Z. angew. Zool.* 58(4): 441-454.

Prasad, B.D. (2008). Content analysis: A method in social science research. *Research methods for social work* (eds D.K. Lal Das and V. Bhaskaran),. Rawat. New Delhi, India. 173-193 pp.

Prasad, G., Shiny, R., Reghunath, R. and Prasannakumar, V. (2011). GIS-based spatial prediction model for human–elephant conflicts (HEC). *Wildlife Biology in Practice*, 7: 30–40.

Prashanth, P.K.M., Kumara, V. and Thirumala, S. (2013). Man-animal conflicts in protected areas: A case study of Gaur *Bos gaurus* H Smith from the Mookambika Wildlife Sanctuary, Kollur, Karnataka, India. *International Journal of Current Microbiology and Applied Sciences*, 2: 466–475.

Prater, S.H. (1980). The book of Indian animals. Bombay Natural History society. 324 pp.

Punidan, D., Jeyasingh, P.D. and Davidar, P. (2003). Crop depredation by wildlife along the eastern boundary of the Kalakad-Mundanthurai Tiger Reserve, Southern India. *Journal of the Bombay Natural History Society*, 100(1): 38-45.

Putzu, N., Bonetto, D., Civallero, V., Fenoglio, S., Meneguz, P.G., Preacco N. and Tizzani, P. (2014). Temporal patterns of ungulate-vehicle collisions in a subalpine Italian region. *Italian Journal of Zoology*, 81(3): 463-470.

Rajpurohit, L.S. and Mohnot, S.M. (1988). Field observation on nilgai, (*Boselaphus tragocamelus*) around Jodhpur. *Tiger paper*, XV (3): 24-29.

Ramakrishnan, B., Sivaganesan, N. and Srivastava, R. (1997). Human interference and its impact on elephant corridors in South India. *Gajah*, 18: 1-20.

Ramkumar, K., Ramakrishnan, B. and Saravanamuthu, R. (2013). Human-elephant (*Elephas maximus*) conflict in southern India: People's perception on conflict and elephant conservation in Coimbatore Forest Division. *Scientific Transactions in Environment and Technovation*, 7(2): 69-76.

Ramkumar, K., Ramakrishnan, B. and Saravanamuthu, R. (2014). Crop damage by Asian elephants *Elephas maximus* and effectiveness of mitigating measures in Coimbatore Forest Division, south India. *International Research Journal of Biological Sciences*, 3(8): 1-11.

Rao, K.S., Maikhuri, R.K., Nautiyal, S. and Saxena, K.G. (2002). Crop damage and livestock depredation by wildlife: A case study from Nanda Devi Biosphere Reserve, India. *Journal of Environmental Management*, *66*: 317-27.

Redpath, S.M., Bhatia, S. and Young, U. (2015). Tilting at wildlife: Reconsidering human-wildlife conflict. *Oryx*, 49(2), 222-225.

Regmi, G.R., Nekaris, K.A., Kandel, K. and Nijman, V. (2013). Crop-raiding macaques: Predictions, patterns and perceptions from Langtang National Park, Nepal. *Endangered Species Research*, 20: 217-226.

Retamosa, M.I., Humberg, L.A., Beasley, J.C. and Rhodes-JR, O.E. (2008). Modeling wildlife damage to crops in northern Indiana. *Human-Wildlife Conflicts*, 2(2): 225-239.

Robert, T.J. (1977). The Mammals of Pakistan. Ernst Benn Ltd. London. 361pp.

Rode, K.D., Chiyo, P.I., Chapman, C.A. and McDowell, L.R. (2006). Nutritional ecology of elephants in Kibale National Park, Uganda, and its relationship with crop-raiding behaviour. *Journal of Tropical Ecology*, 22: 441-449.

Rohini, C.K., Aravindan, T., Das, K.S.A. and Vinayan, P.A. (2017). Peoples attitude towards wildlife conservation in Kerala part of the Western Ghats, India. *International Journal of Conservation Science*, 8(2): 269-280.

Rohini, C.K., Aravindan, T., Vinayan, P.A., Ashokkumar, M. and Das, K.S.A. (2016 a). An assessment of human-elephant conflict and associated ecological and demographic factors in Nilambur, Western Ghats of Kerala, southern India. *Journal of Threatened Taxa,* 8(7): 8970-8976.

Rohini, C.K., Aravindan, T., Das, K.S.A. and Vinayan, P.A. (2016 b). Patterns of human-wildlife conflict and people's Perception towards compensation program in Nilambur, Southern Western Ghats, India. *Conservation Science*, 4. 1. 10.3126/cs.v4i1.16891.

Romanach, S.S., Lindsey, P.A. and Woodroffe, R. (2007). Determinants of attitudes towards predators in central Kenya and suggestions for increasing tolerance in livestock dominated landscapes. *Oryx*, 41(2): 185-195.

Rood, E.J.J. (2006). The status and distribution of the Sumatran elephant in Aceh, Indonesia. WWF, Yayasan Gajah Sumatra, Amsterdam.

Rood, E.J.J., Azmi, W. and Linkie, M. (2008). Elephant crop-raiding in a disturbed environment: The effect of landscape clearing on elephant distribution and crop-raiding Patterns in the North of Areh, Indonesia. *Gajah*, 29: 17-23.

Roy, M. and Sukumar, R. (2015). Elephant corridors in Northern West Bengal. *Gajah*, 43: 26-35.

Roy, M. and Sukumar, R. (2017). Railways and wildlife: A case study of train-elephant collisions northern West Bengal, India. *Railway Ecology*, DOI 10.1007/978-3-319-57496-7.

Saaban, S., Othman, N.B., Yasak, M.N.B., Nor, B.M., Zafii, A. and Compose-Arceiz, A. (2011). Current status of Asian elephants in Peninsular Malaysia. *Gajah*, 35: 67-75.

Saberwal, V.K., Gibs, J.P., Chellam, R. and Johnsingh, A.T.J. (1994). Lion-human conflict in the Gir forest, India. *Conservation Biology,* 8: 501–507.

Sadanandane, C., Elango, A., Marja, N., Sasidharan, P.V. and Raju, K.H.K. (2017). An outbreak of Kyasanur forest disease in the Wayanad and Malappuram districts of Kerala, India. *Ticks and Tick-borne Diseases*, 25-30. DOI: 10.1016/j.ttbdis.2016.09.010.

Salman, S. and Nasharuddin, O. (2003). A preliminary study on disturbance cases by elephants (*Elephas maximus*) in the state of Johor. *Journal of Wildlife and Parks*, 21: 1-11.

Sangay, T. and Vernes, K. (2008). Human-wildlife conflict in the Kingdom of Bhutan: Patterns of livestock predation by large mammalian carnivores. *Biological Conservation*, 141: 1272-1282.

Santiapillai, C. and Jackson, P. (1990). The Asian elephant: An action plan or its conservation. IUCN, Gland. Switzerland.

Santiapillai, C., Chambers, M.R. and Ishwaran. N. (1982). The leopard *Panthera pardus* fusea (Meyer 1794) in the Ruhuna National Park, Sri Lanka and observations relevant to its conservation. *Biological Conservation*, 23: 5–14.

Saraswat, R., Sinha, A. and Radhakrishna, S. (2015). A god becomes pest? Human-rhesus macaque interaction in Himachal Pradesh, northern India. *European Journal of Wildlife Research*, 61(3): 435-443.

Scheufele, D.A. and Tewksbury, D. (2007). Framing agenda setting and printing: The evolution of three media effects models. *Journal of communication*, 57: 9-20.

Schley, L. and Roper, T.J. (2003). Diet of wild boar *Sus scrofa* in Western Europe, with particular reference to consumption of agricultural crops. *Mammal Review*, 33: 43-56.

Schley, L., Dufrene, M., Krier, A. and Frantz, A.C. (2008). Patterns of crop damage by wild boar (*Sus scrofa*) in Luxembourg over 10-year period. *Europian Journal of Wildlife Research*, 54(4): 589-599.

Seidensticker, J.F. (1984). Managing elephant depredation in agricultural and forestry projects (English). World bank technical paper; no. WTP 16. Washington, DC: The World Bank.

Sekar, N. (2013). Tolerance for the charismatic marauders: Culture in wildlife conservation.825. *Economic and Political Weekly June*, 48(24): 10–13.

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.

Seshadri, B. (1986). India's wildlife and wildlife reserves. Sterling publishers, New Delhi. 241 pp.

Sharma, D. and Prasad, S.N. (1992). Tree debarking and habitat use by porcupine (*Hystrix indica* Kerr) in Sariska National Park in Western India. *Mammalia*, 351-361.

Sharma, G., Ram, C., Devilal and Rajpurohit, L.S. (2011). Study of man-monkey conflict and its management in Jodhpur , Rajasthan, (India). *Journal of Evolutionary Biology Research*, 3(1): 1-3.

Sidhu, S., Raghunathan, G., Mudappa, D. and Raman, T.R.S. (2017). Conflict to coexistence: Human-leopard interactions in a plantation landscape in Anamalai hills, India, *Conservation and Society*, 15(4): 474-482.

Siex, K.S. and Struhsaker, T.T. (1999). Colobus monkeys and coconut: A study of perceived human-wildlife conflict. *Journal of Applied Ecology*, 36: 1009-1020.

Sitati, N.W., Walpole, M.J. and Leader-Williams, N. (2005). Factors affecting susceptibility of farms to crop-raiding by African elephants: Using a predictive model to mitigate conflict. *Journal of Applied Ecology*, 42: 1175-1182.

Sitati, N.W., Walpole, M.J., Smith, R.J. and Leader-williams, N. (2003). Predicting spatial aspects of human-wildlife conflict. *Journal of Applied Ecology*, 40: 667-667.

Sivaram, M., Jayson, E.A. and Ramachandran, K.K. (2013). Population estimation of major mammals in the forests of Kerala – 2011. KFRI Extension Report No. 61. Kerala Forest Research Institute, Peechi, 121 pp.

Sivaram, M., Ramachandran, K.K., Jayson, E.A. and Nair, P.V. (2010). Wild elephant census of Kerala State - 2010. KFRI Extension Report No. 52. Kerala Forest Research Institute, Peechi, 40 pp.

Sivaram, M., Ramachandran, K.K., Nair, P.V. and Jayson, E.A. (2007). Population estimation of wild elephants in the elephant reserves of Kerala State – 2007. KFRI Extension Report No. 27. Kerala Forest Research Institute, Peechi.

Sivaram, M., Ramachandran, K.K., Nair, P.V. and Jayson, E.A. (2005). Population estimation of wild elephants in the elephant reserves of Kerala State – 2005. Kerala Forest Research Institute, Peechi.

Smith, R.J. and Kasiki, S.M. (1999). A spatial analysis of human-elephant conflict in the Tsavo Ecosystem. IUCN African Elephant Specialist Group Report. 73 pp.

Soofi, M., Ghoddousi, A., Zeppenfeld, T., Shokri, S., Soufi, M., Jafari, A., Ahmadpour, M., Qashqaei, A.T., Egli, L., Ghadirian., Chahartaghi, N.R., Zehzad, B., Kiabi, B.H., Khorozyam, I., Balkenhol, N. and Waltert, M. (2018). Livestock grazing in protected areas and its effects on large mammals in the Hyrcanian forest, Iran. *Biological Conservation*, 217: 377-382.

Sotolu, R.O., Akanbi, A.O. and Tyowua, B.T. (2017). Impact of human-wildlife conflict on socio-economy of support zone communities of Cross River National Park, Ngeria. *Journal of Research in Forestry, Wildlife and Environment*, 9(1): 75-84.

Southwick, C.H., Siddiqi, M.F. and Johnson, R. (1984). Subgroup relocation of rhesus monkey in India as conservation measures. *American Journal of Primatology*, 6: 428.

Spillett, J.J., Cohen, J.E. and De, R.C. (1966). The large Mammals of the Koeladeo Ghana Sanctuary, Rajasthan. *Journal of the Bombay Natural History Society*, 63(3): 604-607.

Sreedharan, T.P. (2004). Biological Diversity of Kerala: A survey of Kalliasseri Panchayat, Kannur District. Kerala research programme on local level development centre for development studies, Thiruvananthapuram, Discussion Paper No. 62, ISBN No. 81-87621-65-6, 176 pp.

Sreenath, G. (2013). Groundwater information booklet of Malappuram district. Central Ground Water Board, Kerala Region. Ministry of Water Resources, Government of India, 29 pp.

Studsrod, S.E. and Wegge, P. (1995). Park-people relationship: The case of damaged caused by park animals around the Royal Bardia National Park, Nepal. *Environmental Conservation*, 22: 133-142.

Sukumar, R. (1985). Ecology of the Asian elephant (*Elephas maximus*) and its interaction with man in south India. Ph.D. Thesis, Vol.1& 2. Indian Institute of Science, Bangalore, India. 542 pp.

Sukumar, R. (1986). Elephant-human conflict in Karnataka in: C.J Sldanha (Ed), Karnataka State of the environment report 1984-1985, Center for taxonomic studies, Banglore. 46-59 pp.

Sukumar, R. (1989). The Asian Elephant: Ecology and management. Cambridge University Press, Cambridge, UK. 251 pp.

Sukumar, R. (1990). Ecology of the Asian elephant in Southern India: II. Feeding habits and crop-raiding patterns. *Journal of tropical Ecology*, 1990, 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. (2003). The living elephants: Evolutionary ecology, behaviour, and conservation. Oxford University Press, New York. 478pp.

Sutradhar, B.C., Das, B.C., Ferdous, S., Rahman, M., Hossain, S., Hossain, F. and Hasanuzzaman. (2018). Penetrating gunshot wound, emphysema and inanition followed by death in a wild Asian elephant: A case report. *International Journal of Avian & Wildlife biology*, 3(2): 112-115.

Sutton, W.R. (1998). The costs of living with elephants in Namibia. Workshop on cooperative regional wildlife management in South Africa, 15 pp.

Tamang, B. and Baral, N. (2008). Livestock depredation by large cats in Bardia National Park, Nepal: Implications for improving park-people relations. *International Journal of Biodiversity Science and Management*, 4(1): 44-53.

Tesfay, H. (2016). Human-wildlife interaction: Wildlife crop-raiding conflict in Ethiopia. *International Journal of Science and Research*, 5(5): 1188-1191.

Thouless, C.R. (1994). Conflict between humans and elephants on private land in Northern Kenya. *Oryx*, 28: 119-127.

Thurfjell, H., Ball, J.P., Ahlen, P., Kornacher, P., Dettki, H. and Sjoberg, K. (2009). Habitat use and spatial patterns of wild boar *Sus scrofa* (L.): agricultural fields and edges. *European Journal of Wildlife Research*, 55: 517-523.

Thurfjell, H., Spong, G. and Ericsson, G. (2013). Effect of hunting on wild boar *Sus scrofa* behaviour. *Wildlife Biology*, 19(1): 87-93.

Thyagaraj, N.E., Chakravarthy, A.K. and Girish, A.C. (2006). Feeding behaviour of porcupine *Hystrix indica* Kerr in coconut plantations of Western Ghats of Karnataka. *Advances in Indian Entomology: Productivity and Health*, 2: 169-176.

Tisdell, C.A. (1982). Wild pigs: Environmental pest economic resource? Pergamon Press, London. 445 pp.

Trapido, H. (1957). Kyasanur forest disease: A new infection of man and monkeys in tropical India by virus of the Russian spring summer-complex. Proc. Ninth Pac. Sci. Congr. 17: 80-84.

Treves, A. and Karanth, K.U. (2003). Human-carnivore conflict and perspectives on carnivore management worldwide. *Conservation Biology*, 17: 1491-1499.

Treves, A., Wallace, R.B. and White, S. (2009). Participatory planning of interventions to mitigate human-wildlife conflicts. *Conservation Biology*, 23(6): 1577-1587.

Treves, A., Wallace, R.B., Naughton-Treves, L. and Morales, A. (2006). Co-managing human-conflicts: A Review. *Human Dimensions of Wildlife*, 11: 383-396.

Tritsch, M.F. (2001). Wildlife of India. Thomson press Ltd., India

Vahab, A.T. (2018). Industrial potential survey, Malappuram District. District Industries Centre, Malappuram, 1-86 pp.

Veeramani, A. and Jayson, E.A. (1995). A Survey of crop damage by wild animals in Kerala. *The Indian Forester*, 121(10): 949-953.

Veeramani, A., Easa, P.S. and Jayson, E.A. (2004). Socio-economic status of cultivators and their interface with wild animals: A case study of Marayur Forest Range, Kerala. *Indian Forester*, 130: 513-520.

Venkataraman, A.B., Saandeep, R., Baskaran, R., Roy, M., Madhivanan, A. and Sukumar, R. (2005). Using satellite telemetry to mitigate elephant–human conflict: An experiment in northern West Bengal, India. *Current Science*, 88: 1827–1831

Venkataramana, G.V., Sreenivasa and Lingaraju, H.G. (2017). An assessment of crop damage and economic loss caused by elephants in Harohalli and Kodihalli ranges of Bennerghatta national park, Karnataka, India. *Current Science*, 113(1): 161-166.

Viljoen, P.J. (1989). Spatial and movements of elephants (*Loxodonta africana*) in the northern Namib Desert region of the Kaokoveld, South West Africa/Namibia. *Journal of Zoological Society of London* 219: 1-19.

Vogel, C. (1971). Behavioural differences of *presbytis entellus* in two different habitats. Proceedings of the Third International Congress of Primatology, 3:41-47.

Wakoli, E.N. and Sitati, N. (2012). Analysis of temporal and distribution patterns of elephant attacks on humans and elephant mortality in Transmara District, Kenya. *Greener Journal of Environment Management and Public Safety*, 1: 27-37.

Wang, S.W. and Macdonald, D.W. (2006). Live stock predation by carnivores in Jigme Singye Wangchuck National Park, Bhutan. *Biological Conservation*, 129: 558-565.

Wang, S.W., Curtis, P.D. and Lassoie, J.P. (2006 a). Farmer perceptions of crop damage by wildlife in Jigme Singye Wangchuck National Park, Bhutan. *Wildlife Society Bulletin*, 32(2): 359-365.

Wang, S.W., Lassoie, J.P. and Curtis, P.D. (2006 b). Farmer attitudes towards conservation in Jigme Singye Wangchuck National Park, Bhutan. *Environmental Conservation*, 33: 148-156.

Webb, S.L., Gee, K.L., Strickland, B.K. and DeYoung, R.W. (2009). Efficacy of a 15-strand high tensile electric fence to control white-tailed deer movements. *Wildlife Biology in Practice*, 5: 45-57.

Western, D. (1975). Water availability and its influence on the structure and dynamics of a savannah large mammal community. *E. Afr.Wildl.J.*, 13: 265-286.

Wiafe, E.D. and Sam, M.K. (2014). Evaluation of a low tech method, pepper-grease, for combating elephant crop-raiding activities in Kakum conservation area, Ghana. *Pachyderm*, 55: 38-42.

Widman, M. and Elofsson, K. (2017). Costs of livestock depredation by large carnivores in Sweden 2001 to 2013. *Ecological Economics*, 143: 188-198.

Williams, A.C. and Johnsingh, A.J.T. (2004). Elephant-human conflict on community lands in Garo Hills, northeast India. *Journal of the Bombay Natural History Society*, 101(2): 227-234.

Williamson, B.R. (1975). The condition and nutrition of elephant in Wankie National Park. *Amoldia Rodesia*, 7: 1-19.

Wilson, S., Davies, T.E., Hazarika, N. and Zimmermann, A. (2013). Understanding spatial and temporal patterns of human-elephant conflict in Assam, India. *Oryx*, 1-10.

Woodroffe, R., Frank, L.G., Lindsey, P.A., Ole Ranah, S.M.K. and Romanach, S. (2007). Livestock husbandry as a tool for carnivore conservation in Africa's community rangelands: A case–control study. *Biodiversity Conservation*, 16: 1245-1260.

Zarco-Gonzalez, M.M., Monoroy-Vilchis, O. and Alaniz, J. (2013). Spatial model of livestock predation by jaguar and puma in Mexico: Conservation planning. *Biological Conservation*, 159: 80-87.

Zhang, L. and 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 I:** GCMS result of bio-reppellant "Trum guard"

*D:\GCMS Data\Jan 2016\1.1.16\Riju TG result ori.qgd 1 - 1 / 1 1/1/2016 14:44:47* *1 / 1*

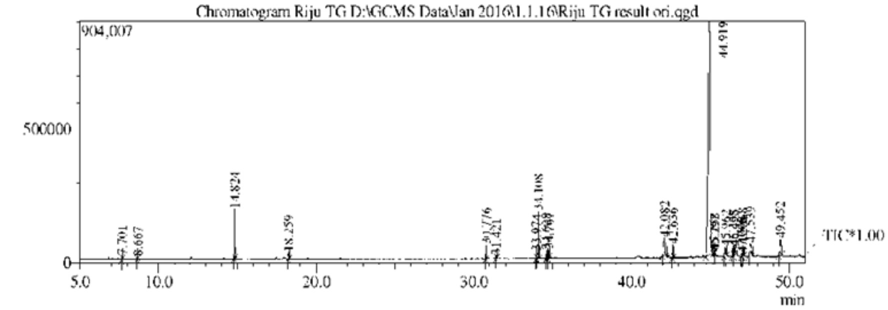
Sample Information
Analyzed : 1/1/2016 12:25:22 PM
Sample Name : Riju TG
Injection Volume : 1.00
Data File : D:\GCMS Data\Jan 2016\1.1.16\Riju TG result ori.qgd
Method File : D:\GCMS all\GCMS METHODS\Unknown Sample analysis\Unknown Sample 23.12.15.qgm
Tuning File : D:\GCMS all\TUNING\2015\Tuning user 17.12.15.qgt

Method

Analytical Line 1

[GC 2010]
Column Oven Temp. :50.0 °C
Injection Temp. :250.00 °C
Injection Mode :Split
Flow Control Mode :Linear Velocity
Pressure :53.6 kPa
Total Flow :104.1 mL/min
Column Flow :1.00 mL/min
Linear Velocity :36.3 cm/sec
Purge Flow :3.0 mL/min
Split Ratio :100.0

Chromatogram Riju TG D:\GCMS Data\Jan 2016\1.1.16\Riju TG result ori.qgd




Peak Report TIC

| R.Time | Area | Height | Name | Base m/z |
|---|---|---|---|---|
| 7.701 | 28264 | 15265 | 2,4,6 CYCLOHEPTATRIEN 1 ONE, 2,3,7 TRIMETHYL | 105.10 |
| 8.667 | 8608 | 7588 | (+) 3,4 Dehydroproline amide | 68.05 |
| 14.824 | 408581 | 184631 | 2,6-OCTADIEN-1-OL, 3,7-DIMETHYL-, (Z)- | 41.05 |
| 18.259 | 46319 | 24537 | 2,6-OCTADIEN-1-OL, 3,7-DIMETHYL-, ACETATE | 41.00 |
| 30.776 | 96082 | 50757 | HEPTADECANOIC ACID, METHYL ESTER | 74.00 |
| 31.421 | 26194 | 12085 | TRIDECANOIC ACID | 41.00 |
| 33.974 | 48198 | 27257 | (Z,Z)-HEPTADECA-8,11-DIEN-1-YL IODIDE | 67.10 |
| 34.108 | 369919 | 177315 | 9-OCTADECENOIC ACID (Z)-, METHYL ESTER | 55.05 |
| 34.608 | 69651 | 30471 | TETRADECANOIC ACID, 12-METHYL-, METHYL ESTER | 74.05 |
| 34.767 | 72950 | 32499 | 6-Tetradecene, (Z)- | 55.00 |
| 42.082 | 437185 | 66361 | Stigmasterol | 55.05 |
| 42.636 | 114752 | 48261 | 2 Anilino 3 dimethylamino 1,4 naphthoquinone | 291.05 |
| 44.919 | 2319477 | 873064 | STIGMAST-5-EN-3-OL, (3.BETA.,24S)- | 43.05 |
| 45.258 | 42715 | 11533 | 5.ALPHA.-PREGN-9(11)-EN-12-ONE | 121.15 |
| 45.292 | 7907 | 5957 | P, P' DIHEXYL CLODRONATE DISODIUM SALT | 93.10 |
| 45.962 | 191032 | 33439 | 3-OXABICYCLO[5.1.0]OCTANE, 5,5-DIMETHYL-4-(3-METHYL-3-BUTENYLIDENE)-2-METHYLENE-, CIS-(+-)- | 218.15 |
| 46.158 | 117751 | 32884 | .alpha.-Amyrin | 79.05 |
| 46.495 | 141637 | 34611 | .beta.-Amyrin | 121.20 |
| 47.008 | 21815 | 10661 | 6,7 EPOXY 3,7,11 TRIMETHYLDODECA 1,3,10 TRIENE | 79.05 |
| 47.068 | 140789 | 43257 | 6,6-DIMETHYL-2-METHYLENE-BICYCLO[3.1.1]HEPTANE | 41.00 |
| 47.539 | 359052 | 46594 | METHYL 2-[1-(2-METHOXY-2-OXOETHYL)-2,4B,6A,9,9,10B,12A-HEPTAMETHYLOCTADECAHYDRO-2-CHRYSENYL]PROPANOA | 95.05 |
| 49.452 | 372409 | 62426 | STIGMAST-4-EN-3-ONE | 124.10 |
| | 5353757 | 1831444 | | |

## **Appendix II:** Questannire survey sheet

**QUESTIONNAIR SURVEY KFRI/653/2012**

**BACKGROUND INFORMATION**

Panchayath: Date &Time:

Ward no: Place:

Colony: GPS:

Nature of settlement: Clustered/ Spread out/ Others

Name & age of the respondent:

1 Educational status?

a) LP b) UP c) HS d) >HS

2 For how many years have you lived in this area?

a) 1-5 b) 5-10 c) 10-15 d) > 15

3 What is/are the main source of income for your household?

a) Farming s b) Animal rearing c) Kooli d) Other (specify)

4 Land size that under your ownership?

a) 0.5-1 Acres b) 1-3 Acres C) 3-6 Acres d) > 6 *Acres*

5 Distance to the reserve forest from the farm land?

a) 0.5-1 Km b) 1-2Km c) 2-3Km d) > 3 (specify)

6 Are you thinking to migrate from this place?

Yes or No

7 If yes What is the reason?

a) Fear of damage from wild animals b) Lack of land facility c) Marriage d) Others

8 How are you using the forest land for your Benefits?

a) Source of fuel wood b) NTF collection c) Cattle grazing d) other (specify)

9 How much time do you spend for this within the forest?

a) 1-2hrs b) 2-4hrs c) 4-6hrs d) > 6hrs

10 Source of drinking water?

a) Well b) Forest stream c) Spring d) Others 9specify)

**DETAILS OF FARMING**

11 What is your farm size?

a) < 0.5 Acres b) 0.5-1 Acres c) 1-2 Acres d) > 2Acres

12 Types of crop cultivated?

a) Coconut b) Plantain c) Rubber d) Areca nut e) Vegetables f) Paddy g) Others

13 Do you have damage from animals to your crops?

Yes or No

14 If yes, What is the frequency of raiding?

a) Every day b) Twice in a week c) Once in a week d) Once in a month e) Once in a year f) Never

15 Rank the following crops according to the vulnerability to damage from wild animals?

a) Coconut b) Plantain c) Rubber e) Areca nut e) Vegetables f) Paddy

16 What proportion of the cultivation was affected?

a) Totally b) About two third c) About half d) About one forth

17 Rank the following as the constraints to your agricultural practices?

a) Insufficient land b) Shortage of labor c) Unavailability of water d) Wildlife raids

18 Brief outline of the agricultural activities?

a) Time of planting (mention the crop)………………………………………………………
b) Harvesting (mention the crop)……………………………………………………………

19 Rank the following animal species according to the severity of damage to the crops?

a) Elephant b) Wild pig c) Monkey d) Porcupine e) Others

20 In which season the incidents happen?

a) In the rainy season b) In the dry season c) Any time in the year

21 Is there any synchronization between the maturation of crops and the raiding behavior wild animals?

Yes or No

22 If yes, which is the animal you observed that keeping this timing?

a) Elephant b) Wild pig c) Porcupine d) Monkey e) All of these

23 What time of the day the damage occurred?

a) Early morning b) During day time c) During evening d) During night

24 Parts of crop damaged?

a) Root b) Tuber c) Stem d) Fruits e) All

25 The crops present but not damaged?

a) ………….. b) ………… c) …………. d) ………… e) ………….

26 Where the animal species are coming from?

a) Reserve forest b) Plantation c) Private land

27 Are you aware about the ex-gratia getting for crop damage by wild animals?

Yes or No

28 Any ex-gratia received for crop damage?

Yes or No

29 If yes please mention the amount & year

Rs………………………………………………./-

30 How do you mitigate the crop raiding by animals?

a) Traditional b) Custom c) Rules d) Others

31 What are the methods used to prevent the animals from doing damage?

a) Crackers b) Watch & ward c) Changing the crops d) Fence

32 Approximate loss?

In rupees ………………………………………………/day/week/month/year

In % ………………………………………………………/day/week/month/year

**CATTLE LIFTING & HUMAN CASUALTIES**

33 How would you describe the status of animals in your nearby forest?

a) Very good b) Good c) Neither good nor bad d) Don't know

34 What is the dynamics in their number?

a) It is increasing b) It is decreasing c) No change

35 Do you know any species which was previously not in this area but is found now?

Yes or No

36 If yes, please list the species?

a) ……………… b) ……………….. c) ……………….. d) ………………..

37 Do you have the following livestock?

a) Cattle b) Goat c) Poultry d) Others (specify)

38 Have you ever lost livestock to wild animals?

a) Yes or No if yes please mention the number

39 What are the animals involved in the attack?

| Wild animals | victims |
|---|---|
| a) Leopard……………………….. | a) ……………………… |
| b) Wild dog………………………. | b) ……………………… |
| c) Tiger………………………….. | c) ……………………… |

40 Mode of attack?

a) Bite on neck   b) Bite on other body parts (specify).

41 Details of the human casualties/injury by wild animals if any?

a) Elephant.....................................
b) Wild pig......................................
c) Monkey......................................
d) Leopard......................................

42 Any ex-gratia received?

a) Yes   or   No   if yes how much?.........................

**SOCIAL DIMENSION**

43 Do you believe conserving wild animals is necessary ?

a) Yes   or   No

44 Do local communities think that they will get benefits from wildlife?

a) Yes   or   No

45 Local beliefs and taboo system regarding wildlife?

..........................................................................................................................

..........................................................................................................................

46 Local knowledge of wildlife laws and conservation issues?

a) Not satisfactory   b) Satisfactory   c) Good   d) Very good   e) Excellent

47 According to local community who should be responsible for protecting crop against the activities of wildlife?

a) Government   b) People itself   c) Both People and Government

48 Local perception of the severity of the damage?

a) Very severe   b) Severe   c) Less severe   d) Moderate

49 According to you what are the benefits getting from the conservation of wild animals?

50 What are the local views on how crop raiding by wild animals deal with?

**Appendix III:** Newspaper reports on beehive fence experiment

കാട്ടാനകളെ തുരത്താൻ കെനിയയിൽ നടപ്പാക്കിയ തേനീച്ചക്കൂട് വേലി സംസ്ഥാനത്തും പരീക്ഷിക്കുന്നു

നിലമ്പൂർ വനമേഖലയിൽ കരുളായിക്കടുത്ത് മൈലംപാറയിൽ തേനീച്ചക്കൂട് വേലി സ്ഥാപിച്ചു

# എന്തിനും തയാറായി തേനീച്ചക്കൂട്ടം; ഇനി എന്തു 'കാട്ടാന'...

**ജോമിച്ചൻ ജോസ്**

മലപ്പുറം ● നാട്ടിലിറങ്ങി കൃഷി നശിപ്പിക്കുന്ന കാട്ടാനകളെ തുരത്താൻ ആഫ്രിക്കൻരാജ്യമായ കെനിയയിൽ പരീക്ഷിച്ചു വിജയിച്ച തേനീച്ചക്കൂട് വേലി സംസ്ഥാനത്ത് വ്യാപിപ്പിക്കാൻ പദ്ധതി. പീച്ചിയിലെ വന ഗവേഷണ ഇൻസ്റ്റിറ്റ്യൂട്ടിന്റെ (കെഎഫ്ആർഐ) നേതൃത്വത്തിൽ നടക്കുന്ന പരീക്ഷണങ്ങൾ വിജയം കണ്ടാൽ കൊമ്പന്മാരെ തേനീച്ചകൾ കുത്തിവീഴ്ത്തും; കാടിനോടു ചേർന്നുള്ള ജനവാസമേഖലകളിലെ താമസക്കാരുടെ ആനപ്പേടിക്ക് അവസാനവുമാകും.

പരീക്ഷണാടിസ്ഥാനത്തിൽ നിലമ്പൂർ വനമേഖലയിൽ കരുളായിക്കടുത്ത് മൈലംപാറയിൽ തേനീച്ചക്കൂട് വേലി കെഎഫ്ആർഐ സംഘം സ്ഥാപിച്ചു. വനമേഖലയിൽനിന്ന് സ്വകാര്യ കൃഷിയിടത്തിലേക്ക് ആനയെത്തുന്ന വഴിത്താരയിൽ 18 കൂടുകൾ തൂക്കിയിട്ടുണ്ട്. നിശ്ചിത അകലത്തിൽ സ്ഥാപിച്ചിട്ടുള്ള തടിക്കാലുകൾ തമ്മിൽ കമ്പി കൊണ്ടു ബന്ധിപ്പിച്ചശേഷം ആ കമ്പിയിലാണു തേനീച്ചക്കൂട് തൂക്കിയിടുന്നത്. കർഷകർ വളർത്തുന്ന ഇനത്തിൽപ്പെട്ട തേനീച്ചകളെയാണ് പരീക്ഷണമെന്ന നിലയ്ക്ക് ഇവിടെ തൂക്കിയിട്ടുള്ളത്.

തേനീച്ചകളുടെ സാധാരണയായുള്ള മൂളൽ ആനകളെ അകറ്റുമെന്നാണു പഠനങ്ങൾ തെളിയിക്കുന്നത്. ആനകൾ കമ്പിയിൽ തട്ടുമ്പോൾ തേനീച്ചക്കൂട്ടത്തിന്റെ മൂളൽ മറ്റൊരുരീതിയിലാകും. അതും കാട്ടാനകളെ അകറ്റിയേക്കാം. 'വയലന്റ്' ആകുമ്പോൾ ആനകളെ കുത്തിയോടിക്കാനും തേനീച്ചകൾക്ക് കഴിയുമെന്നാണു കെനിയയിലെ അനുഭവം.

ലൂസി കിങ് എന്ന ശാസ്ത്രജ്ഞയാണ് കെനിയയിൽ തേനീച്ചകളെ ഉപയോഗിച്ച് കാട്ടാനകളെ തുരത്തിയോടിച്ചത്. 'കില്ലർ ബീ' എന്നറിയപ്പെടുന്ന വിനാശകാരികളായ പ്രത്യേകതരം ആഫ്രിക്കൻ തേനീച്ചകളെയാണ് ലൂസി കിങ് കെനിയയിൽ പരീക്ഷണത്തിനായി ഉപയോഗിച്ചത്. അവരുമായി ആശയവിനിമയം നടത്തി കേരളത്തിലും അതേ മാതൃക പകർത്താമെന്ന ആശയമുണ്ടാക്കിയത് കെഎഫ്ആർഐ വന്യജീവി വിഭാഗത്തിലെ ഡോ. ഇ.എ. ജയ്സൺ ആണ്.

# കാട്ടാനകളെ തുരത്താൻ തേനീച്ചവേലി; രണ്ടാം ഘട്ടം തുടങ്ങി

## പ്രദേശവാസികളെ ഉൾപ്പെടുത്തി വിപുലപ്പെടുത്തും: കെ.എഫ്.ആർ.ഐ

കാട്ടാനകളെ തുരത്താൻ കേരള ഫോറസ്റ്റ് റിസർച്ച് ഇൻസ്റ്റിറ്റ്യൂട്ടിന്റെ നേതൃത്വത്തിൽ കരുളായി മൈലമ്പാറയിൽ സ്ഥാപിച്ച തേനീച്ച വേലി

# കാട്ടാനയെ അകറ്റാൻ തേനീച്ചക്കൂട് വേലി; പ്രതീക്ഷയോടെ കർഷകർ

മൈലമ്പാറയിൽ പരീക്ഷണാടിസ്ഥാനത്തിൽ സ്ഥാപിച്ച തേനീച്ചക്കൂട് വേലി

# ആനകളെ തുരത്താൻ തേനീച്ചകളെക്കൊണ്ട് വേലികെട്ട്

വിദേശ രാജ്യങ്ങളിൽ ഉപയോഗിക്കുന്ന തേനീച്ചക്കൂടുവേലി

# ACRONYMS

| | | |
|---|---|---|
| $AIC_C$ | - | Corrected Akaike's Information Criterion |
| DBH | - | Diameter at Breast Height |
| DEM | - | Digital Elevation Model |
| ELISA | - | Enzyme-Linked Immunosorbent Assay |
| FAT | - | Fluorescent Antibody Test |
| GCMS | - | Gas chromatography-mass spectrometry |
| GIS | - | Geographical Information System |
| GPS | - | Global Positioning System |
| HEC | - | Human-Elephant Conflict |
| HWC | - | Human-Wildlife Conflict |
| IUCN | - | International Union for Conservation of Nature |
| KFD | - | Kyasanur Forest Disease |
| NDVI | - | Normalized Difference Vegetation Index |
| NE | - | North-East |
| NNFD | - | Nilambur North Forest Division |
| NSFD | - | Nilambur South Forest Division |
| NTFP | - | Non Timber Forest Products |
| PCQ | - | Point Centered Quarter Method |
| RF | - | Reserve Forest |
| RTPCR | - | Reverse Transcription Polymerase Chain Reaction |
| SPSS | - | Statistical Package for the Social Sciences |
| SW | - | South-West |
| WPVC | - | Wild Pig-Vehicle Collision |

# *Publications*

RESEARCH ARTICLE Agricultural Scinece Digest, Volume 39 Issue 4: 301-305 (October-December 2019)

# Occurrence of the Indian Crested Porcupine (*Hystrix indica* Kerr.1792) and the Damage on Plantation Crops in the Nilambur Forest Divisions of Southern Western Ghats, Kerala, India

Riju P. Nair and E.A. Jayson

10.18805/ag.D-4907


## ABSTRACT

The damage to coconut and rubber plantations by the Indian crested porcupine (*Hystrix indica*) in the Nilambur Forest Division, Malappuram District was reported for the first time. The objectives of this study were to document the mode of attack and estimate the extent of damage by Indian crested porcupine in the plantation crops of the forest fringes. The study was carried out from June 2013 to May 2016 as part of the documentation of human-wildlife conflict in Malappuram District. Stratified random sampling, along with quadrat (10 m x 10 m) method was used to assess the crop damage. Estimation of the economic loss to farmers was carried out by using the market price of the coconuts during the period, collected from the website of Farm Information Bureau, Govt. of Kerala. The mean economic loss of crops damaged by Indian crested porcupine was Rs.1322.35/- per ha/annum. The debarking behavior of Indian crested porcupine on coconut palms (n=31), rubber trees (n=27) and consumption of newly formed bamboo culms (n=42) were also reported. No one has implemented proper mitigation measures against the Indian crested porcupine in the District.


**Key words:** Bamboo culms, Debarking behavior, Economic loss, Fallen coconuts.

## INTRODUCTION

Indian crested porcupine is one of largest rodents in Asia. They are nocturnal and burrowing and the hairs have been modified into spine-like structures called quills (Prater, 1980) which are used in defence against their enemies. The vision of porcupine is poor whereas the auditory and olfactory perception is well developed which helps them to forage at night time (Woods, 1973). All kinds of vegetables, fruits, grains and roots of trees are the main food source of the porcupines and they were also found to feed on the bark of several trees (Ahmad and Chaudhry, 1977; Khan *et al*., 2000). During the survey conducted as part of the documentation of human-wildlife conflict issues in the Malappuram District, we noticed that Indian crested porcupine was a serious pest of the plantation crops in the forest fringes. The objectives of this study were to document the mode of attack and estimate the extent of damage by Indian crested porcupine in the plantation crops of the forest fringes. The foraging ecology of the animal in the cultivated ecosystem of the Western Ghats region of the Karnataka was reported earlier by Chakravarthy and Girish (2002). The basic information about the feeding behaviour and damage to coconut crop was reported by Chakravarthy and Girish (2007) in Karnataka and by Govind and Jayson (2018) in central Kerala. No such study had been carried out in the Nilambur forest Divisions of the Malappuram District.

### Study area

Malappuram District, in the Kerala State of India (10040' to 11030' N and 75035' to 76033' E) spanning an area of 3,550 km$^2$ is situated 50 km southeast of Kozhikode city, bounded by the Nilgiri Hills on the east, the Arabian Sea in the west, Thrissur and Palakkad Districts in the South. The main crop species are Arecanut (*Areca catechu*), coconut (*Cocos nucifera*), rubber (*Hevea brasiliensis*), plantain (*Musa paradisiaca*), paddy (*Oryza sativa*), cashew nut (*Anacardium occidentale*), pepper (*Piper nigrum*), ginger (*Zingiber officinale*), tapioca (*Manihot esculenta*) and pulses. It comprises of three Forest Ranges namely Edavanna, Nilambur and Vazhikadavu of Nilambur North Forest Division and two Forest Ranges namely Kalikavu and Karulai of Nilambur South Forest Division. The District with 1034.2 km$^2$ of forest lands of all the seven forest type of southern India, tropical moist deciduous, tropical semi evergreen, subtropical hills forest, sub-tropical savannahs, montane wet temperate grasslands apart from teak (*Tectona grandis*) plantations. Asian elephant (*Elephas maximus*), Wild pig (*Sus scrofa*), Leopard (*Panthera pardus*), Indian crested porcupine (*Hystrix indica*), Bonnet Macaque (*Macaca radiata*) are the wild animal species commonly found.

The dry season is from December to February and hot spell prevails from March to May and the South-West monsoon (SW) is from June to September and the Northeast monsoon (NE) from October to December. The normal rainfall of the District is 2,793.3 mm (Sreenath, 2013). Temperature is generally hot and humid and March and April months are the hottest and January, February being the

Wildlife Department, Kerala Forest Research Institute, Peechi, Thrissur-680 653, Kerala, India.

**Corresponding Author:** Riju P. Nair, Wildlife Department, Kerala Forest Research Institute, Peechi, Thrissur-680 653, Kerala, India. e-mail: rijupnair2009@gmail.com

**How to cite this article:** Riju P. Nair and E.A. Jayson (2019). Occurrence of the Indian Crested Porcupine (*Hystrix indica* Kerr. 1792) and the Damage on Plantation Crops in the Nilambur Forest Divisions of Southern Western Ghats, Kerala, India. Agricultural Science Digest. 39(4): 301-305.

**Source of support:** Nil

**Conflict of support:** None

**Submitted:** 12-03-2019 **Accepted:** 12-10-2019 **Published:** 06-12-2019

coldest months. The maximum temperature ranges from 28.90 to 36.20°C and minimum temperature ranges from 17.00 to 23.40°C.

## MATERIALS AND METHODS

Two locations in the forest fringe areas were selected randomly in each of the five Forest Ranges of the Nilambur Forest Divisions and the quadrats were laid in the farmlands (Fig 1). The quadrats of the size 10 m x 10 m were selected as follows. Five sample plots (Quadrats) in the coconut plantation, one control plot in the Reserve Forest near to the sample plot. Coconut damage by the Indian crested porcupine was recorded from the sample plots. The control plot within the forest was used to detect the presence of animals in the Forest fringes. Coconut palms in each plot were demarcated and marked by the colored ribbon. Crop damage incidences from the quadrats were recorded in each month (n=36 months). The details such as the number of fallen coconuts damaged in each plot, trees damaged in the plot and near to plot and age of the trees were recorded from the field. The occurrence of Indian crested porcupine in each permanent quadrat was identified by recording the indirect evidence such as droppings, diggings, feeding signs and nail marks. Estimation of the economic loss was calculated by using the market price of the coconuts during the study period, collected from the Farm Information Bureau, Kerala. In each month (n=36), the price of coconut in Northern Kerala for three days were selected, with a gap of 10 days. The Economic loss was calculated by multiplying the average market price of the coconut and the quantity of coconut damaged from the quadrats (Mean economic loss = Total economic loss of the District/ Total number of Forest Ranges). The length and breadth of the coconut husk removed by Indian crested porcupine in the field were measured by using vernier caliper and the length of the debarked portion of the coconut tree and rubber tree was measured by using Freemans measuring tape.

## RESULTS AND DISCUSSION

The Indian crested porcupine was recorded from all the Forest Ranges except Nilambur Range in the Malappuram District (Table 1). A survey conducted around the Jigme Singye Wangchuk National Park, Bhutan reported that Porcupines were responsible for several complaints from the respondents as an agricultural pest, but they had little effect on agriculture income (Wang *et al*., 2006). In this study, severe damage was recorded to the coconut plantations both by the consumption of the fallen coconuts and by debarking the basal portion of coconut palms (n=31). Indian crested porcupine consumed 0.12±0.09 coconut/ tree/month (n=91). The fallen coconuts were consumed by removing the mesocarp and endocarp and then consuming

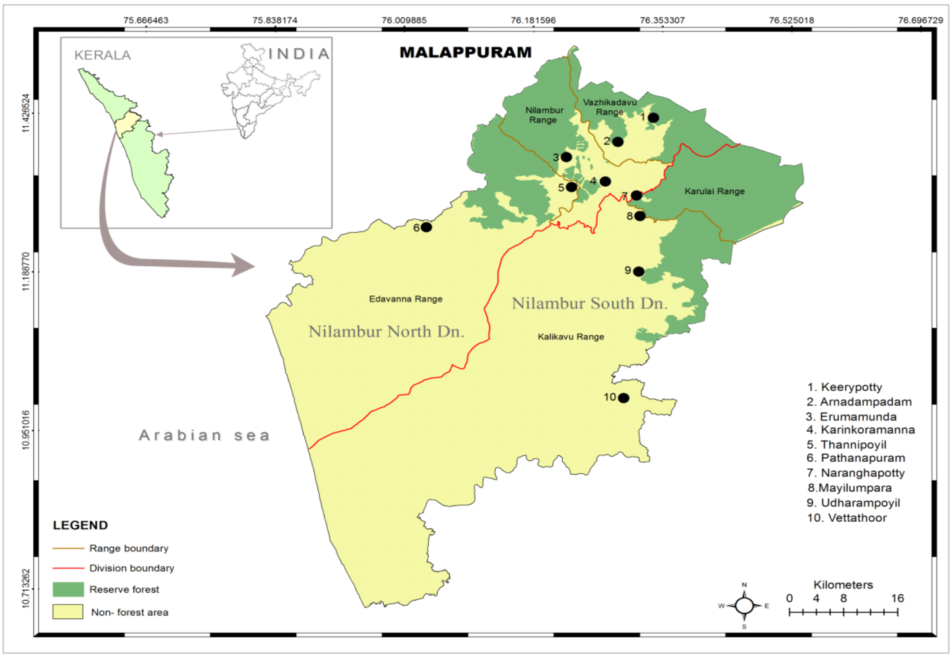



**Fig 1:** Map showing the Intensive study area.

**Table 1:** The occurrence of Indian crested porcupine in the study area in different years.

| Forest Ranges | 2013 (n=7) | 2014 (n=12) | 2015 (n=12) | 2016 (n=5) |
|---|---|---|---|---|
| Kalikavu | 4 | 2 | 1 | 0 |
| Karulai | 5 | 6 | 10 | 5 |
| Vazhikadavu | 2 | 4 | 10 | 2 |
| Nilambur | 0 | 0 | 0 | 0 |
| Edavanna | 7 | 11 | 12 | 4 |

Note: The numbers indicate the presence of porcupine detected from the field (as indirect signs).

the endosperm. As the Indian crested porcupine belongs to the order Rodentia, they remove the mesocarp with sharp edges with uniform size, which was considered as the indirect sign of porcupine in the field (Plate 01). Indirect evidence showed that Indian crested porcupine frequently carries the coconut into the forest for consumption. The mode of feeding by the Indian crested porcupine on the coconut that reported in this study was also reported in Thrissur District, Kerala by Govind and Jayson, 2018.

The mean economic loss by Indian crested porcupine in the District was Rs.1,322.35/- per ha/annum and the highest occurrence and crop damage was recorded from Edavanna Forest Range followed by Karulai, Vazhikadavu and Kalikavu (Table 2 and Fig 2). The estimated value is high compared to the amount of Rs. 615.47 estimated in Thrissur District near to Malappuram District (Jayson, 2013). Indian crested porcupine is considered as a generalist herbivore in the diet as its food includes both vegetative matter and animal matter. There is a significant difference in the content of bark in the diet according to the season (Akram *et al*., 2017). The crop species like maize, potato and groundnut are recognized as vulnerable to Indian crested porcupine damage (Brooks *et al*., 1998; Khan *et al*., 2000; Mian *et al*., 2007). The fallen coconuts were the most damaged crop which caused economic loss to the farmers in Malappuram District. The absence of crop mentioned above and the availability of coconut plantation in the forest fringe may be the reason for the damage.

The different hypothesis proposed on tree debarking behaviour of the ungulates says that it is due to the presence of trace elements and minerals in the bark, quality variation in the nutritional level of twigs and barks and the less availability of high-quality forage (McIntyre, 1972). These hypotheses can be attributed to Indian crested porcupine also as it is a mammal and there is no other established hypothesis to explain its debarking behaviour. In the coconut tree, the average length of the basal portion without bark from the ground level was 18.3 (±3.03) cm and it was started from the exposed root system itself (Plate 2). The debarking behavior of porcupine on the rubber trees (n=27) and consumption of newly sprouted bamboo culms (n=42) was also recorded from the Edavanna Forest Range (Plate 03). The debarking as girdling was not observed in coconut trees. In rubber trees, the girdling has occurred and the average length of the basal portion without bark from the ground level is 9.65 (±1.83) cm. A significant difference

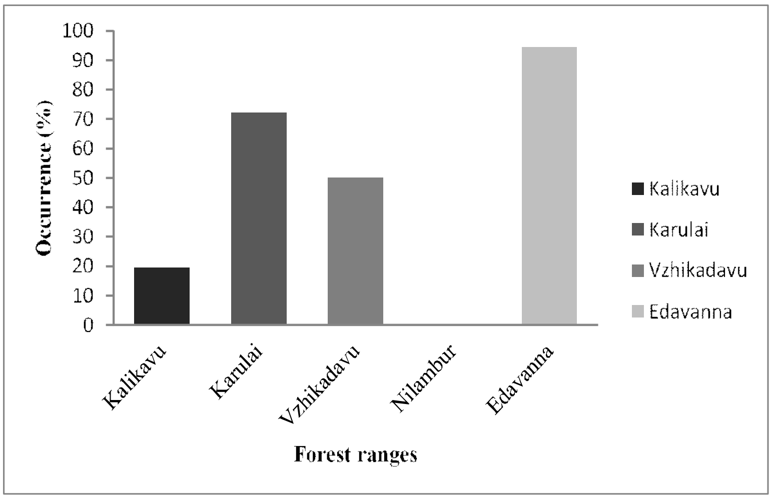



**Fig 2:** Incidence of crop damage by Indian crested porcupine in various Forest Ranges.

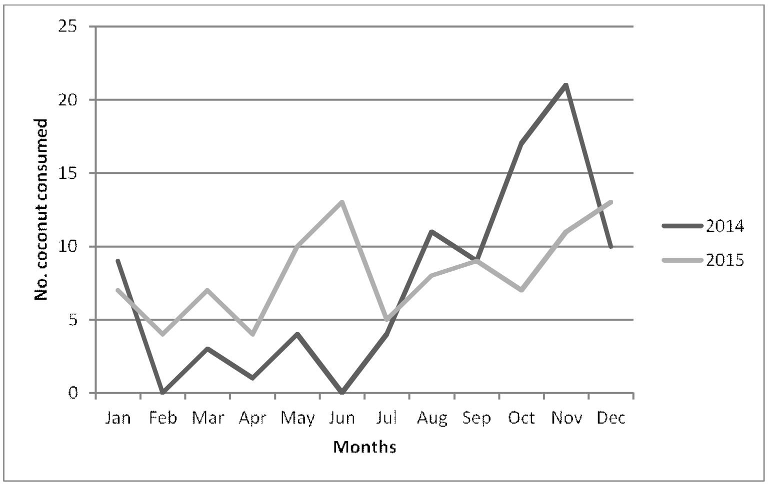



**Fig 3:** Yearly difference in the coconut consumption by Indian crested porcupine.

**Plate 1:** Coconut husk removed by Indian crested porcupine.

**Plate 2:** Debarked basal portion of coconut tree.

**Plate 3:** Debarked basal portion of rubber tree.

in the length of the basal portions without bark was observed in these two plant species ($t= 11.800$ $p < 0.001$). The debarking mark on the coconut palm was observed more frequently from October to February, which is similar to the finding from Karnataka (Chakravarthy and Girish 2007). The damage on fallen coconuts, rubber trees and coconut palms by Indian crested porcupine were recorded within a distance of 300 m from the Reserve Forest. Chakravarthy and Girish (2007) also reported that crop damage by Indian crested porcupine was severe nearby of Reserve Forest.

Many studies reported the attack of Indian Crested Porcupine on forest plantations and other trees (Ahmad and Chaudhry, 1977; Sharma and Prasad, 1992; Khan *et al*., 2010; Khan *et al*., 2014). The rubber trees over 15 years of age were debarked in the basal portion by the Indian Crested porcupine reported in this study was not reported in previous studies. Even though the mortality of the trees due to the girdling by Indian Crested Porcupine was reported earlier in many studies (Ahmad and Chaudhry, 1977; Greaves and Khan, 1978; Sharma and Prasad, 1992) no such observation was there in our study area. The forest edge sharing the boundary of the rubber plantation near to selected plot of Edavanna Forest Range was filled with bamboo. The bamboo clump sprouting occurred during the October to December, during this period no new attack was observed

**Table 2:** Economic loss due to Indian crested porcupine.

| Forest Range | Economic loss (Rs.) |
|---|---|
| Kalikavu | 364.32 |
| Karulai | 1,416.80 |
| Vazhikadavu | 580.21 |
| Edavanna | 2,928.05 |

**Table 3:** Population estimation of Indian crested porcupine (indirect signs).

| Year | Forest Division | Animal density (No. /Km$^2$) |
|---|---|---|
| 1997 | Nilambur north | 575.01 |
| | Nilambur south | 930.10 |
| 2002 | Nilambur north | 46.11 |
| | Nilambur south | 38.96 |
| 2011 | Nilambur north | 1844.21 |
| | Nilambur south | 1481.88 |

Easa and Jayaraman, 1997; Easa *et al*., 2002; Sivaram *et al*., 2011.

on the rubber tree whereas the consumption on newly formed bamboo clumps was recorded. However, no such change was observed on the consumption of fallen coconuts (Fig 3). The population status of Indian crested porcupine in the District showed a drastic decrease in 2002, compared to 1997, in both the Forest Divisions of Nilambur and then it again resurged into a high figure in 2011 (Table 3).

## CONCLUSION

In the current study the negligence of the farmers towards the fallen coconut in the field and the over hype on the crop raiding incidences of large mammals like elephant and wild pig, along with the lack of quantified data on the crop loss to Indian crested porcupine was the reason for the increased occurrence of Indian crested porcupine in the plantation crops near the forest. The girdling on the basal part of the rubber trees will affect its health so that it creates the huge psychological problem for the farmer and also causing economic loss as the affected tree has to be treated with some chemicals for curing. No one has given attention to implementing proper mitigation measures against the attack of Indian crested porcupine in the District. This study will help to change the farmer's attitude as they can aware of the potential loss and thereby proper management strategies can be implemented to reduce the problem.

## ACKNOWLEDGEMENT

The authors are grateful to Kerala Forest Research Institute for providing necessary financial support. Special thanks to the farmers in the forest fringe and Forest Department Officials of Malappuram District for their cooperation and support during the field work. We would like to extend our gratitude to Dr. Suresh K. Govind and Mrs. Greeshma Paleeri and Mr. Shonith E.G. for their support during the manuscript preparation.

## REFERENCES

Ahmad, A. and Chaudhry, M.I. (1977). Studies on habits, habitat and damage of porcupines Hystrix Indica, Rodentia, Mammalia. Pakistan J. For. 27: 147-150.

Akram, F., Ilyas, O. and Haleem, A. (2017). Food and feeding habits of Indian crested porcupine in Pench Tiger Reserve, Madhy Pradesh, India. Ambient Science. 04(1): DOI:1021276/ambi.2017.04.ra02.

Brooks, J.E., Ahmed, E. and Hussain, I. (1988). Characteristics of damage by vertebrate pests to groundnut in Pakistan. Proc.13th Vert. Pest Conf., Univer. California, Davis, pp. 129-133.

Chakravarthy, A.K. and Girish, A.C. (2002). Porcupine (Hystrix indica Kerr) damage to three coconut verities in coastal Karnataka. Rod. Newsl. 26(2): 1-2.

Chakravarthy, A.K. and Girish, A.C. (2007). Feeding ecology of Indian porcupine (Hystrix indica Kerr) in coconut (Cocos nucifera L) plantations of the Western Ghats of Karnataka. Journal of the Bombay Natural History Society. 104(1). 40-44.

Easa, P.S. and Jayaraman, K. (1997). Population estimation of major mammals in the forests of Kerala - 1997. KFRI Consultancy Report. Kerala Forest Research Institute, Peechi.

Easa, P.S., Sivaram, M. and Jayson, E.A. (2002). Population estimation of major mammals in the forests of Kerala - 2002. KFRI Consultancy Report No. 9. Kerala Forest Research Institute, Peechi.

Govind, S.K. and Jayson, E.A. (2018). Coconut (Cocos nucifera) damage by wild pig (Sus scrofa) and Indian crested porcupine (Hystrix Indica) in Central Kerala, India. Current Science. 115(1): 9-10.

Greaves, J.H. and Khan, A.A. (1978). The status and control of Porcupines, genus Hystrix as forest pests. Commonw. For. Rev. 57: 25-32.

Jayson, E.A. (2013). Assessment of crop damage by wild animals in Trichur District, Kerala. KFRI Research Report No. 491. ISSN 0970-8103.

Khan, A.A., Ahmad, S., Hussain, I. and Munir, S. (2000). Deterioration impact of Indian crested porcupine, Hystrix indica, on forestry and agricultural systems in Pakistan. Int. Biodet. Biodeg. 45: 143-149.

Khan, A. A., Mian, A. and Hussain, R. (1988). Deterioration Impact of Indian Crested Porcupine, Hystrix indica, on Irrigated Forest Plantations in Punjab, Pakistan. Pakistan Journal of Zoology. 46: 1691-1696.

McIntyre, E.G. (1972). Barkstripping- A natural phenomenon. J.R. Scottish For. Soc. 26: 43-50.

Mian, A., Khan, A.A. and Hussain, R. (2007). Biology and management of porcupine, Hystrix indica in Central Punjab, Pakistan. Final Progress Rep. (2003-2007, unpublished). ALP Project, Development of Zoology, University of Arid Agriculture, Rawalpindi, 129 pp.

Prater, S.H. (1980). The book of Indian animals. Bombay Natural History society. 324 pp.

Sharma, D. and Prasad, S.N. (1992). Tree debarking and habitat use by porcupine (Hystrix indica Kerr) in Sariska National Park in Western India. Mammalia. 351-361.

Sivaram, M., Jayson, E.A. and Ramachandran, K.K. (2011). Population estimation of major mammals in the forests of Kerala - 2011. KFRI Extension Report No. 61. Kerala Forest Research Institute, Peechi.

Sreenath, G. (2013). Ground water information booklet of Malappuram District. Technical Report, Government of Kerala.1-4.

Wang. S.W., Lassoie, J.P. and Curtis, P.D. (2006). Farmer attitudes towards conservation in Jigme Singye Wangchuck National Park, Bhutan. Environmental Conservation. 33: 148-156.

Woods, C.A. (1973). Erethizon dorsatum. Mammal Species. 29:1-6.



ISSN: 0976-0547 (Online), 0253-150X (Print), Naas Rating: 4.21

# PEOPLE'S PERCEPTION ON HUMAN-WILDLIFE CONFLICT IN THE FRINGE AREAS OF NILAMBUR FOREST DIVISIONS, KERALA, INDIA[1]

RIJU P. NAIR[2,3,*] AND E.A. JAYSON[2,4]

[1]Accepted December 10, 2019
First published: May 30, 2020 | doi: 10.17087/jbnhs/2020/v117/131800
[2]Kerala Forest Research Institute, Peechi, Thrissur 680 653, Kerala, India.
[3]Email: rijupnair2009@gmail.com
[4]Email: jayson@kfri.org
*Corresponding author

Against background of an increased occurrence of human-wildlife conflict (HWC) in the forest fringes of Nilambur forest divisions of Malappuram district, Kerala, a questionnaire survey was conducted from January to March 2016, to primarily analyze people's perceptions on HWC and their attitude towards conservation. Three hundred households under 25 panchayats were surveyed in the district. The primary source of income was agriculture for about 61.67% of the families interviewed, and 50% of the respondents reported more than 40% of crop loss per annum to wildlife. The majority of the respondents put the onus of preventing crop depredations solely on the forest department. The overall conservation attitude of the people was negative due to the economic loss from crop depredations by wildlife. Proper and prompt implementation in the distribution of ex gratia payment is essential to help change the negative attitude of the people towards wildlife conservation. Awareness programmes should be conducted to increase local participation in the implementation of mitigation measures. The need for a "first-line defence" system to reduce crop damage from wildlife is also suggested.

**Key words**: human-wildlife conflict, crop damage, Nilambur forest divisions

## INTRODUCTION

Human-wildlife conflict (HWC) has a long history, and in the current scenario, with the growth and spread of human populations in India, the perception and interpretation of HWC have changed and led to more vociferous complaints. HWC occurs where the needs of human beings and wildlife meet at a common point, like in the case of space, crops, and other natural resources. The increased need for expanded human populations and the resultant land-use changes that are incompatible with wildlife habitat in the forest fringes also contribute to the problem to a large extent. Managing HWC without destroying wildlife and taking into consideration human welfare requires a delicate balance of agricultural extension and wildlife conservation (Treves *et al*. 2006).

Although a large number of farmers suffer from crop-raiding by wildlife, most of the affected communities do not file complaints to the concerned bodies, due to the lack of communication (Tesfay 2016). Another problem is that the farmers view animals as government property and draw the analogy of the government being a bad neighbour, allowing its animal to damage crops but not offering compensation (Naughton-Treves 1998). Many studies have indicated that it is essential to ensure local support and participation for the successful establishment of conservation activities (Durbin and Ralambo 1994; Fiallo and Jacobson 1995; Heinen 1993). Most often, the reason for an unenthusiastic and negative attitude towards wildlife conservation among the people in India is the increase in crop-raiding cases and the restrictions on collecting forest resources (Panwar *et al*. 2014).

Infield and Namara (2001) surveyed the attitudes of the people towards conservation around Lake Mburo National Park, Uganda, after the implementation of the Community Conservation Programme (CCP) and found that communities who benefited from the programme were significantly more positive towards the Park. Infield (1988) found that a positive attitude tended to increase with an increasing level of respondent's education in South Africa. Thus, a proper understanding of the perceptions of farmers regarding crop damage and human causalities needs to be ascertained for the effective conservation of wildlife in an area. In this manuscript, we discuss the perception of farmers to human-wildlife conflict and their conservation attitudes in the Nilambur part of the southern Western Ghats of Kerala, India, based on a questionnaire survey conducted from January 2016 to March 2016.

## STUDY AREA

Malappuram district (10° 45′ – 11° 25′ N; 75° 55′ – 76° 24′ E) in Kerala, India, spanning an area of 3,550 sq. km, is bounded by the Nilgiri Hills in the east, the Arabian Sea in the west, and Thrissur and Palakkad districts in the south. The district is in the central part of Kerala, starting from the core of the Nilgiris and traversing the highland, midland, and lowland areas up to the sea coast. The district is mainly drained by Kadalundi, Chaliyar, and Bharathapuzha rivers.

Malappuram district has three forest ranges, Edavanna, Nilambur, and Vazhikadavu of the Nilambur North Forest Division; and two forest ranges, Kalikavu and Karulai of the Nilambur South Forest Division (Fig. 1). The district, covered with 1,034.2 sq. km of forest land, has tropical moist deciduous, tropical semi-evergreen, subtropical hill forests, subtropical savannahs, and montane wet temperate grasslands. Teak *Tectona grandis* plantations had been raised in the reserves. The wildlife includes Asian Elephant *Elephas maximus*, Wild Pig *Sus scrofa*, Leopard *Panthera pardus*, Indian Crested Porcupine *Hystrix indica*, and Bonnet Macaque *Macaca radiata*.

Climatic conditions are tropical. The dry season extends from December to February, and the hot spell prevails from March to May. The southwest monsoon covers June to September, while the northeast monsoon prevails from October to December. The rainfall of the district averages around 2,793 mm, southwest monsoon accounts for nearly 73.5% of the rainfall and the northeast monsoon contributes nearly 16.4%; the March to May summer rains contributes nearly 9.9%; and the balance 0.2% falls in January and February (Sreenath 2013). The climate is generally hot and humid. March and April are the hottest months, while January and February are the coldest. Maximum temperature ranges from 28.9 to 36.2 ºC, and minimum temperature from 17.0 to 23.4 ºC.

## METHODS

A structured questionnaire survey was carried out in 25 panchayats around the forests in the Nilambur forest divisions (Table 1). The study area was divided into 2 km x 2 km grids. Areas towards the western and southern parts of the district were excluded, as human-wildlife

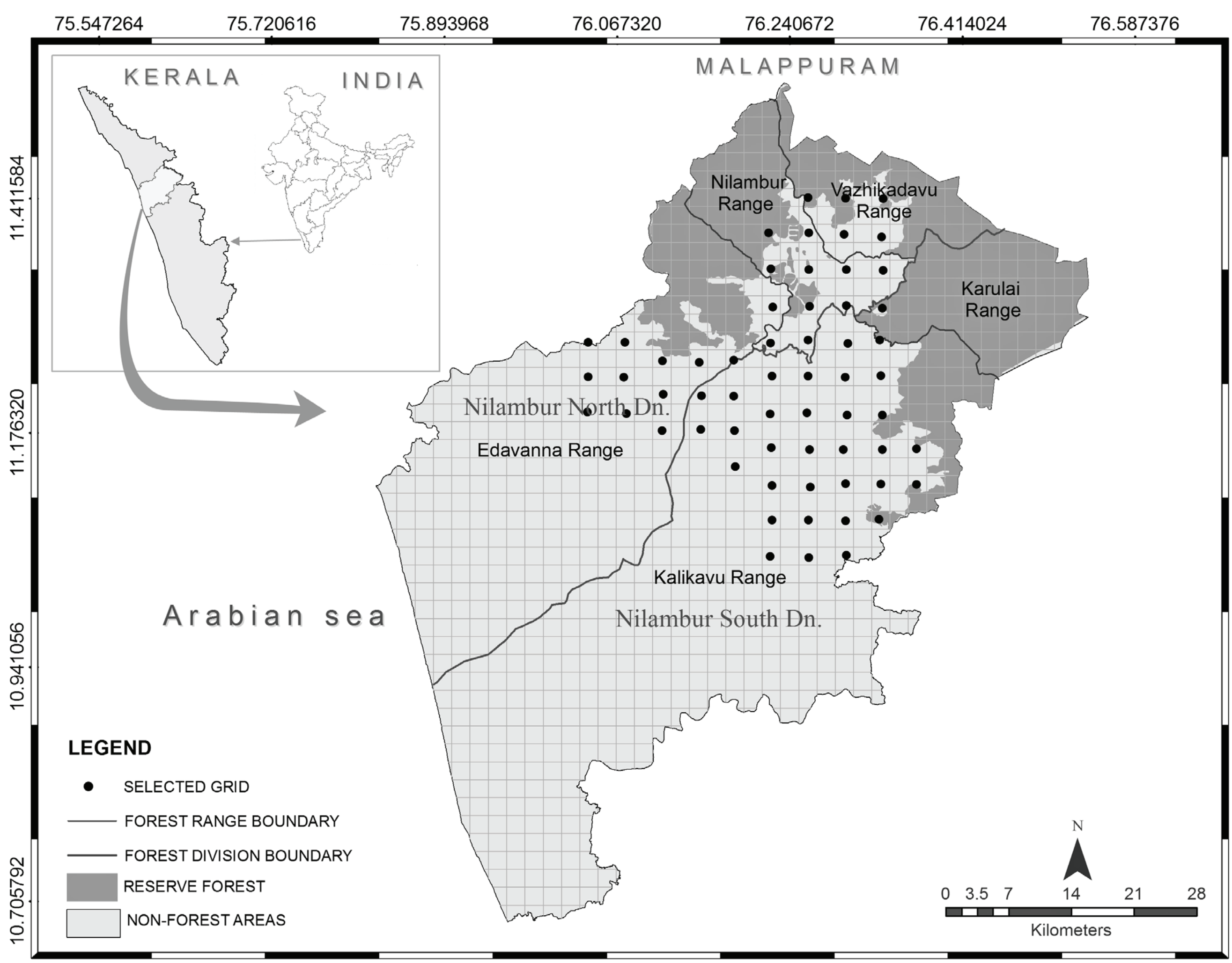



Fig. 1: Selected grids marked for the questionnaire survey in the study area

**Table 1**: Panchayats surveyed in the different forest ranges

| S. no. | Forest Ranges | Panchayats surveyed | Number of grids surveyed |
|---|---|---|---|
| 1 | Kalikavu | Amarambalam, Mambad, Chokkad, Wandoor, Thiruvali, Kalikavu, Thrikalamgodu, Porur, Karuvarakundu, Thuvvur, Pandikkad, Edapatta, Keezhattur | 32 |
| 2 | Karulai | Karulai | 4 |
| 3 | Edavanna | Urngattiri, Keezhparambu, Edavanna, Areekkode, Kavannoor, Kuzhimanna | 9 |
| 4 | Vazhikadavu | Pothukallu, Vazhikadavu, Edakkara | 5 |
| 5 | Nilambur | Chungathara, Nilambur | 10 |

interactions were negligible since these areas were away from the forest. The first grid was selected randomly, and after that, alternate grids were selected for undertaking the questionnaire survey (Fig. 1); a total of 60 grids were sampled.

Five houses spaced out to cover 2 km x 2 km area within each grid were selected for the questionnaire survey. The questionnaire comprised 50 questions, mainly focusing on the socio-economic background of the family, crops grown in the area, crop-raiding species involved, the extent of crop damage (and also livestock loss and human casualties), their perception of human-wildlife conflict, and attitude towards nature conservation. About 15 to 20 minutes were spent interviewing each respondent. These interviews were conducted primarily with the head of the household, most of whom were male. The exception was when they were absent during the visit. If a member of more than 18 years of age was not present during the survey, the house was skipped and the next house was surveyed.

## RESULTS

### Socio-economic background

Males (75%) and females (25%), aged between 18 and 80 years, responded to the structured questionnaire survey; all were permanent residents of the area. Of the 300 respondents interviewed, 10.7% had attended lower primary school, 31% had completed upper primary school, 45% completed high school education, and 12.3% had gone for further studies. Only 1% of the respondents were illiterate.

The main source of income was agriculture for most of the families (61.67%). Other sources of income were: 18% coolie, 12.67% others, 3.33% animal rearing and coolie, 2.33% agriculture and animal rearing, 1.33% animal rearing, 0.67% others and agriculture. Around 43.33% of the respondents had livestock in their house, of which 28.33% depended on cattle, 12.33% on goats, and 3% on poultry. 95% of the respondents depended on open wells for drinking water. It was observed that the forest fringe areas of the district were occupied by the descendants of the farmers who had migrated from southern Kerala.

### Crop raiders, damage, protection measures, and compensation.

The main crops grown in the area are rubber, arecanut, and coconut. Other crop species include turmeric, ginger, plantain, cassava, and vegetables. The majority (82%) of the respondents reported Wild Pig as the major crop-damaging species followed by Bonnet Macaque (11.16%), Asian Elephant (6.05%) and Indian Crested Porcupine (0.47%) (n=215).

More than 40% of crop damage in the annual yield of the farmers was reported by 52.1% of the respondents (n=216). There was a negative correlation between crop loss to wildlife and distance from the forest area (Fig. 2). According to the farmers, the most vulnerable crop to wildlife damage was plantain (61.93%) followed by coconut (21.10%), tuber crops (7.34%), paddy (4.59%), rubber (2.75%), vegetables (1.38%) and arecanut (0.92%) (n=218). Regarding the frequency of crop-raiding, 38.67% of the respondents reported presence of wildlife in the farmland on a daily basis, followed by twice a week (18%), once a week (14%), and once a month (2.67%).

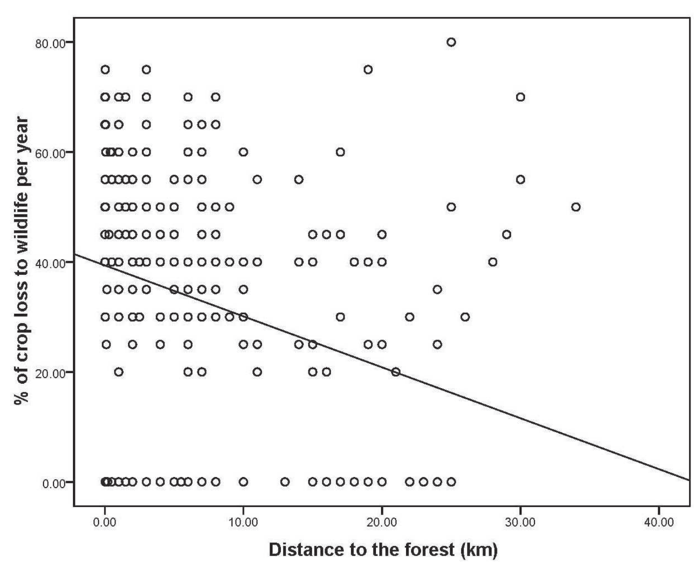



Fig. 2: Relationship between distance to forest and crop loss due to wildlife (n=300) (F(1,298)=30.313, P < 0.001) with an $R^2$ of 0.092

The remaining respondents (26.67%) were either unaware about the frequency of crop-raiding by wild animals or did not face this problem. Twenty-six per cent of households surveyed did not report any damage from wildlife, as most of them were living far away from the forest, and the rest were not growing crops preferred by animals.

Absence of the use of any crop protection measures was reported by 51% of the farmers interviewed; 35% had fences around the farm; 6.3% used crackers to scare away the animals; 3% used both crackers and fences; 1.3% used fence and watch and ward; 1.3% used crackers and watch and ward; 0.7% used fence, watch and ward, and crackers; 0.3% used watch and ward; 0.3% relied on guard dogs; and 0.3% used watch and ward and guard dogs. Most of the respondents (68.3%) were unaware of the ex gratia scheme of the Kerala Forest and Wildlife Department for crop loss by wildlife, and only 3% of the cases filed received compensation for the crop loss.

A simple linear regression was performed to predict the effect of distance from the forest on the reported crop loss. A significant regression equation was found ($F(1,298) = 30.313$, $P < 0.001$) with an $R^2$ of 0.092. The predicted crop loss is equal to 39.381-0.927 (distance to forest) percentage when the distance was measured in kilometres.

### People's perception on human-wildlife conflict, and conservation attitudes

The majority of the respondents put the onus of preventing crop depredations solely on the forest department. Only 13.5% opined that addressing human-wildlife conflict (HWC) was the joint responsibility of both people and the government/forest department, while the rest felt it was solely the latter's responsibility to prevent wildlife from straying into cultivation areas.

About 86% of the respondents spoke for the conservation of wildlife and their habitat and the remaining 14% were neutral (n=296). More than half of the respondents (52.4%) said that they were not getting any benefits from wildlife/nature, while 47.6% felt that they were deriving benefits in terms of ecological value. The farmers (n=296) awareness of wildlife laws and conservation issues was satisfactory (95.6%), with an additional 0.3% having good knowledge of these topics. No significant correlation was found between education and a positive conservation attitude ($r_s = -0.031$; $P > 0.595$) (n=290).

## DISCUSSION AND CONCLUSION

Since more than 60% of the households were dependent on agriculture as their primary source of livelihood and more than 40% of crop damage by wildlife was reported by more than 50% of the respondents, any damage to their crops was a serious issue for the people.

It was found that there was no significant correlation between the level of education and positive conservation, which is consistent with some studies (Gadd 2005; Groom and Harris 2008; Mir *et al*. 2015). Even though more than half of the respondents had completed their high school education, only 3% had received compensation for their crop losses, which indicates that despite their educational background, there was reluctance on their part to apply for compensation. It was observed that the submission of applications and availing of ex gratia were restricted to a few people; this finding is also supported by the study of Rohini *et al.* (2016). Delayed and low compensation could lead to increased attacks on wildlife by people (Wakoli and Sitati 2012).

The interviews revealed that 86% of the respondents were of the view that wildlife conservation is the responsibility of the government, which is in line with the findings of other studies from India and Sri Lanka (Fernando *et al*. 2005; Ogra 2009). This is mainly due to the low dependency of the people on the forest for forest resources. The young generation of this area is educated and has an improved standard of living, and more facilities than the older generation. This financial status, and the awareness and fear of wildlife laws, has helped to lessen exploitation of forest produce, and the forests are considered as a different entity (as people did not have a feeling of belonging towards the forest and forest officials) under the ownership of government.

The negative attitude of the people towards conservation in Nilambur forest divisions was primarily the outcome of significant economic loss from crop damage by wildlife. Such a situation was also reported by Panwar *et al*. (2014) from Mayureshwar Wildlife Sanctuary in India, and Wang *et al*. (2006) from Bhutan. In the Kashmir Valley, gender, crop damage, livestock predation, and livestock holding were identified as the factors that influenced attitudes towards conservation (Mir *et al*. 2015). Thus, it is important to increase awareness among the farmers about the ex gratia paid by Kerala Forest and Wildlife Department, and to smoothen application procedures to improve the people's tolerance to wildlife in the district, as recommended in many studies (Treves and Karanth 2003; Treves *et al*. 2006; Naughton-Treves 1998). Providing timely and adequate ex gratia to affected people is a must, to make an immediate change in the negative attitude of the people towards conservation. Awareness campaigns by Kerala Forest and Wildlife Department by participating representatives from Vana Samrakshan Samithi (VSS), local politicians, and farmers is necessary to ensure the involvement of forest fringe farmers in the development of an effective mitigation strategy.

It was found that the earlier "first line of defence" for farmers against crop-raiding mammals does not exist now, since most of the farms at the forest fringes have been converted into rubber plantations. These plantations are without human habitations and are managed by owners staying in faraway places. Moreover, the young generation is not taking any interest in the "first line of defence" to prevent wildlife from entering agriculture fields. Hence, a new strategy needs to be taken up by the Kerala Forest and Wildlife Department to create the "first line of defence" that was in existence at these fringe areas of the Nilambur forest divisions in the past.

**ACKNOWLEDGEMENTS**

The authors are grateful to Kerala Forest Research Institute for providing necessary financial support. Special thanks to the forest fringe farmers and forest officials of Malappuram district for their cooperation and support during the fieldwork. We would like to extend our gratitude to Dr Suresh K. Govind, Mrs Greeshma Paleeri, and Mr Shonith E.G., for their support during the manuscript preparation. We also thank the anonymous reviewers for improving the manuscript through their comments and suggestions.

**REFERENCES**

Durbin, J.C. & J.A. Ralambo (1994): The role of local people in the successful maintenance of protected areas in Madagascar. *Environmental Conservation 21*: 115–120.

Fernando, P., E. Wikramanayake, D. Weerakoon, L.K.A. Jayasinghe, M. Gunawardene & H.K. Janaka (2005): Perceptions and patterns of human-elephant conflict in old and new settlements in Sri Lanka: Insights for mitigation and management. *Biodiversity and Conservation 14*: 2465–2481.

Fiallo, E.A. & S.K. Jacobson (1995): Local communities and protected areas: Attitudes of rural residents towards conservation and Machalilla National Park, Ecuador. *Environmental Conservation 22*: 241–249.

Gadd, M.E. (2005): Conservation outside parks: Attitudes of local people in Laikipia, Kenya. *Environmental Conservation 32*: 50–63.

Groom, R. & S. Harris (2008): Conservation on community lands: The importance of equitable revenue sharing. *Environmental Conservation 35*: 242–251.

Heinen, J.T. (1993): Park people relations in Kosi Tappu Wildlife Reserve, Nepal: A socio-economic analysis. *Environmental Conservation 20*: 25–34.

Infield, M. (1988): Attitudes of a rural community towards conservation and a local conservation area in Natal, South Africa. *Biological Conservation 45*: 21–46.

Infield, M. & A. Namara (2001): Community attitudes and behaviour towards conservation: an assessment of a community conservation programme around Lake Mburo National Park, Uganda. *Oryx 35(1)*: 48–60.

Mir, Z.R., A. Noor, B. Habib & G.G. Veeraswami (2015): Attitudes of local people toward wildlife conservation: A case study from the Kashmir Valley. *Mountain Research and Development 35(4)*: 392–400.

Naughton-Treves, L. (1998): Predicting pattern of crop damage by wildlife around Kibale National Park, Uganda. *Conservation Biology 12*: 156–168.

Ogra, M. (2009): Attitudes toward resolution of human-wildlife conflict among forest-dependent agriculturalists near Rajaji National Park, India. *Human Ecology 37*: 161–177. doi.: 10.1007/s10745-009-9222-9.

Panwar, N., J.A. Khan & R.S. Gavali (2014): Attitude and perceptions of local people towards a conservation based approach for poverty alleviation in a semiarid region wildlife sanctuary, India. *The Journal of Ecology 109*: 414–424.

Rohini, C.K., T. Aravindan, K.S.A. Das & P.A. Vinayan (2016): Patterns of Human-Wildlife Conflict and People's Perception towards Compensation Program in Nilambur, Southern Western Ghats, India. *Conservation Science 4*: 1. doi: https://doi.org/10.3126/cs.v4i1.16891

Sreenath, G. (2013): Ground water information booklet of Malappuram District. Technical Report, Government of Kerala. Pp.1–4.

Tesfay, H. (2016): Human-wildlife interaction: Wildlife crop raiding conflict in Ethiopia. *International Journal of Science and Research 5(5)*: 1188–1191.

Treves, A. & K.U. Karanth (2003): Human-carnivore conflict and perspectives on carnivore management worldwide. *Conservation Biology 17*: 1491–1499.

Treves, A., R.B. Wallace, L. Naughton-Treves & A. Morales (2006): Co-managing human-conflicts: A review. *Human Dimensions of Wildlife 11*: 383–396.

Wakoli, E.N. & N. Sitati (2012): Analysis of temporal and distribution patterns of elephant attacks on humans and elephant mortality in Transmara District, Kenya. *Greener Journal of Environment Management and Public Safety 1*: 27–37.

Wang. S.W., J.P. Lassoie & P.D. Curtis (2006): Farmer attitudes towards conservation in Jigme Singye Wangchuck National Park, Bhutan. *Environmental Conservation 33*: 148–156.

**Recommended Citation**

Nair, Riju P. & E.A. Jayson (2020): People's perception on human-wildlife conflict in the fringe areas of Nilambur forest divisions, Kerala, India. *J. Bombay Nat. Hist. Soc. 117*. doi: 10.17087/jbnhs/2020/v117/131800

■ ■ ■