Assessment of human-wildlife conflict and mitigation measures in Northern Kerala

(FINAL REPORT OF THE RESEARCH PROJECT KFRI/653/12)

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ABSTRACT OF THE PROJECT PROPOSAL

1. Project No. : KFRI/653/12

2. Title of Project : Assessment of human-wildlife conflict and mitigation measures in Northern Kerala

3. Objectives :

1. To assess and estimate the extent of crop damage by wild animals in the intensive study area.

2. To suggest suitable mitigation measures to reduce and prevent the crop damage by wild animals.

4. Date of commencement : December 2012

5. Scheduled date of completion : May 2016

6. Funding agency : Plan Funds

7. Project Team

Principal Investigator : Dr. E. A. Jayson

Associate Investigator : Nil

Research Fellow : Riju P

8. Study area : Malappuram District

9. Duration of study : 3 Years

10. Project budget : Rs.11 Lakhs

CONTENTS

ABSTRACT

Human-wildlife conflict is a growing concern everywhere in the world and the problem is getting worst due to the uncontrolled behavioral problems of both human beings and wildlife. A practical approach of the researchers towards the human-wildlife issues can provide better output and new solutions to lead a peaceful co-existence along with livelihood activities. The present study on the human-wildlife conflict was carried out in Nilambur, Kerala, State India and the objectives of the investigation was

1. To assess and estimate the extent of crop damage by wild animals in Nilambur South and Nilambur North Forest Divisions.
2. To suggest suitable mitigation measures to reduce and prevent the crop damage by wild animals

The research was initiated in the year December 2012 and the field data collection continued up to May 2016. The intensive study was conducted in a tropical area and the main method was of direct observation and field surveys. On an average 20 days were spent in the field in each month. Vehicle based reconnaissance surveys were also conducted initially to understand the problem, where intensive crop damage was recorded. An announcement was given in all the local newspapers to report occurrences of crop damage and cattle lifting in the District. After analyzing the response, plots were selected and crop damage occurring in each month in the selected plots and also in other areas were recorded and data collected in a structured format. Efficacy of control measures employed by the farmers and Kerala forest and wildlife department were also analyzed. Efficacy of novel control methods, the honey-bee fence, a bio-repellent and yellow coloured cloth were also evaluated. Conservation attitude of local people was collected using a structured questionnaire survey and analyzed to understand the response of people to the conservation initiatives.

Crop raiding, cattle lifting, wild animals intruding into the settlements and human casualties were the four type of human –wildlife conflicts reported from the area whereas poaching and snaring are some of the adverse impacts of people on wild animals. The major crop raiding species were Asian elephant (*Elephas maximus*), Wild pig (*Sus scrofa*), Bonnet macaque

(*Macaca radiata*), Indian crested porcupine (*Hystrix indica*), and Hanuman langur (*Semnopithecus priam).*

Major crops damaged by elephants were plantain (*Musa paradisiaca*), coconut (*Cocos nucifera*), arecanut (*Areca catechu*), rubber (*Hevea braziliensis*), nutmeg (*Myristica fragrans*) and teak (*Tectona grandis*). Karulai, Kalikavu and Vazhikadavu Forest Ranges recorded the highest damage of crops. Highest crop damage was reported during the months of July and August and most of the encounters were recorded at midnight and highest crop damage (89%) was recorded for plantains. Elephant damage was recorded from twenty two areas and maximum encounters were recorded from the sites namely Chenappady and Panichola. Wild pig damage on plantain and coconut was recorded from all the five Forest Ranges namely Kalikavu, Karulai, Nilambur, Vazhikadavu and Edavanna. All the five Ranges were equally affected by the wild pig menace and human-wild pig encounters were reported from ten localities. Highest crop damage by Indian crested porcupine was recorded from Edavanna forest Range followed by Karulai, Vazhikadavu and Kalikavu. Density of trees in the periphery of Reserve Forest of Vazhikadavu, Nilambur, Edavanna and Karulai Forest Ranges depicts that the natural vegetation in the periphery of the forest was diverse and representative of a natural plant community. The estimation of economic loss showed that the Asian elephant damaged cash crops worth about Rs.22 lakhs per annum in the District. Highest damage of arecanut was recorded from Karulai Forest Range by Asian elephants.

Among the other crop raiders the highest damage by wild pig was recorded from Nilambur Forest Range followed by Kalikavu, Karulai, Vazhikadavu and Edavanna with mean economic loss estimated as Rs.15000/- per ha per annum. Mean economic loss by Indian crested porcupine in the Malappuram District was Rs.1322/- per ha per annum and highest damage was recorded from Edavanna Forest Range. Bonnet macaque raided the crops mostly in morning and late evening hours. Highest loss of coconuts by bonnet macaque was recorded from Kalikavu Forest Rage followed by Edavanna with a mean loss of 7 nuts per tree. A case of wild pig rabies was confirmed and reported and a case study on the death of Indian gaur at Mayilumpara was also reported. Leopard and wild dog were responsible for the cattle lifting incidences reported and among them, five incidences were from Kalikavu and one from Vazhikadavu Forest Range. Honey bee fence which was initially developed in Africa was experimented at Nilambur and the

result showed that as a technology the honey bee fence was effective in stopping the crop raiding elephants. On social angle it provided an additional income to the farmers by the sale of honey obtained from the fence and on the implementation side, theft of bee hive by locals and the difficulty in the maintenance of honey bees during the months of monsoon was an issue.

Yellow coloured cloth proved effective in protecting crops from wild pig. A bio-repellent experimented in the field to control the wild pig showed that, it is effective in reducing the menace. Conservation attitudes of the local people were assessed through a questionnaire survey and 59 per cent of the respondents reported wild pig as the major menace followed by bonnet macaque, Asian elephant and Indian crested porcupine. Around 4 per cent of the respondents reported livestock predation by leopard, wild dog and small Indian civet.

Contrary to the general belief that, elephants came out of the forest in search of water and fodder, it was observed that highest crop damage were during the months of July to August when the south-west monsoon was in full swing. It was observed that they were raiding only cash crops like plantain, coconut and arecanut, which are rich in nutrients only during the monsoon months when the vegetation was lush in the forest.

To resolve the human-wildlife conflict more attention is needed on the social angle of the problem. It was found that the “first line of defence” of elephants by farmers is not existing now and this has happened because most of the farms in the forest fringes has been converted into rubber plantations and these farms without any habitation are managed by owners staying in the faraway places. The young generation is not taking any interest in the “first line of defence” to prevent the elephants from entering into the agriculture fields. Due to this scenario, elephants can travel long distances to the nearby villages without any hindrance and in such villages people are not traditionally trained to defend the elephants or other animals on their own. 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. The study highlights that crop damage by wild animals is severe in the Malappuram District and reports the localities where intervention is needed. Practical suggestions to mitigate the human-wildlife conflict is reported in the study.

1. INTRODUCTION

Over the years, Human-Wildlife Conflict (HWC) is of grave concern for all those who are involved in conservation and also to the people who stay in the fringe areas of the forests. It happens when the needs and behavior of wildlife impact negatively on the goals of the human beings (Cumming *et al*., 2005). The negative interactions may result in (a) crop damage by wild animals (b) cattle-lifting, (c) human casualties and (d) household damage (Conover, 2002). It can be considered as inevitable in all areas where humans and wildlife coexist and share the same habitat. A review of human-wildlife conflict in Kerala was reported by Jayson (2012), while describing the human-wildlife problems in Trichur District, Kerala. Previous studies in the Kerala Forest Research Institute, Peechi, showed that the crop damage is largely affecting the marginal farmers (Veeramani *et al*., 2004 b). Being the pioneers in this field in Kerala, past efforts were focused on the issues of human-wildlife conflict in the Wayanad Wildlife Sanctuary (Easa and Sankar, 2001), Peppara Wildlife Sanctuary (Jayson and Christopher 2008) and in the Idukki District, Kerala (Veeramani *et al*., 2004 a). Detailed and site specific studies are required to formulate integrated management strategies for mitigating human-wildlife conflict in the State. Immediate verification of damage and compensation schemes with strong institutional support will reduce the severity (Nyhus *et al*., 2003). The present study was initiated to assess the overall pattern of crop damage, livestock lifting and human casualties in the Malappuram District of Kerala, India and also for evaluating the efficacy of novel mitigation measures in the field. The previous studies have revealed that, each area has unique problems of human-wildlife conflict (Jayson, 1998, 1999, 2008). So this study was specifically formulated to suggest mitigation measures to the human-wildlife conflict in the Nilambur area in Malappuram District, Kerala. Nilambur was selected for the study because many human-wildlife conflict issues were reported from the region before the study period.

1.1 Review of literature

1.1.1 Studies in other countries

Human-wildlife conflict was studied all over the world by many researchers. The perception and patterns of human-elephant conflicts in old and new settlements in Sri Lanka revealed that more elephant signs in the fields were observed during the fallow dry season from April to September than during the cultivated wet season. In addition, the monitoring data indicated differential use of the area by adult male and female herds, with some males using the areas in the wet season but female herds using the area mainly in the dry season (Fernando *et al.* 2005). The human-rhesus monkey conflict at Rampur village of Bangladesh was studied by Ahsan and Uddin (2014) and revealed that the rhesus macaque consumed plant part of 10 species as food of which, fruits were from eight species, leaves from three and inflorescence and seeds from one species and the crop most damaged was the betel and the plantain. The food habitat of Indian crested porcupine (*Hystrix indica*) in Faisalabad, Pakistan was examined by Hafeez *et al.* (2011) by analyzing the stomach content and fecal pellets and it revealed that twenty seven species of plants including the tubers, leaves, stem and spike of agricultural crops like *Triticum aestivum, Zea mays, Saccharum officinarum, Hordeuum vulgare, Brassica oleracea, Brassica campestris, Allium cepa* were consumed extensively. The spatial and temporal habitat use of male cheetahs in modified bush land habitat was studied by Nghikembua *et al.* (2016) by tracking using the satellite based Global System for Mobile (GSM) collars providing a higher resolution on ranging behavior and recorded that they spend more time in high visibility shrub land, the individuals exhibited significant temporal activity partitioning, showing peak between late afternoon and early morning hours. They reported that re-visits to the same locations were not correlated to habitat type.

The study of Orga *et al*. (2008) revealed that most of the farmers are not ready to apply for compensation and their interest on compensation was shaped by factors like wealth, gender social network and pre-existing expectation. Mashalla and Ringo (2015) assessed the status of human-wildlife conflict in Mpanga/Kipengere game reserve Tanzania and indicated that crop raising was associated more to human males than females and this could be due to the time spend by men, both at the day and the night, by guarding crops against destructive wild animals.

Moreover most women were associated with land scarcity for agriculture, restriction on the access to reserve resources and boundary disputes. Nyhus and Tilson (2004) reported on balancing conservation theory and practice in human-dominated landscapes of Southeast Asia in the background of agroforestry and the conservation of elephants and tigers. Again, inadequate remuneration, processing delays and corruption are the key problems related to compensation (Ogra and Badola, 2008).

Constant *et al.* (2015) reported from South Africa that, livestock attacks were associated with seasonal grazing patterns and the erosion of the traditional management of livestock strategies due to the economic costs of their implementation and the migrant labor system altering management roles in the community. Mutanga and Adjorlolo (2008) assessed the spatial patterns of crop damage by wildlife using GIS explained that there was a strong correlation between the location, size and distance of damaged crop fields and the protected area boundary. The crop damage index between farms index varied significantly with the distance to the protected area boundary as well as to water sources and the correlation coefficient indicated that the proximity of the planted fields to permanent water sources is a significant factor influencing crop raiding in the farms.

Osborn and Parker (2002 & 2003) conducted a survey on community-based methods for deterring the elephants from crop field in Zimbabwe and the study revealed that individual experimental methods were more effective than current traditional methods. Different methods used to reduce the crop damage by wild animals were also evaluated and they suggested an integrated, community-based and low-tech approach to mitigate human-elephant conflict. The effectiveness of an Anatolian breed of livestock guarding dogs in two South African provinces over a nine year period was assessed by Leijenaar *et al.* (2015) and they found that it is reducing perceived livestock losses due to predation, regardless of sex of dog.

1.1.2 Studies in India

Chakravarthy *et al.* (2006) revealed that Indian crested porcupine became 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 areca nut with porcelain pipes. Smearing the seedlings as well as adult

palms with coal tar was also examined for preventing the debarking by porcupine. The consumption of fallen coconut and areca nut and debarking behavior of palm by Indian crested porcupine was reported by Thyagaraj *et al.* (2006). Chauhan *et al.* (2009) investigated the agricultural crop depredation and attacks on humans by wild pig in five States in India. A total of 309 human deaths and injury cases were reported in these States in which highest number of casualties occurred in the month of November and the people developed antagonistic attitudes towards the wild pigs which adversely affected the conservation efforts. Srivasthava (2000) conducted a study on the consumption of 19 varieties of sugarcane by Indian crested porcupine in Lucknow, Uttar Pradesh. The results revealed that 31.68 per cent of damage was done to the clumps and in damaged clumps, 49.76 per cent of internode was eaten up by porcupines. Damaged canes suffered a weight loss of 30 per cent on an average. Different climatic zones with complex tropical patterns and crop practices were the main cause for increasing the vertebrate pests. Prashanth *et al. (*2013*)* studied the crop raiding behavior of *Bos gaurus* in Mookambika Wildlife Sanctuary, India and found that maximum crop raiding cases were reported in the months of March, April, May (during summer) 56.84 per cent and minimum cases during June, July and August (Monsoon) 9.79 per cent and the maximum damage was caused by medium seized herd (9-12 individuals) and most damage was caused to paddy. Sidhu *et al.* (2015) analyzed the prey abundance and leopard diet in a plantation and rainforest landscape, Anamalai Hills, Western Ghats and revealed that in the commercial plantation dominated region of Valparai Plateau that is surrounded by protected areas, large carnivores predominantly consumed wild prey species (98.1%) and domestic prey species contributed < 2 per cent to overall prey biomass and the preferred prey size for leopards was just above 30 kg.

The livestock and crop depredation by large mammals in the interior villages of Bhadra Tiger Reserve, India was studied by Madhusudan (2003) and revealed that annually each household lost an estimated 12 per cent (0.9 head) of their total holding to large felines and approximately 11 per cent of their annual grain production (0.82 tons per family) to elephants. Compensations awarded offset only 5 per cent of the livestock loss and 14 per cent of crop losses and were accompanied by protracted delays in the processing of claims. Allwin *et al*. (2016) studied the behavior of wild pig in the adjoining regions of Western Ghats and Eastern Ghats and documented seventeen types of behavior patterns that includes social unit organization, habit utilization, daily activity patterns, movement patterns, modes of mobility, home range, male-

male competition, maternal behavior, resting/loafing beds, mannerism and attitudes, vigilance behavior, vocalizations, wallowing, rubbing, symbiotic grooming behavior, scent marking, senses, which are necessary to cutting down human-wild pig conflict. Human-wildlife conflict in the forest fringe villages of Barak Valley, Assam, India was examined by using a close ended questionnaire survey by Dutta *et al.* (2015) and he documented that jackal, civet, wild boar, and monkey were the most problematic species involved in the livestock predation and crop damage respectively. Nigam (2002) mentioned the levels of damage caused by a small group of elephants in Jharkhand as the habitat degradation led to human-wildlife conflict.

The attitudes of local people towards wildlife conservation in the Kashmir Valley was surveyed and it was reported that seventy five per cent of the respondents suffered crop damage while 23 per cent suffered livestock predation by wild animals. The majority of the respondents expressed favorable attitudes towards wildlife with only about 16 per cent expressing a negative perception. Gender, crop damage, livestock predation and total live stock holdings were the strongest variables influencing the attitudes of local people (Mir *et al.*, 2015). Malaviya and Ramesh (2015) examined the pattern of human-wildlife conflict in wildlife corridors and its implications for the long-term persistence of tiger and leopard and reported that leopard caused more frequent losses, whereas tiger caused greater economic losses. Local communities perceived leopard as a bigger threat than tiger due to the intrusive nature of leopard and 87.5 per cent tiger attacks on livestock took place inside the corridor.

Agarwal *et al.* (2011) monitored the human-leopard conflict in altitudinal variations with landscape characteristic using GIS and remote sensing in Pauri Garhwal District Uttaranchal, India and the findings reflect that elevation 900 m-1500 m is highly prone to human-leopard conflict because of the high percentage of scrub as compared to forest cover and habitation/agriculture. Alternatively it was seen that in elevation 400m-800m and 1600m-2300m, human-leopard conflict was found to be least. Karanth *et al.* (2012) surveyed 735 households from 347 villages around Kanha National Park, India and reported that crop loss was associated with greater number of cropping months per year and proximity to the park, livestock loss was associated with proximity and grazing animal inside the park and among mitigation measures, only use of physical structures was associated with reduced livestock loss. Distribution of

compensation was more likely in tiger related incidents and house located in the buffer zones. Goswami *et al.* (2014 a) examined whether wildlife friendly land use as being a subsidiary or substitute to protected areas for the Asian elephant and the result revealed that the probability of elephants using site regardless of intensity did not vary between protected areas and wildlife-friendly land uses, however high intensity use declined with distance to protected areas, and this effect was accentuated by an increase in village density. Goswami *et al.* (2014 b) assessed the importance of conflict-induced mortality for conservation planning in areas of human-elephants co-occurrence and the result revealed that population persistence adversely affected human-elephant conflict management and its detrimental effect was magnified as the proportion of the core area declined. Under moderate human-elephant conflict management, small increments in mortality rates necessitated disproportionately large increases in core area availability to avoid quasi-extinction. Furthermore, benefits of core area supplementation were driven more by core area quality than size and these benefits declined as human-elephant conflict management increased.

Prasad and Reddy (2002) provided suggestions to alleviate human-elephant conflict, when elephants were returned to the areas of former habitat. The efficiency of chilly-tobacco rope against the crop raiding elephants in Karnataka was analyzed by Chelliah *et al.* (2010) and it proved that the method was significantly better in low-rainfall seasons than medium and high-rainfall regimes. Jasmine *et al.* (2015) assessed the attitude of human-elephant conflict in a critical wildlife corridor within the Terai Arc landscape, India and the results indicated that the most important management measures used were a combination loud noise and scaring away elephant using fire and also revealed that 89 per cent of respondents feel an effective approach to compensation is a way to reduce sufferings due to wildlife conflict.

1.1.3 Studies from Kerala

At Marayur Range in Kerala, crop damage by gaur was noticed but it was absent in other areas. Highest crop damage were recorded from the forest ranges under the Northern Circle (30 %) followed by Southern Circle (28 %). The crops which are more susceptible to the wildlife attack were coconut, pineapple (*Ananas comosus*), sweet potato (*Ipomaea batatas*), tapioca, colacasia, beans and plantain. In Marayur Range, elephant did the maximum damage followed

by gaur, sambar and wild boar among others. These animals were recorded as destructive to mulberry, plantains, paddy followed by sugar cane (*Saccharum officiniarum*) (Jayson, 1999). In Peppara Wildlife Sanctuary, five species of animals were recorded as destructive to seventeen crops. But wild boar did the highest damage followed by Asian elephant and blacknaped hare. The crops vulnerable to the attack of wild animals were tapioca, cassava, paddy and plantain. Tapioca is a crop which is highly affected by the wild animals (Jayson, 1999). Easa and Sankar (2001) studied the human-wildlife interaction in the Wayanad wildlife sanctuary, Kerala and reported the various causes for the human-wildlife conflict in the region.

Rohini *et al.* (2016) after a questionnaire survey at Nilambur reported that the majority of the people opinioned as conflict management is the exclusive responsibility of the Kerala Forest and Wildlife Department. Prasad *et al.* (2011) studied GIS based spatial prediction model for human-elephant conflict in the Agali Forest range of Attappady Valley of Kerala and it reported a strong correlation of human-elephant conflict occurrence with distance to hamlets, slope and agriculture land can serve as a scalable model for prediction and mitigation. Rohini *et al.* (2016) suggested that forest frontage and livestock population were significant predictors of conflict incidents.

Veeramani *et al.* (2004 b) studied the socio-economic status of cultivators and their interface with wild animals in Marayur Forest Range, Kerala. In Kerala, washing soap was found to be a good short term control measure at Marayur against Sambar (Jayson, 1999). Indian giant squirrel (*Ratufa indica*) causing damage to coconut plantations in Kerala were also recorded (Govind and Jayson, 2010). In South Asia and Kerala crop guarding, shouting, fire, repellents like chilli rope, vehicle patrols, physical barriers like wire fences, log and stone walls, ditches and psychological fence like electric fence are the protective methods used to mitigate the human- wildlife conflict (Veeramani *et al*., 2004 c, Fernando *et al*., 2008). Greeshma and Jayson (2016) studied the impact of human-wildlife conflict in Peechi-Vazhani wildlife sanctuary and reported that the economic value of crop damaged by wild animal was Rs.1242/- per hectare in which Indian wild pig and Indian giant squirrel were responsible for 90 % of the crop depredation.

1.2 STUDY AREA

1.2.1 Location

Malappuram District, in Kerala State ($10^0$40' to $11^0$30' N and $75^0$35' to $76^0$33' 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.1). The innumerable streams that meander these hills reach the coconut fringed and charming seacoast, in many places, these streams are linked with backwaters which facilitate a network of inland waterways. The main crop species includes paddy, areca nut, cashew nut, pepper, ginger, pulses, coconut, banana, tapioca and rubber. 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 covered with 1034.2 km^2 area of forest have all the seven forest type of southern India, tropical moist deciduous, tropical semi evergreen, subtropical hills forest, sub-tropical savannahs, montane wet temperate grasslands with vast collection of wildlife apart from teak plantations raised in the reserve. The soil types include alluvial soil, lateritic soil, hydromorphic soil and forest loamy soil. The Malappuram District is the central part of the State of Kerala starting from the core of the Nilgiri and traversed through the high land, midland and low land areas up to the sea coast. The District is mainly drained by Kadalundi, Chaliyar and Barathapuzha Rivers.

High value biodiversity area: New Amarambalam Reserve

It is spanning an area of 26,572 hectares and it shows very high altitudinal gradation from 40 m to 2554 m which intern results 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 has been identified from New Amarambalam Reserve and is classified as important bird area of the Western Ghats.

1.2.2 Human settlements in the forest

Paniyan

Paniyas are the largest tribal community in Kerala. They were believed to be brought to Wayanad by the King of Malabar, centuries ago as slaves for agricultural labor. They are mainly concentrated in northern part of Western Ghats, Wayanad District, the eastern region of Kozhikode (Calicut), Malappuram and Kannur Districts. The word Paniya is derived from Pani which is a Malayalam word, meaning work. The people of this tribal community are mainly laborers. In ancient period, paniyas were subjected as bonded laborers in the field of rich land owners. The paniya females and children generally take part in digging of the forests for roots or herbs. At Nedungayam they reside in houses constructed by Government in colonies. Paniya tribes use a dialect of the Malayalam language and they also use Paniya dialect.

Cholanaikans

The Cholanaikans are the most primitive and vanishing tribes in Kerala and one of the oldest native communities of Kerala. They are only seen in the Karulai and Chungathara Forest Ranges in Nilambur in Malappuram District. They are one of the last remaining hunter- gatherer tribes of South India, living in rock shelters or crude huts beside brooks. They speak the Cholanaikan language, but around half of them can interact in Malayalam. The Cholanaikan call themselves as ‘Malanaikan’ or ‘Sholanaikan’. ‘Shola’ or ‘chola’ means deep thicket in the forest and ‘naikan’ means king. They are generally of short stature, well-built strong bodied, fair complexion, round or oval face and curly hair. They prefer semi evergreen and moist deciduous forests. For livelihood they collect Non Timber Forest Products (NTFP) and sell them to the co-operative society of Nilambur. They also collect honey, black dammer, mosses, nutmeg, shikakai from the forest and take back rice, tobacco, salt, oil and other necessities from the Society. Now, their population is numbered approximately to 426. The tribe, unlike any other tribes, under the leadership of the Mooppan (Elder) is unwilling to come out of the deep forest but use dress and ornaments, household articles, tools and weapons in their day to day life.

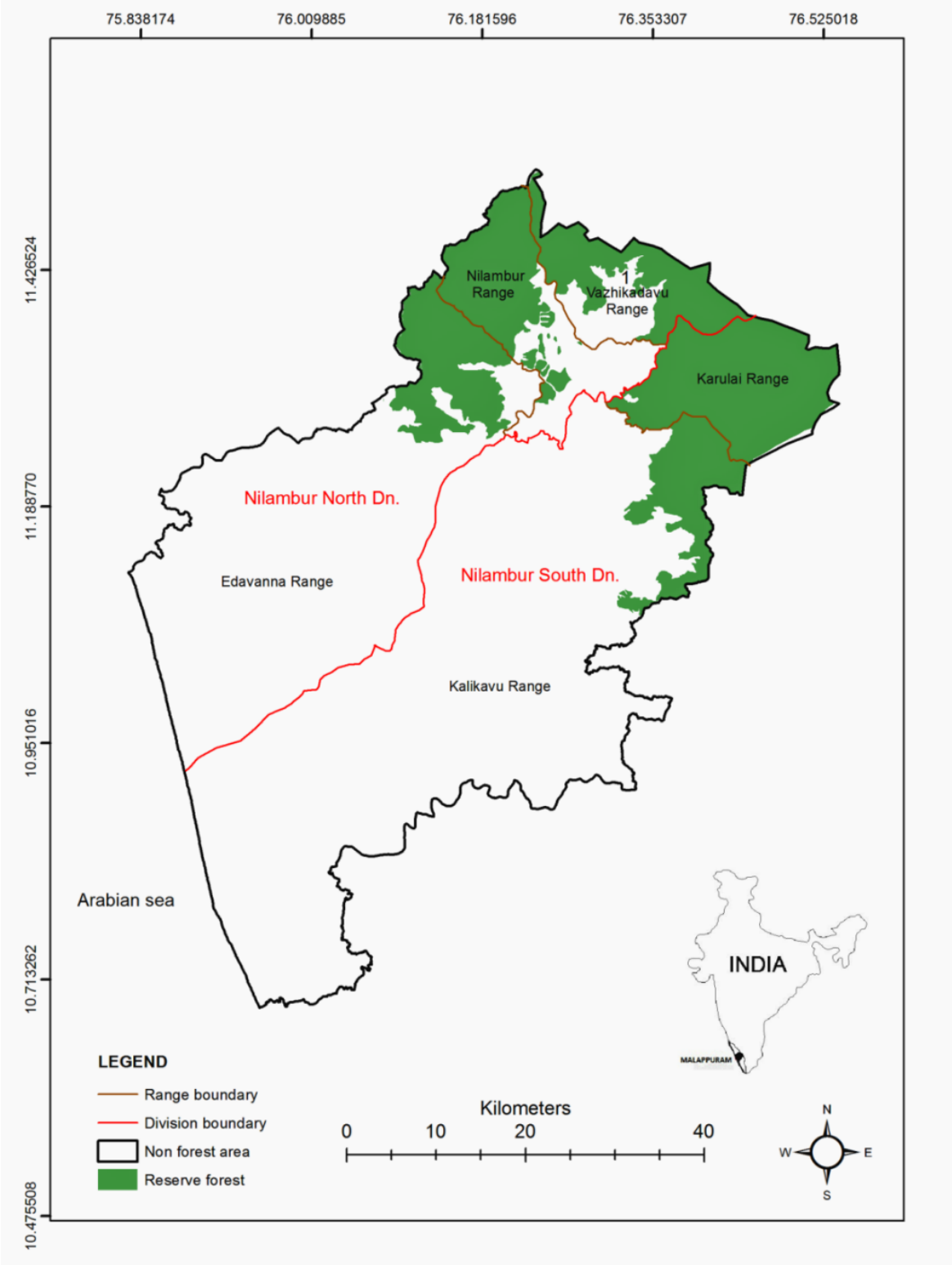

Fig. 1. Intensive study area

Kattunaicken

The Kattunaicken get their name from words “Kadu” which means forest and “nayakan” which means leader and they are considering them as the leaders of forest. They live in Uchakulam, Pattakarimbu, Mannarmala, Chenappady, Cheengakallu and Mundakkadavu areas of Nilambur South Forest Division. They live as a nuclear family and follow patriarchy. The primary occupation of this community is based on hunting and gathering, especially honey. Their settlement sizes are very small with an average of 5-8 households, sometimes just 1-2 families can be found living together. They collect NTFP during the season, but not in large quantities. Honey is the main collection item other items includes forest pepper, cinnamon and nutmeg.

Aranadan / Eranadan

This community seen in Eranadu taluk of Malappuram District, mostly in Vazhikadavu, Edakkara, Aranadankara, Kavalamukkatta, Telppara, Pattakkarimpu and Chokkad. They are nomadic hill tribe and engaged in hunting. Some of the families are settled by the tribal colonies constructed by the Government including one near to Chokkad.

Muthuvan

It is one of the few tribes who have still abstained from developing connections with the people of the outside world. These Muthuvan tribes are quite independent and do not rely the people of the civilized society. They have restrained from partaking in academics and education. So that most of these Muthuvan tribes also refuse to maintain connection with other tribes. Especially, the Muthuvan females have to obey to the strict rules of the society of not maintaining any relation with the people outside their tribal community, including all the males. They are seen in Kanjirapuzha, Karimba, Kalluvari, Veettikunnu and Palakkayam of Nilambur North Forest Division and Chokkad 40 cent colony of Nilambur South Forest Division of Malappuram District.

1.2.3 Climate

Climatic conditions are more or less similar to elsewhere in the State. 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 2793.3 mm. Out of this major contribution is from SW monsoon followed by NE (Fig. 2). SW monsoon is very heavy and nearly 73.5 per cent of the rainfall is received during this season. NE monsoon contributes nearly 16.4 per cent and March to May summer rain contributes nearly 9.9 per cent and the balance 6.2 is accounted for January and February (Sreenath, 2013). Temperature is generally hot and humid and March and April months are the hottest and January and February months are the coldest (Fig.3). The maximum temperature ranges from 28.9 to 36.2^0 C and minimum temperature ranges from 17.0 to 23.4^0 C.

1.2.4 Flora and fauna

Flora : *Hydnocarpus pentandra, Hopea ponga, Terminalia paniculata, Stereospermum colais, Trewia nudiflora, Persea macrantha, Dalbergia latifolia, Thespesia populnea, Holigarna arnottiana, Calophyllum calaba, Terminalia elliptica, Terminalia paniculata, Tectona grandis, Lagerstroemia microcarpa, Butea monosperma, Gmelina arborea, Bombax ceiba, Xylia xylocarpa, Alstonia scholaris, Grewia tillifolia, Anogeissus latifolia, Melia azedarach, Bridelia retusa, Artocarpus hirsutus, Bambusa bambos, Strychnos nux-vomica, Wrightia tinctoria, Spondias pinnata, Ailanthus triphysa, Miliusa tomentosa, Terminalia bellirica, Cassia fistula, Mitragyna parvifolia, Lannea coromandelica, Ficus recemosa, Santalum album, Sapindus trifoliatus, Olea dioica, Mallotus philippensis, Albizia lebbeck, Ziziphus rugosa, Macaranga peltata, Tetrameles nudiflora, Pterocarpus marsupium, Bombax ceiba, Ricinus communis, Bauhinia malabarica, Hopea glabra, Hopea parviflora,* and *Hydnocarpus laurifolia* are some of the plant species found in the area.

Fauna : Mammals:-Nilgiri langur (*Trachypithecus johni*), Bonnet macaque (*Macaca radiata*), Lion-tailed macaque (*Macaca silenus*), Malabar giant squirrel (*Ratufa indica*), Palm squirrel (*Funambulus palmarum*), Flying squirrel (*Petaurista petaurista*), Sambar (*Rusa unicolar*), Spotted deer (*Axis axis*), Barking deer (*Muntiacus muntjak*), Asian Elephant (*Elephas maximus*), Black napped Hare (*Lepus nigricollis*), Gaur (*Bos gaurus*), Porcupine (*Hystrix indica*), Mouse

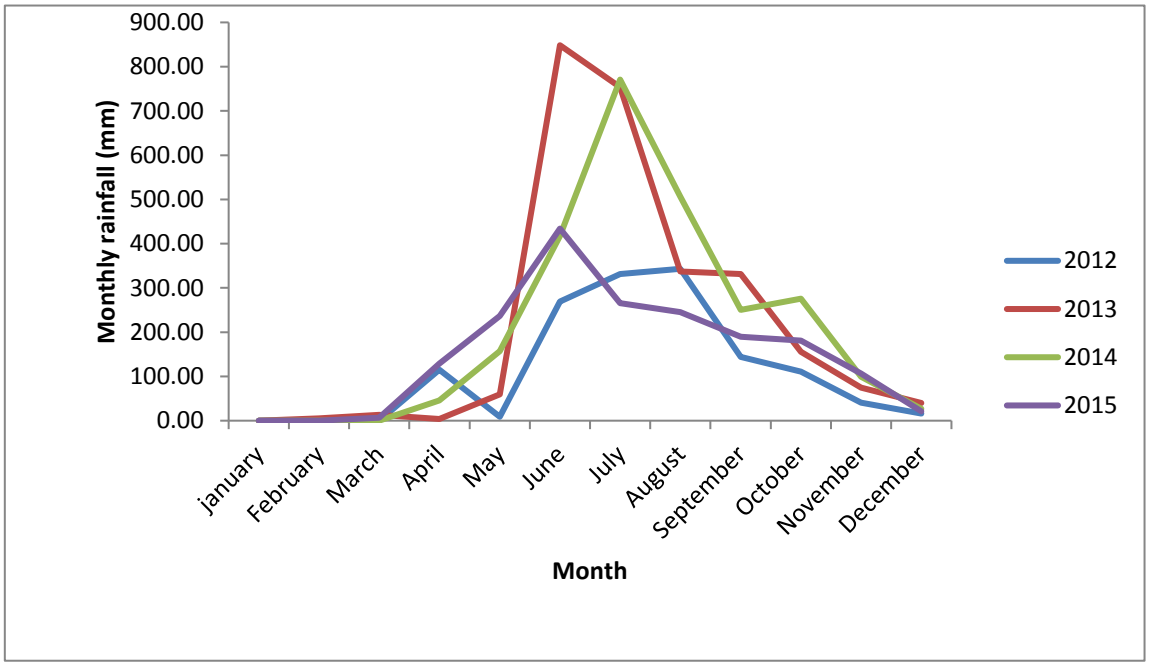

Fig. 2. Mean monthly rainfall over the years

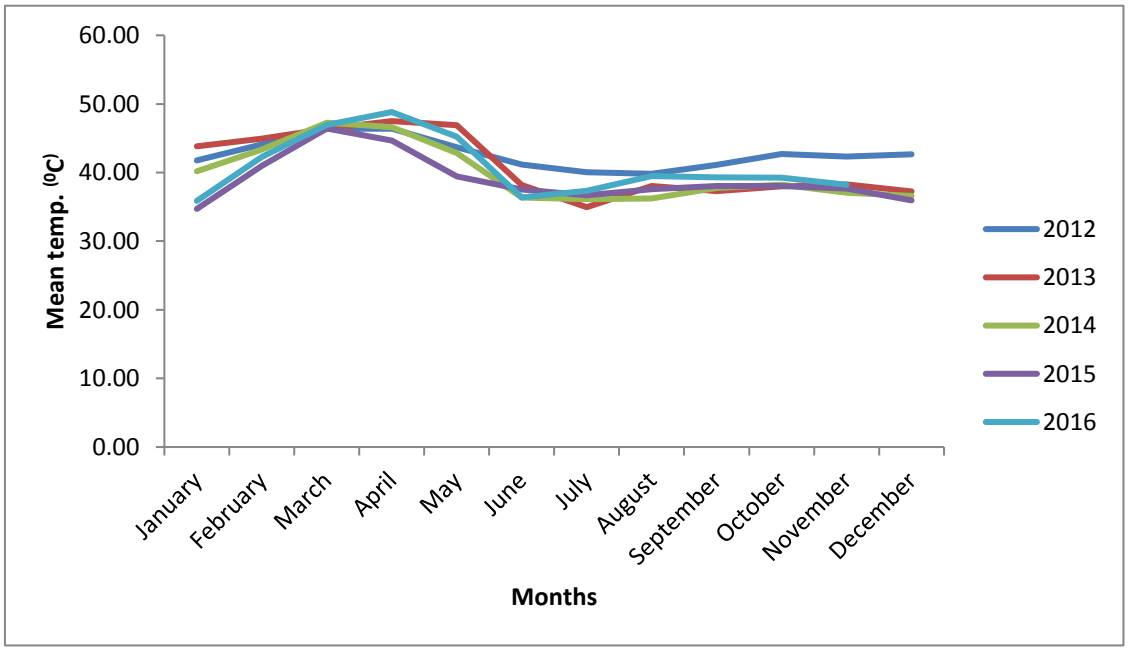

Fig. 3. Mean monthly temperature over the years

deer (*Tragulus meminna*), Nilgiri Marten (*Martes gwatkinsi*), Leopard (*Panthera pardus*), Leopard cat (*Prionailurus bengalensis*), Jungle cat (*Felis chaus*), Jackal (*Canis aureus*), Wild dog (*Cuon alpinus*), Clawless-otter (*Amblonyx cinereus*), Mangoose (*Herpestes edwardsii*), Otter (*Lutra lutra*), Scaly anteater (*Manis crassicaudata*), Sloth bear (*Melursus ursinus*), and Wild pig (*Sus scrofa*) are the larger mammals.

Avian diversity:- Nilgiri Wood Pigeon (*Columba elphinstonii*), Blue-winged Parakeet (*Psittacula columboides*), Malabar grey hornbill (*Tockus griseus*), Southern Tree Pie (*Dendrocitta leucogastra*), Small sunbird (*Nectarinia minima*), Grey-headed bulbul (*Pycnonotus priocephalus*), Flame-throated bulbul (*Pycnonotus gularis*) Nilgiri Flycatcher (*Eumyias albicaudata*), Wayanad laughing thrush (*Garrulax delesserti*), Rufous babbler (*Turdoides subrufa*), Malabar trogon (*Harpactes fasciatus*), Malabar whistling thrush (*Myophonus horsfieldii*), White-bellied blue flycatcher (*Cyornis pallipes*), Malabar starling (*Sturnia blythii*), Red spur-fowl (*Galloperdix spadicea*), Grey jungle-fowl (*Gallus sonneratii*), Emerald dove (*Chalcophaps indica*), Indian nightjar (*Caprimulgus asiaticus*), Jungle nightjar (*Caprimulgus indicus*), Banded bay cuckoo (*Cacomantis sonneratii*), Drongo cuckoo (*Surniculus lugubris*), 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 (Jojo, 2015; Abideen, 2015).

2. METHODOLOGY

2.1. Crop damage

Preliminary survey

An announcement was given in the visual media and in the newspapers about the proposed study and inputs was invited from affected people (Plate 1). This brought out good response from the local people. After studying the responses intensive study area were selected. All the areas were perambulated in a four wheeler for a reconnaissance survey before the data collection from plots were initiated. For assessing the crop damage, two methods were employed and they are 1. Quadrat method and 2. Structured questionnaire survey.

2.1.1. Quadrat method

Based on the responses from the print and visual media, detailed survey was conducted and two locations in the fringe areas of the forest were selected randomly in each of the five Forest Ranges of the intensive study area and the quadrats were laid in the farmlands. The quadrats of the size of 10 m x 10 m were selected as follows.

1) Five sample plots (Quadrates) in the mixed crop farm land (Fig.4).
2) Two control plots in the cultivated land near to the sample plots which are blocked or fenced to prevent the entry of wild animals.
3) One control plot in the Reserve Forest near to the sample plot.

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 2). Crop damage incidences from the quadrates were recorded in each month (n=36), and the species of crop damaged was identified and quantified. In order to quantify the consumption of tubers, estimate was taken after discussing with the farmers of the respective land. 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.

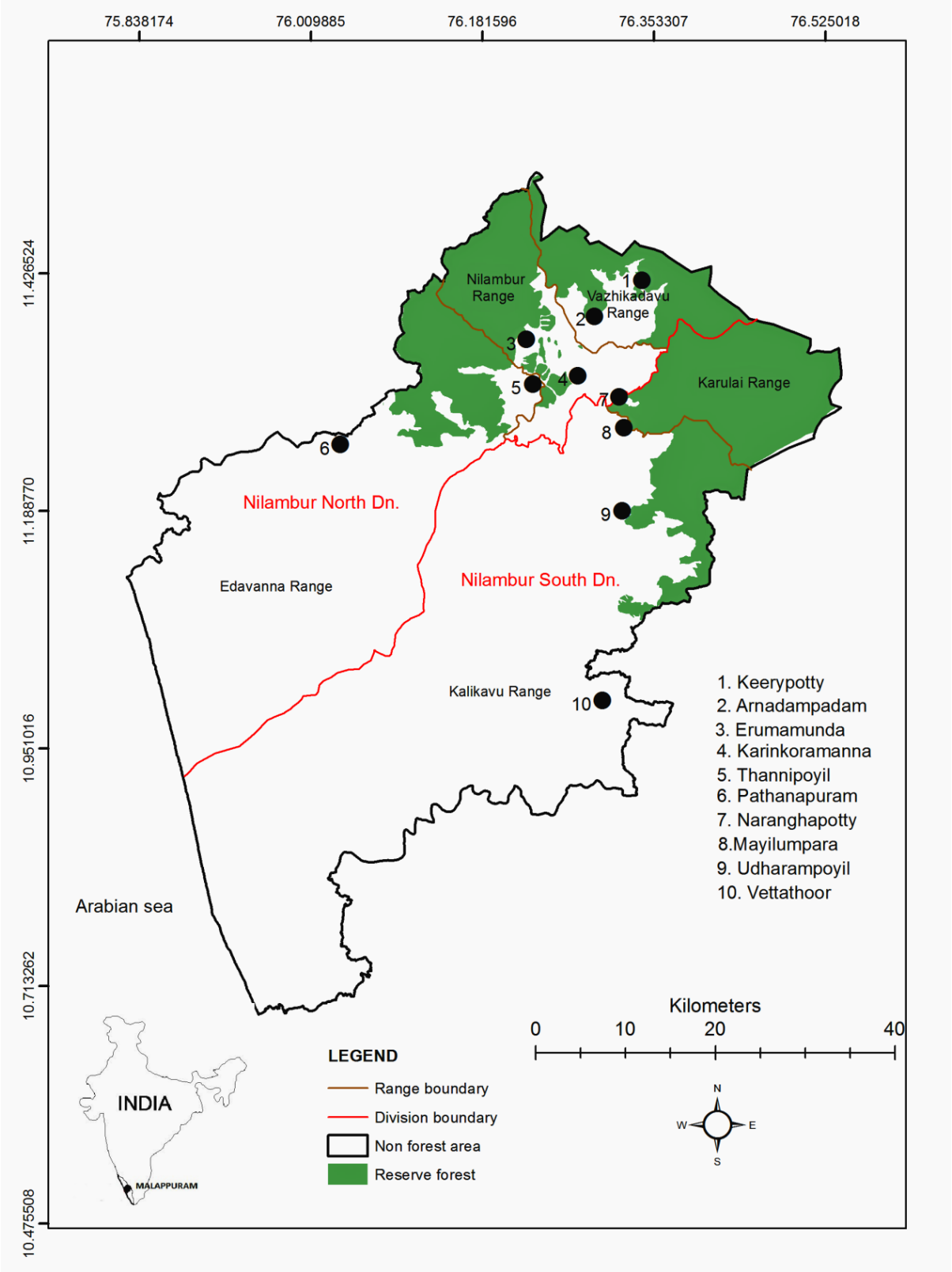

Fig. 4. Locations from where permanent quadrats were selected

വന്യമൃഗശല്യം: പഠനം നടത്താൻ വിദഗ്ധ സംഘം തയാറെടുക്കുന്നു

മലപ്പുറം: മലയോര മേഖലകളിലെ കൃഷിയിടങ്ങളിലെ വന്യമൃഗശല്യം തടയുന്നതിനെ കുറിച്ച് പഠിക്കാൻ വിദ്ഗ്ധ സംഘം എത്തുന്നു. തൃശൂർ പീച്ചി കേന്ദ്രമായി പ്രവർത്തിക്കുന്ന കേരളാ വന ഗവേഷണ സ്ഥാപത്തിലെ 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.

Plate 1. News item published about the study

Plate 2. Marking of permanent quadrat

a) Damage in the nearby areas to the quadrates.

Details of the crop species, age of the crop plant, vegetation type, animal causing the damage, nature of damage and the cost and efficacy of the protective methods employed at the time of visit were 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 quadrate the indirect evidences such as scats, droppings, diggings, feeding signs and scratching mark were also identified and recorded. A total of 80 permanent quadrates (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 01).

Table 01. Details of the sample plots selected from Forest Ranges in the Malappuram District

Forest Division	Forest Range	Location	Latitude & Longitude	Number of sample plots
Nilambur South	Kalikavu	Udharampoyil	$11^0$11’19.6”N $76^0$19’17.9”E	5
		Vettathoor	$11^0$59’57.3”N $76^0$18’06.1”E	5
	Karulai	Mayilumpara	$11^0$16’19.6”N $76^0$19’24.4”E	5
		Naranghapotty	$11^0$18’10.6”N $76^0$19’07.1”E	5
Nilambur North	Edavanna	Thannipoyil	$11^0$18’56.6”N $76^0$13’56.4”E	5
		Pathanapuram	$11^0$15’19.4”N $76^0$02’21.6”E	5
	Nilambur	Erumamunda	$11^0$21’37.9”N $76^0$13’32.0”E	5
		Karinkoramanna	$11^0$19’25.9”N $76^0$16’37.7”E	5
	Vazhikadavu	Arnadampadam	$11^0$22’59.8”N $76^0$17’38.1”E	5
		Keerypotty	$11^0$25’10.9”N $76^0$20’28.5”E	5
Total				**50**

2.1.2 Running quadrats

In order to quantify the crop damage by Asian elephant in the crop field other than permanent Quadrats, the running quadrats of 10 m x 10 m were laid and the details collected are 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. A total of 278 running quadrats were laid during the study. Seasonal encounter of Asian elephants in the crop field was also calculated using the formula, Seasonal encounter index = (Mean encounter in different seasons/Overall mean) x 100.

2.1.3 Estimation of economic loss

Estimation of the economic loss to farmers was calculated on the basis of the market price of the commodities during the study period, collected from the website of Farm Information Bureau, Kerala. In each month, the price of commodities in northern Kerala for 3 days were selected, with a gap of 10 days (n=36). Economic loss was calculated by multiplying the average market price of the commodities and the quantity of crops damaged from the quadrates. For estimating the potential loss of perennial crops, initially, its economic life period was divided into 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. 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 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. Only the perennial crops seriously damaged by wild animals (partial damage was not considered) and the species of crops damaged more than 15 trees were accounted for the potential loss estimation. Average yield per annum of the perennial crops was collected from Rubber Board Kottayam, Kerala and Kerala Agricultural University, Thrissur, Kerala.

2.1.4 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 method (Fig.5). Point Centered Quarter method (PCQ) is the most commonly used distance sampling method for the estimation of tree density (Cottam & Curtis, 1956). Four transects of 100 m length were laid in four directions (90^0) (Fig.6). In each transect, a minimum of five sampling points were 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. The trees were identified with the help of the software "Flowering plants of Kerala" and also with the help of experts in KFRI.

2.2 Control measures

2.2.1 Beehive fence

The natural fear of elephants keeps them away from the bees. Mayilumpara ($11^0$16'19.6"N & $076^0$19'24.4"E), of Karulai Forest Range was selected for the experiment where the presence of elephants was rampant in the crop field. Previous observations in this area (n=21) 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 fence. Three to five beehive boxes were hanged in an iron wire, supported by wooden posts (having a width of 10 m) for blocking a single path (Plate 3). The remaining two paths were left unblocked. All the twenty boxes were protected from monsoon rains using plastic sheets (Plate 4). Whenever the elephants touch the iron wire which is installed across the path, the beehive boxes will be disturbed and the guard bees will attack the elephants and deter them. It was found effective during both day and night hours (King *et al*., 2009). The guard bees will attack the elephants on its sensitive areas like tip of the trunk, 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. Expertise of a trained apiculturist Mr. Pradeep was obtained for maintaining the honey bees. Social aspects

of maintaining the bee-hive fences were also recorded the beehive-fence was maintained from March to December months in the year 2014.

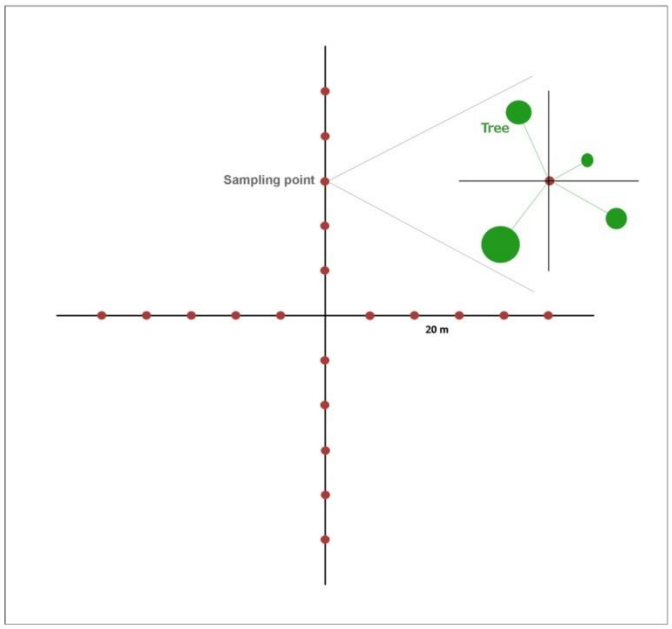

Fig. 6. Pictorial representation of Point Centered Quadrat (PCQ) method

2.2.2 Yellow-coloured cloth

The putting up of a yellow coloured cloth as fence was carried out in Kalikavu Forest Range in a private plantain plantation (*Musa paradisiaca*), 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. The study area was selected in a private land (fringe area of the forest) having plantain cultivation. Yellow cloth (120 cm height) was fixed in the boundary of this farm. 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, this was invested by the farmers. A total 10 quadrats (10 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 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).

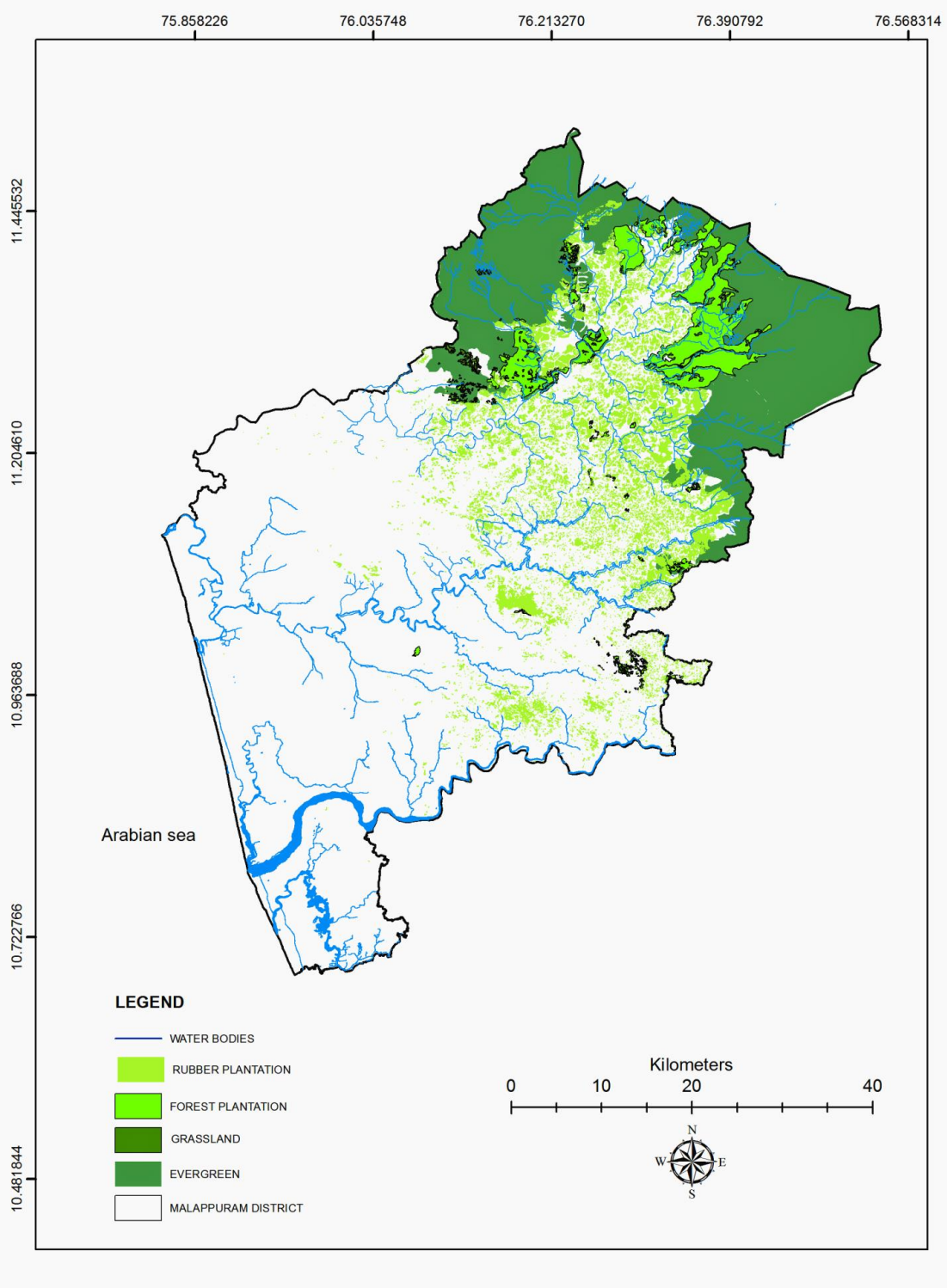

Fig. 5. Vegetation Map of the area

Plate 3. Beehive fence at Mayilumpara

Plate 4. Beehive fence at Mayilumpara

2.2.3 Bio-repellent (Trump guard)

"Trump guard" is a biological product for repelling wild pigs without killing them. 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 liters 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 quadrates for evaluating its efficacy (Appendix-1). Month-wise observations were recorded with the help of farmers from July 2015 to December 2015 (n=6).

2.3. Conservation attitude

2.3.1 Questionnaire survey

Structured questionnaire survey (Appendix-2) was carried out in the Forest Ranges of Malappuram District (Plate 5) to find out the conservation attitude of local people (Christopher, 1998). 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 and the portion of Silent Valley National Park were omitted from the grids, as the human-wildlife interaction in the non-forest areas and human habitations within the National Park were negligible. Grids were selected in a checkerboard pattern for the survey (Fig.7). The houses within the grids were selected non-randomly (Table 2). Five houses were selected for the survey from each grid. Fifty questions were included in the questionnaire performa, 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 mostly were male. The exception was where they were absent during the household visit. Interview with respondents were made after visiting them in the homes and roughly 15 to 20 minutes was utilized for a 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.

Almost all questions were close ended (close ended questions have multiple options and respondents are required to choose one from among these options, therefore, respondents are

directed 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 02. Number and location of grids selected using systematic random method

Sl. No.	Forest Ranges	No. of grids selected using checkerboard pattern	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 2).

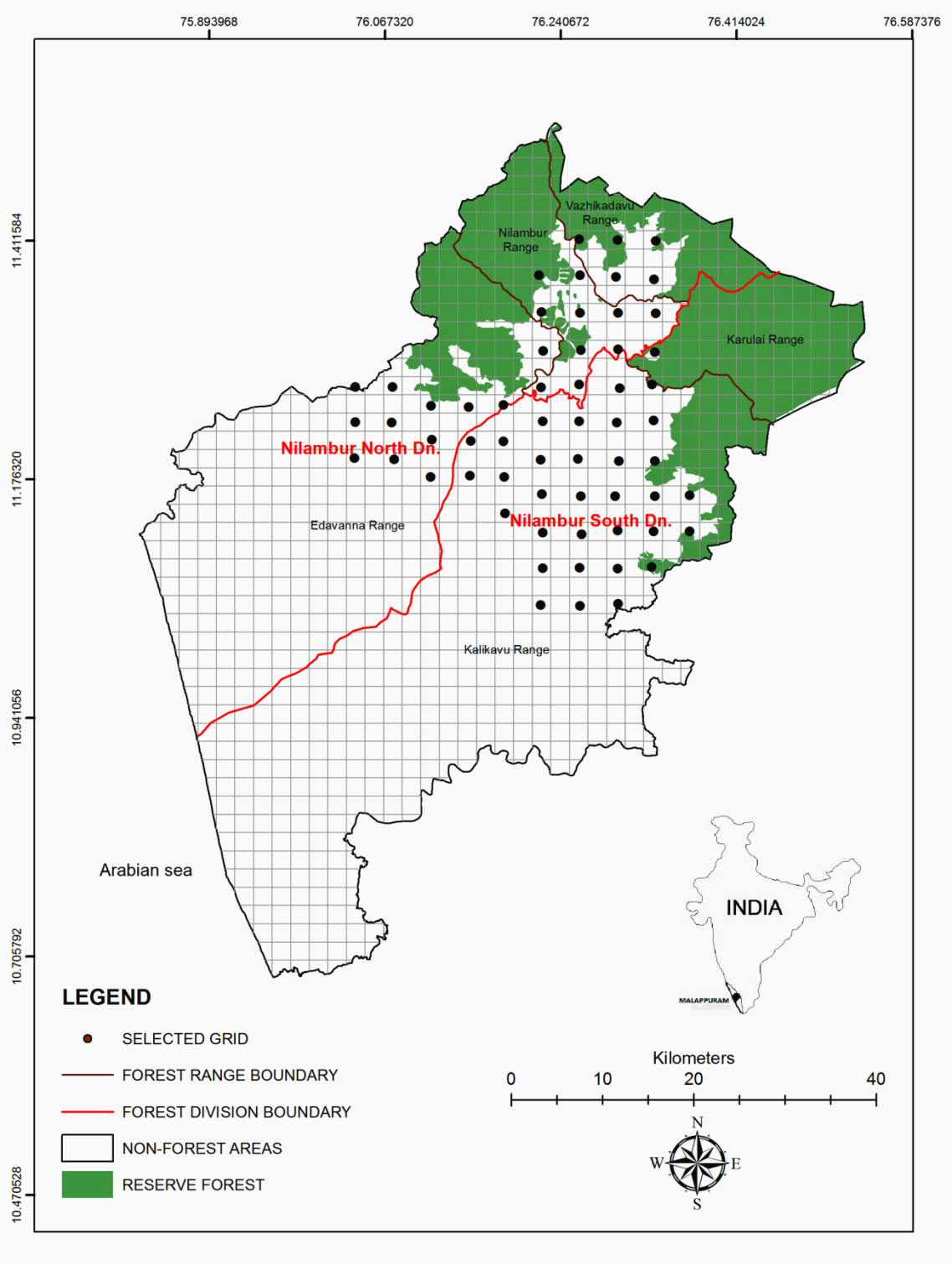

Fig. 7. Grids showing the locations of focus group discussion were conducted

Plate 5. Questionnaire survey

3. RESULT

3.1. Crop damage

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 grey tufted langur *(Semnopithecus priam*). The crops damaged by wild animals are coconut (*Cocos nucifera*), arecanut (*Areca catechu*), plantain (*Musa paradisica*), paddy (*Orysa sativa*), pineapple (*Ananas comosus*), jack tree (*Artocarpus heterophylla*), rubber (*Hevea braziliensis*) (Table 03). Highest crop damage has happened during the month of July and lowest during March.

Table 03. Number of plants damaged by wild animals in the permanent quadrats in the study area during the study period.

Sl. No.	Species	Plants cultivated in the quadrates		No. of coconut trees in the quadrates	No. of coconuts damaged
		Total plants cultivated	No. of plants damaged		
Kalikavu Forest Range					
1	Rubber	85	-	37	1482
2	Plantain	62	46		
3	Areca nut	28	-		
Karulai Forest Range					
1	Rubber	77	-	36	211
2	Plantain	71	40		
3	Areca nut	6	-		
Vazhikadavu Forest Range					
1	Rubber	80	-	59	539
2	Plantain	3	-		
3	Areca nut	13	-		
4	Teak	13			

Nilambur Forest Range					
1	Rubber	35	-	37	161
2	Areca nut	41	-		
3	Plantain	182	165		
Edavanna Forest Range					
1	Rubber	32	-	57	764
2	Plantain	5	4		
3	Areca nut	16	-		

3.1.1 Asian elephant (*Elephas maximus*)

Asian elephants are in conflict with people in the Nilambur South Forest Division and also Vazhikadavu Range of the North Forest Division. Cash crops damaged by elephant in the District were plantain (*Musa paradisica*), Coconut (*Cocos nucifera*), areca nut (*Areca catechu*), Rubber (*Hevea braziliensis*), nutmeg (*Myristica fragrans*), Teak (*Tectona grandis*). Human elephant conflict was reported from Mayilumpara, Panichola, Mundakadavu, Naranghamoola, Narnghapotty, Nambooripotty, Palengara, Kalkulam, Theekadi, Thanipotty from the Karulai forest range, T.K Colony, Chenappady, Kelunairpady, Pullangodu estate, Chenkodu, Munadi, Parayanmedu, Kalikavu, Udharampoyil and Mayiladist colony of Kalikavu Forest Range; Chetiyaranghadi, Udhiramkulam, Onichandam, Anamari, Thkepalodu and Moothedam of Vazhikadavu; Veetikunnu Colony of Edavanna Forest Range (Fig.8). A total of 2.78 hectare of crop damage by Asian elephant was recorded from the District during the study period (Table 04). Elephants forage on cultivated crops which has additional nutritive value than wild crops and the high level of crop raiding by male elephants is a consequence of its 'high-risk, high-gain' strategy (Sukumar, 1991).

HWC was not reported from Nilambur Forest Range, farmers in the fringe areas of the forest cultivate different varieties of crops like coconut, areca nut, rubber, plantain, paddy and pineapple. Rubber is the main cash crop in the forest boundaries of the District. During the study period, elephants fed mostly on plantain, areca nut, coconut and rubber (Plate 6). Paddy and teak were also damaged in negligible quantity. Karulai forest range, followed by Kalikavu and

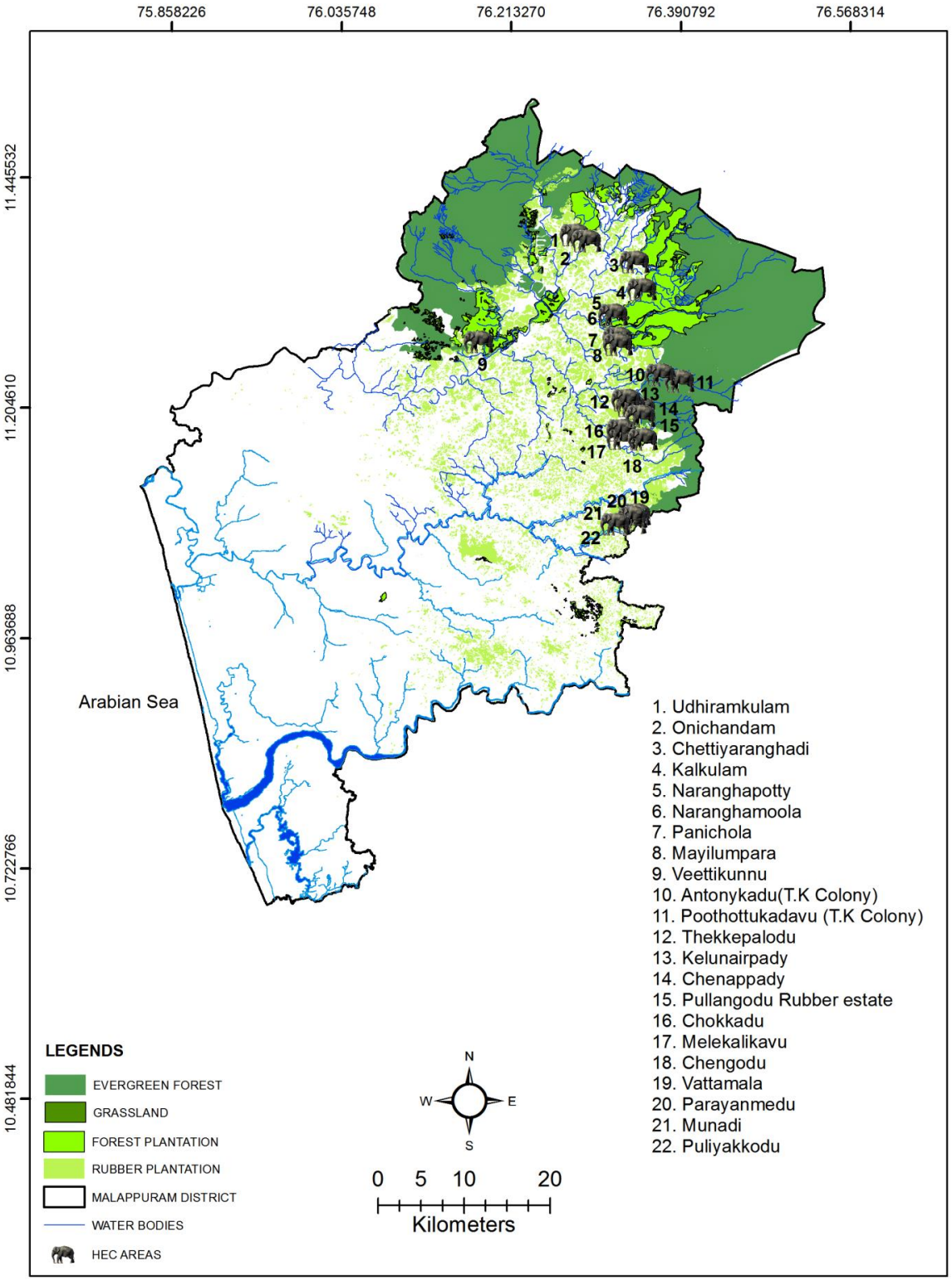

Fig. 8. Areas where elephants were encountered

Vazhikadavu were facing serious crop damage (Fig.9). Twenty one per cent of the herd contained juveniles at the time of crop raiding (Fig.10).

Highest crop damage was reported during the months of July and August (Fig.11). Fifty five per cent of the total encounters occurred during the south-west monsoon (June-September). Forty cases of encounters in crop field were reported during the period. Sukumar (1985) stated that during dry season (January - April), browsing is important for elephants and the rainy season (May-August) is the time for consuming freshly growing tall grass. When the tall grass becomes unpalatable, they will consume protein rich fodder during the north-east monsoon season (September-December) and they may come to low elevation area. The crop raiders intruded into the crop lands up to 6 km from the forest through the human habituated area, only 30 per cent of the encounters occurred within 1 km from the forest land (Fig.12). Most of the encounter (50 per cent) occurred in the early mid night (Fig. 13). Elephants mostly damaged plantains (59.09%) followed by rubber (26.63%), arecanut (9.71%), coconut (3.29%), teak (1.09%), jack fruit (0.14%), mango tree (0.04%) (Fig.14). Ninety per cent of the areca nut 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 (95.89%) were uprooted during the productive phase and the fresh leaves were consumed.

An average of 4.21±2.79 elephants were recorded per herd during the time of crop raiding (n=24) and 21per cent of herds had juveniles (n=40). Area of elephant damage in the Forest Ranges of Malappuram District is presented in Table 04. Highest damage occurred in the Karulai Forest Range and lowest in Edavanna Range.

Table 04. Area of crop damage by Asian elephant in Malappuram District (n=278)

Forest Ranges	**Total area of crops damaged (ha)**
Karulai	1.32
Kalikavu	0.86
Vazhikadavu	0.58
Edavanna	0.02
Total	**2.78**

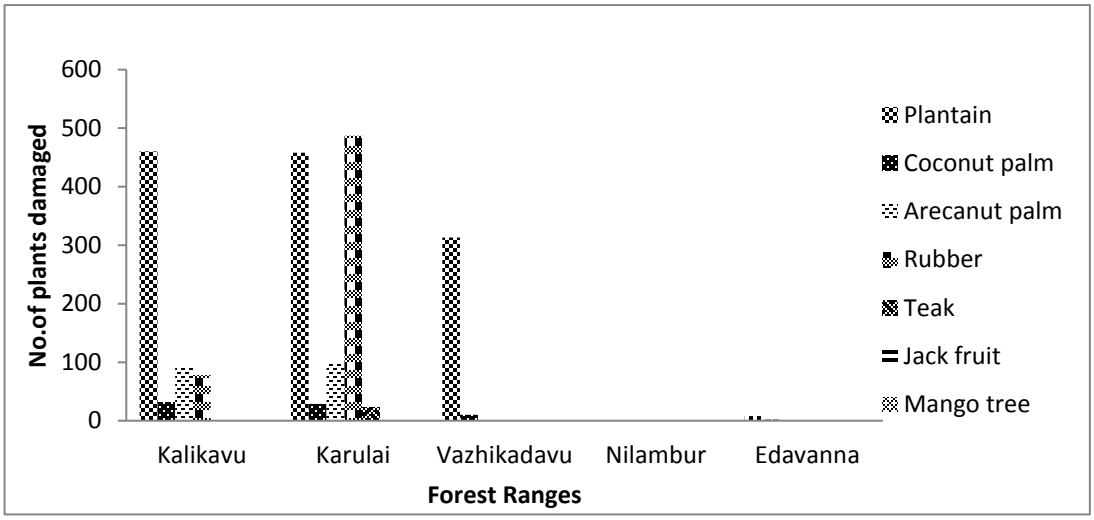

Fig. 9. Crop damage recorded from various Forest Ranges

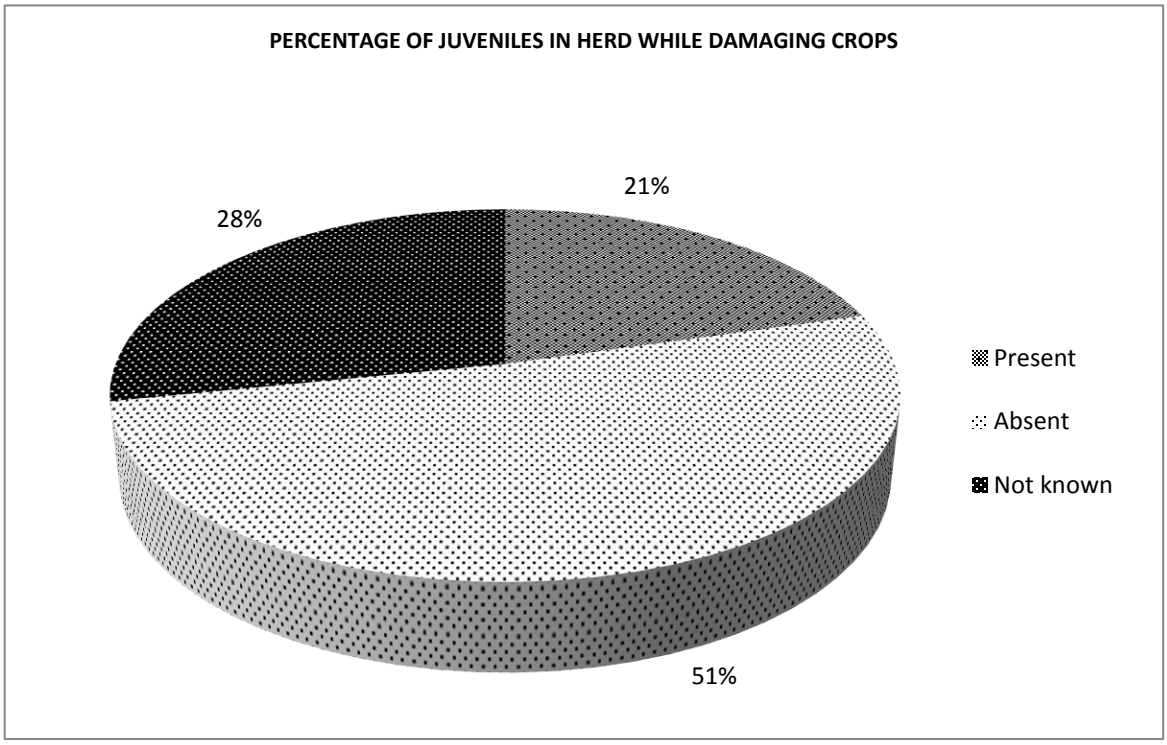

Fig. 10. Percentage of juveniles in an elephant herd while damaging the crops

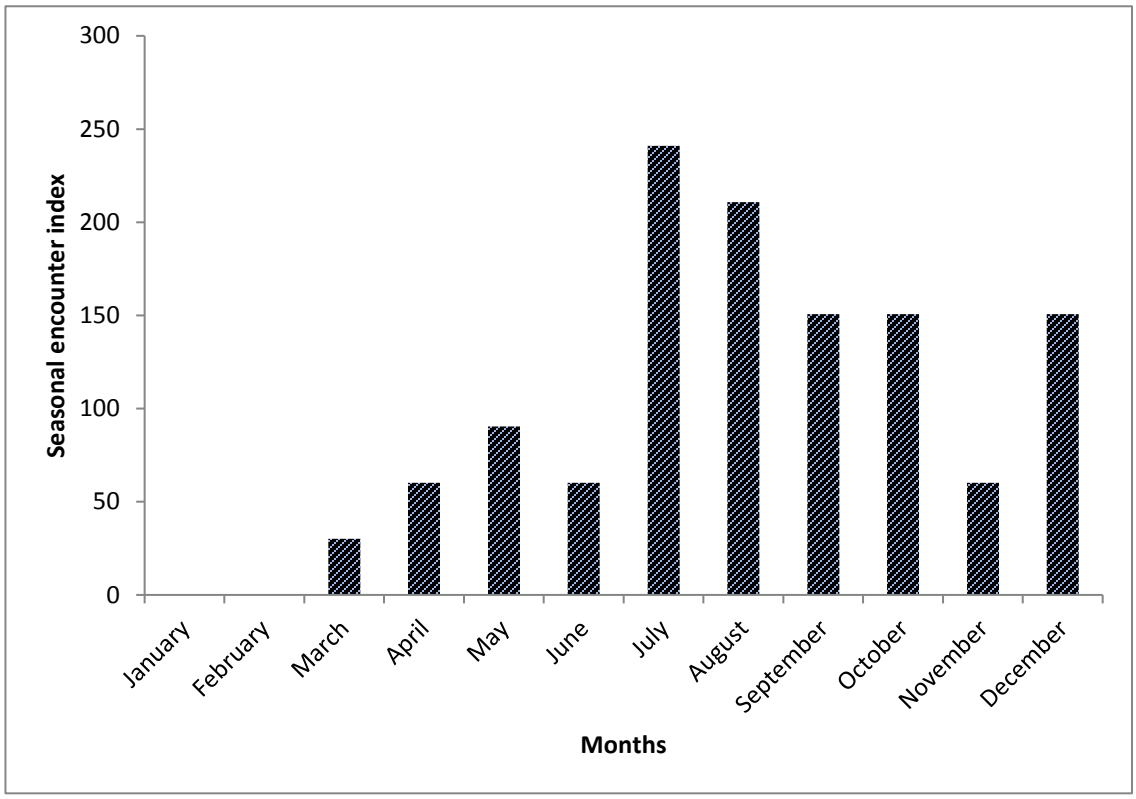

Fig. 11. Occurrence of crop damage during different months

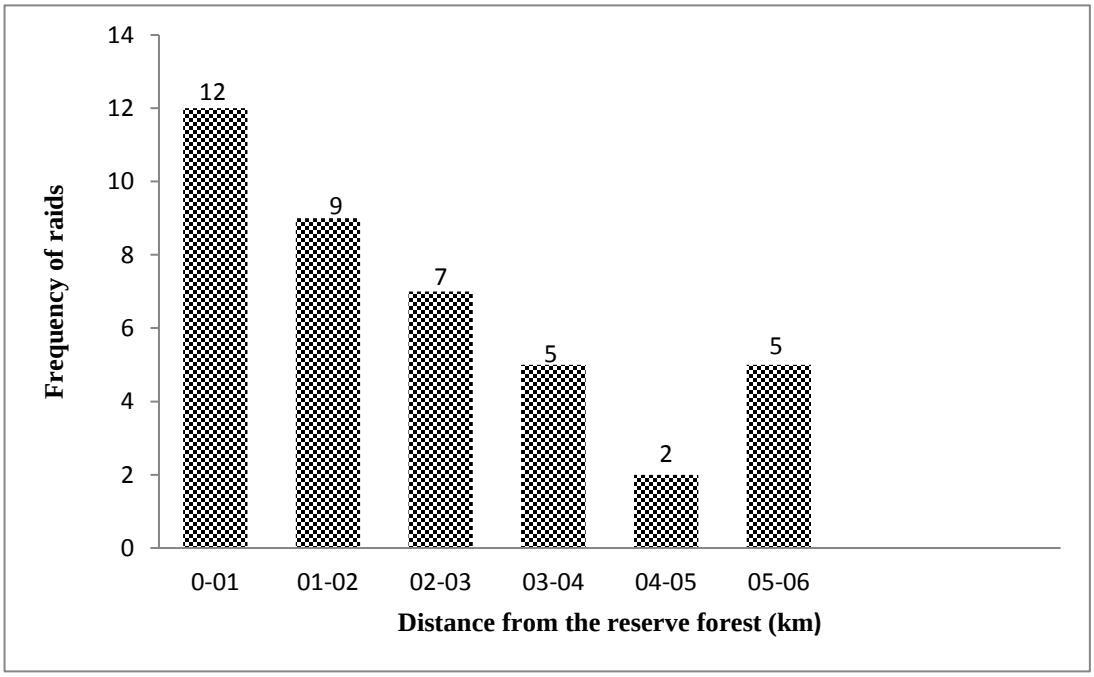

Fig. 12. Effect of distance from the forest on crop damage

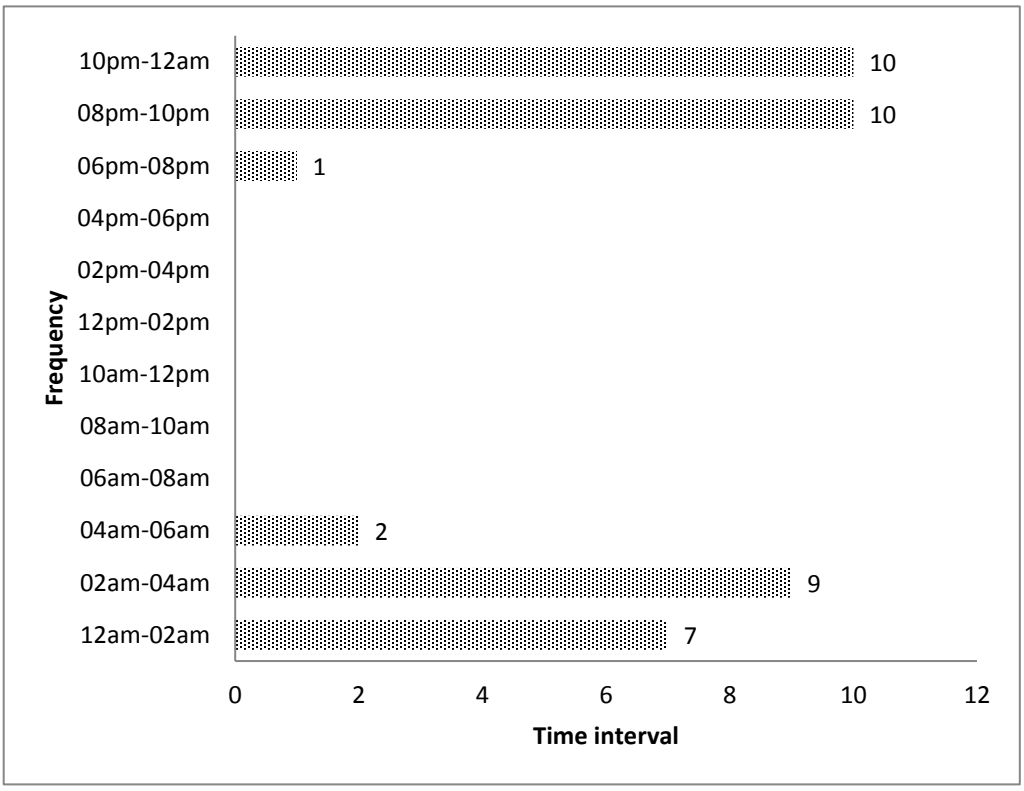

Fig. 13. Occurrence of crop damage during different time period of the day

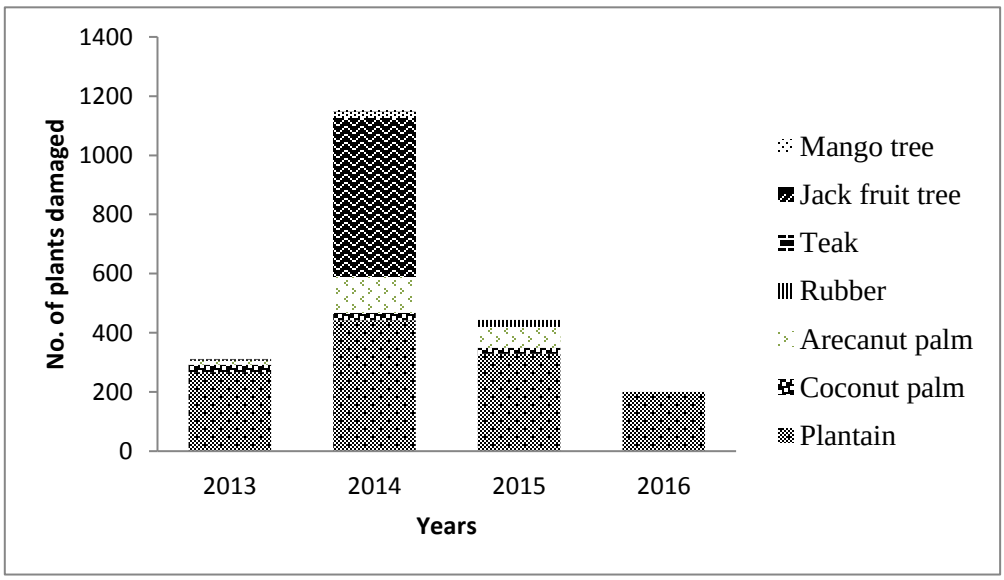

Fig. 14. Intensity of crop damage by elephants over the years

3.1.2 Wild pig (*Sus scrofa* Linnaeus)

This species is showing a cosmopolitan distribution, including different types of plantation and agricultural areas even though it was far away from the forest fringes. It is a nocturnal feeder primarily feeding on the underground root and rhizome of the crops. Damage to the agricultural crop was recorded from all the five Forest Ranges namely Kalikavu, Karulai, Nilambur, Vazhikadavu and Edavanna (Table 05). Highest damage was recorded from Nilambur followed by Edavanna, Vazhikadavu, Kalikavu and Karulai (Fig.15). The most severely targeted crop species were plantain and coconut. The highest damage to plantain was recorded from Nilambur Range and the highest damage to fallen coconuts was recorded from Vazhikadavu Range. The rhizome of the plantain and tubers like tapioca, Colocasia were consumed by trampling the plant by using its tush and snout (Plate 7). The coconuts were consumed by removing the mesocarp and endocarp and feeding on the endosperm, it removed the mesocarp exactly like the human beings which is considered as an indirect sign of wild pig in the field (Plate 8). As this species prefers an omnivorous diet, it feed on soil organisms by grubbing the soil and this mode of attack was recorded from the paddy fields and while searching the earthworms, it damaged the paddy also.

Table 05. 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

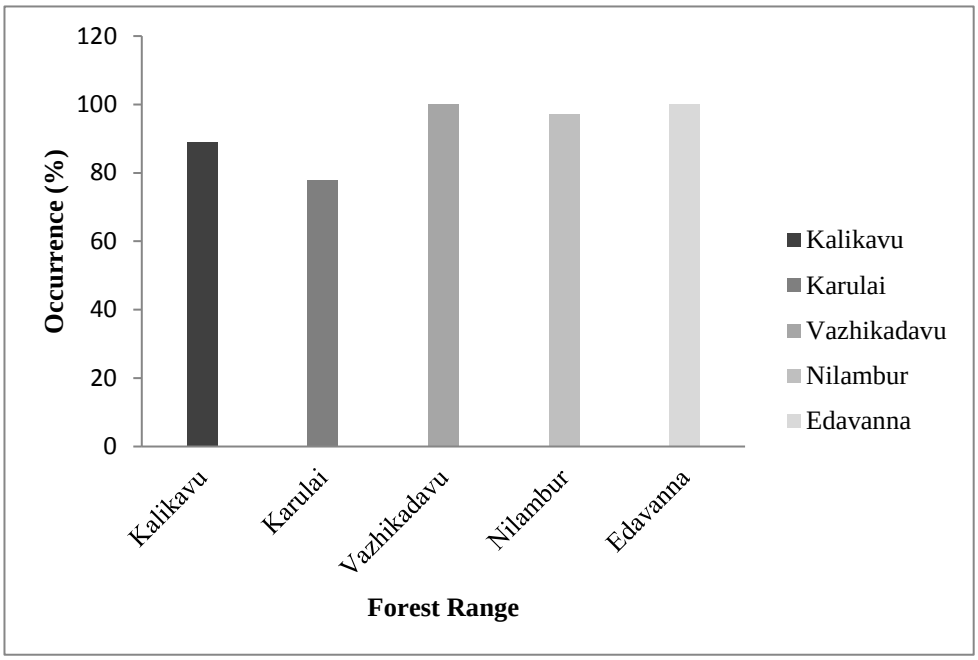

Fig. 15. Crop damage by wild pig in various forest ranges

3.1.3 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 06). The highest crop damage was recorded from Edavanna Forest Range followed by Karulai, Vazhikadavu and Kalikavu (Fig.16). Severe damage was recorded to the coconut plantation both as consuming the fallen coconuts and by debarking the basal portion of coconut palms. The fallen coconuts were consumed by removing the mesocarp and endocarp and then consuming the endosperm (Plate 9). Occasionally it was seen to carry the coconuts into the forest for consuming. As the Indian crested porcupine belongs to the order Rodentia they remove the mesocarp by sharp edges with uniform size, which was considered as the indirect sign of porcupine in the field. The debarking behavior of porcupine on the rubber plants and consumption of newly formed bamboo culms were also recorded from the Edavanna forest range. Govind and Jayson (2014) have reported the mode of coconut damage by Indian crested porcupine from Thrissur, Kerala.

Plate 6. Plantain damaged by Asian elephant

Plate 7. Plantain damaged by Wild pig

Plate 8. Coconut mesocarp removed by Wild pig

Plate 9. Mesocarp of coconut removed by Indian crested porcupine

Plate 10. Coconut damaged by Bonnet macaque

Table 06. 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

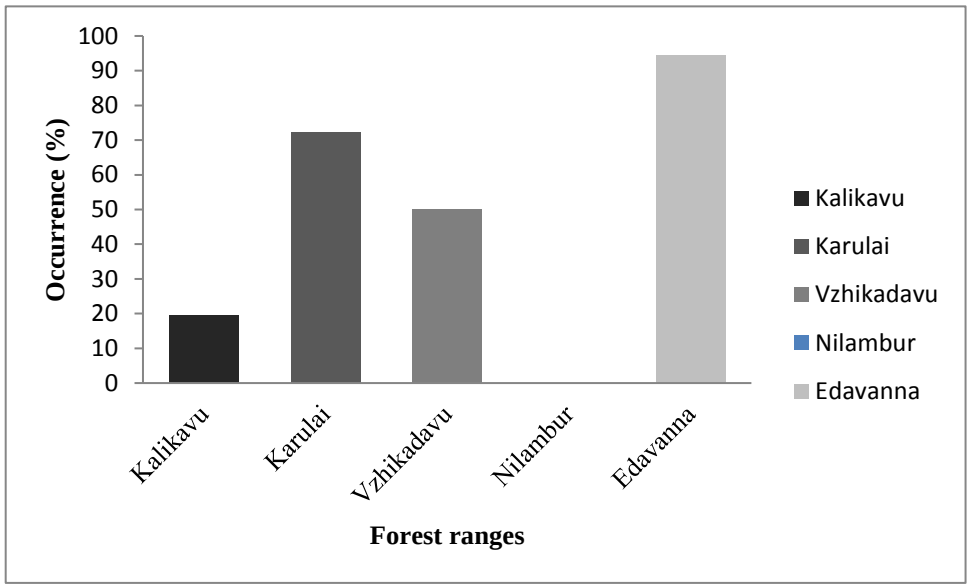

Fig. 16. Incidence of crop damage by Indian crested porcupine in various ranges

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

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

Sl. No.	Species	Relative dominance	Relative density
1	*Artocarpus hirsutus*	2.708	8.553
2	*Bauhinia racemosa*	0.047	0.658
3	*Bambusa bambos*	0.665	1.316

4	*Holigarna arnottiana*	5.301	1.974
5	*Xylia xylocarpa*	30.779	32.237
6	*Hopea ponga*	6.708	4.605
7	*Terminalia chebula*	0.312	0.658
8	Unidentified	1.453	1.974
9	*Wrightia tinctoria*	0.769	1.316
10	*Sageraea laurina*	4.462	5.921
11	*Cassia fistula*	0.457	1.316
12	*Strychnos nux-vomica*	4.158	1.316
13	*Swietenia macrophylla*	3.791	1.316
14	*Terminalia paniculata*	11.841	17.763
15	Unidentified	2.353	1.316
16	*Alstonia scholaris*	0.019	0.658
17	*Mallotus philippensis*	2.533	3.289
18	*Terminalia bellirica*	14.184	7.895
19	*Dalbergia latifolia*	4.703	3.289
20	*Terminalia cuneata*	0.841	1.316
21	*Lagerstroemia microcarpa*	1.917	1.316

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

Sl. No.		**Relative dominance**	**Relative density**
1	*Lannea coromandelica*	18.259	2.632
2	*Xylia xylocarpa*	24.854	40.789
3	Unidentified	1.789	1.316
4	*Sageraea laurina*	4.117	11.842
5	*Cassia fistula*	0.321	1.316
6	*Strychnos nux-vomica*	7.569	5.263
7	*Terminalia paniculata*	37.495	27.632
8	*Briedelia retusa*	0.397	1.316
9	*Alstonia scholaris*	0.098	1.316
10	*Calophyllum calaba*	4.166	1.316

11	*Terminalia bellirica*	0.613	2.632
12	*Mitragyna parvifolia*	0.223	1.316
13	*Dalbergia latifolia*	0.098	1.316

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

Sl. No.	**Species name**	**Relative dominance**	**Relative density**
1	*Spondias pinnata*	4.097	0.658
2	*Artocarpus hirsutus*	0.154	0.658
3	*Ficus racemosa*	6.631	1.974
4	*Bambusa bambos*	0.102	0.658
5	*Grewia tillifolia*	13.643	11.842
6	*Santalum album*	0.102	0.658
7	*Mallotus philippensis*	0.347	1.316
8	*Holigarna arnottiana*	0.962	0.658
9	*Xylia xylocarpa*	6.840	11.842
10	*Wrightia tinctoria*	0.385	1.974
11	*Sageraea laurina*	0.481	1.974
12	*Cassia fistula*	0.471	1.316
13	*Strychnos nux-vomica*	0.677	1.316
14	*Elaeocarpus serratus var.serratus*	2.948	0.658
15	*Terminalia elliptica*	2.176	2.632
16	*Persea macrantha*	2.948	0.658
17	*Terminalia paniculata*	24.650	31.579
18	*Ailanthus triphysa*	2.162	2.632
19	*Briedelia retusa*	0.376	0.658
20	*Miliusa tomentosa*	0.472	0.658
21	*Hydnocarpus pentandra*	1.867	2.632
22	*Butea monosperma*	0.094	0.658
23	*Macaranga peltatta*	4.409	2.632
\24	*Stereospermum colais var.colais*	1.221	1.316

25	*Schleichera oleosa*	0.677	2.632
26	*Calophyllum inophyllum*	2.325	1.316
27	*Tectona grandis*	1.016	1.974
28	*Terminalia bellirica*	1.986	1.974
29	Unidentified	1.819	0.658
30	*Sapindus trifoliatus*	0.117	0.658
31	*Albizia lebbeck*	6.019	0.658
32	*Dalbergia latifolia*	3.278	1.974
33	*Terminalia cuneata*	2.494	3.289
34	*Lagerstroemia microcarpa*	2.047	1.316

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

Sl. No.	Species name	Relative dominance	Relative density
1	*Glochidion zelylaniumVar.zeylanicum*	0.103	3.289
2	*Holigarna grahamii*	1.621	4.605
3	*Ricinus communis*	0.099	0.658
4	*Tetrameles nudiflora*	0.340	0.658
5	*Xylia xylocarpa*	3.068	3.947
6	*Hopea ponga*	0.621	0.658
7	Unidentified	0.224	0.658
8	*Anogeissus latifolia*	0.033	1.316
9	*Terminalia elliptica*	2.356	1.316
10	*Melia azedarach*	0.011	0.658
11	*Persea macrantha*	8.551	5.263
12	*Gmelina arborea*	0.034	0.658
13	Unidentified	0.004	0.658
14	*Terminalia paniculata*	9.597	6.579
15	*Zanthoxylum rhetsa*	0.696	3.289
16	*Bombax ceiba*	3.193	0.658

17	*Hydnocarpus pentandra*	11.796	21.711
18	*Lophopetalum wightianum*	2.061	2.632
19	*Alstonia scholaris*	2.884	3.289
20	*Butea monosperma*	0.044	0.658
21	*Kydia calycina*	5.593	0.658
22	*Stereospermum colaisVar.Co*	8.673	6.579
23	*Schleichera oleosa*	7.502	6.579
\24	*Calophyllum inophyllum*	9.187	5.263
25	*Mallotus philippensis*	0.034	0.658
26	*Tectona grandis*	4.848	3.947
27	*Grewia tiliifolia*	2.016	1.974
28	*Terminalia cuneata*	0.103	1.316
29	*Trewia nudiflora*	0.343	1.316
30	*Dalbergia latifolia*	1.975	1.974
31	*Syzygium salicifolium*	2.922	3.289
32	*Pterocarpus marsupium*	1.587	0.658
33	*Lagerstroemia microcarpa*	8.280	2.632

The result showed that natural vegetation exists in the area without much disturbance to the plant community.

3.2 Economic loss

Eight species of crops were damaged by 5 species of wild animals in the District. The method of calculating the economic loss is described in the methodology part. The price of the crops varied during the period of the study and this was collected from the Farm Information Bureau, Kerala (Table 11).

Table 11. Market price of different crops

Sl. No	Cash crops	Market price (Rs) (Mean ± SD)
1	Coconut	8.096 ± 1.523 per nut

2	Areca nut	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

3.2.1 Asian elephant

The economic loss due to Asian elephant in the District was calculated from the potential value of perennial crops (Table 12). Asian elephant mainly damaged the perennial crops (coconut tree, arecanut tree and rubber) and plantains. Elephant did the crop damage for Rs.22,17,363/-per annum in the District (Table 13).

Table 12. 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	21803.40
					Secondary stage	20 – 32	10901.70
2	Coconut tree	60	80 coconuts	Immature phase		0 – 9	75.00
				Productive phase	Primary stage	10 – 34	32,384
					Secondary stage	35 – 60	16,192
3	Areca nut tree	20	16 kg of nut	Immature phase		0 – 5	15.00

	Productive phase	Primary stage	6 – 13	33400.8
		Secondary stage	14 – 20	16700.4

Table 13. Economic loss due to Asian elephants in the Malappuram District

Sl. no.	Forest range	Loss of coconut/ annum (Rs.)	Loss of areca nut/annum (Rs.)	Loss of plantain /annum (Rs.)	
				Nendra	Palayamthodan
1	Kalikavu	3,13,095.33	6,45,788.80	27,624.75	4134.40
2	Karulai	2,59,097.00	6,95,905.00	27,256.42	6092.80
3	Vazhikadavu	1,07946.67	44,534.40	59,792.24	8921.60
4	Edavanna	16192.00	-	982.21	-

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3.1.2 Wild pig (*Sus scrofa* Linnaeus)

Wild pig caused huge loss of the plantain and coconut farmers in the District with 88.83 per cent of economic 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. Mean economic loss was estimated as Rs.15793.82/-per ha per annum (Table 14).

Table 14. Economic loss due to wild pig

Sl. no.	Forest Range	Crop and economic loss		
		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

3.1.3 Indian crested porcupine (*Hystrix indica* Kerr)

The mean economic loss by Indian crested porcupine in the District was Rs.1322.35/- per ha/annum and the highest damage was recorded from Edavanna Forest Range followed by Karulai, Vazhikadavu and Kalikavu (Table 15).

Table 15. Economic loss due to Indian crested porcupine

Sl. no.	Forest Range	Crop and economic loss		
		Coconut Ha/annum	Plantain Ha/annum	
			Nendra	Palayamthodan
1	Kalikavu	364.32	-	-
2	Karulai	1416.80	-	-
3	Vazhikadavu	580.21	-	-
5	Edavanna	2928.05	-	-

3.2.4 Bonnet macaque (*Macaca radiata* Geaffroy Saint-Hilaire)

The bonnet macaque (*Macaca radiata*) is an endemic primate to southern India and is listed as least concern species under IUCN red list. It is a great menace to agricultural crop due to its behavior of crop raiding in troops of large numbers. The crop raiding occurred throughout the day but mostly in the morning and late evening hours. The highest loss of coconuts due to bonnet macaque was recorded from Kalikavu Forest Range followed by Edavanna in which the mean loss of 8 nuts per tree, as recorded from Kalikavu Forest Range (Fig.17). 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 (Table 16 & 17). The only targeted species of crop by bonnet macaque in the District was coconut palms (Plate 10).

Table 16. Economic loss due to bonnet macaque and hanuman langur.

Sl. no.	Forest Range	Species	Crop and economic loss		
			Coconut Ha/annum	Plantain Ha/annum	
				Nendra	Palayamthodan
1	Kalikavu	Bonnet macaque	11,239.95	-	-
		Hanuman langur	4412.32	-	-
2	Edavanna	Bonnet macaque	877.07	-	-

Table 17. 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

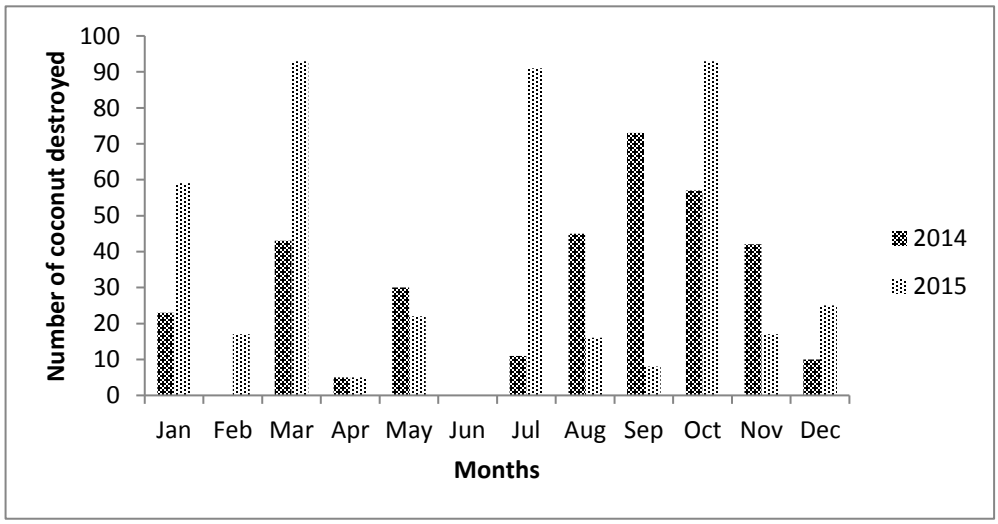

Fig. 17. Coconut damage by *Macaca radiata* from Kalikavu Forest Range (2014-2015)

3.3 Case studies

3.3.1. Wild pig rabies

The attack of wild pig on human beings is a rare incident in the area. In a rare incident a wild sow first appeared in a house near a teak plantation on 06/07/2014, where it damaged vessels and other house hold materials including the dress hanging outside. On its journey of 6 km from the forest through 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 (Plate 11). He was on his way to home from 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 (Plate 12). The mad sow charged him without any provocation and he lost one of the fingers from the left hand and also he got injured on his right hand while he was trying to take out his fingers from the mouth of the pig. His wife Mariyakutty also got severely attacked by the pig on her buttocks, legs and hands while she was trying to get rid of the animal from the hand of her husband. Based on the apple green florescence by conducting fluorescent antibody test the rabies case was confirmed by the Department of Pathology, College of Veterinary and Animal Sciences, Mannuthy, Thrissur. FAT is considered as golden standard for the diagnosis of rabies as it is more sensitive (Daly *et al.*, 2014). All the three persons were provided with anti-rabies vaccination and the hospital charges were paid by 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 diseases between wild and domestic animals (Nair and Jayson, 2016 b). Ten cases of human casualties by wild pig were reported from the Dstrict (Fig.18).

3.3.2. Gaur (*Bos gaurus*)

Mayilumpara and Mullapally were the places coming under Karulai and Kalikavu Forest Ranges and close to Karulai reserve forest. A gaur intruded into the human habitations of Mayilumpara and Mullapally ($11^0$16’20.7” N and $076^0$18’16.7” E) at 6.30 am and the people sited the gaur in the rubber plantations close to the reserve forest. A group of people with their maximum effort tried to prevent its entry into the area of human settlements, but the presence of people made the gaur out of its control and it became aggressive and began to run amok which

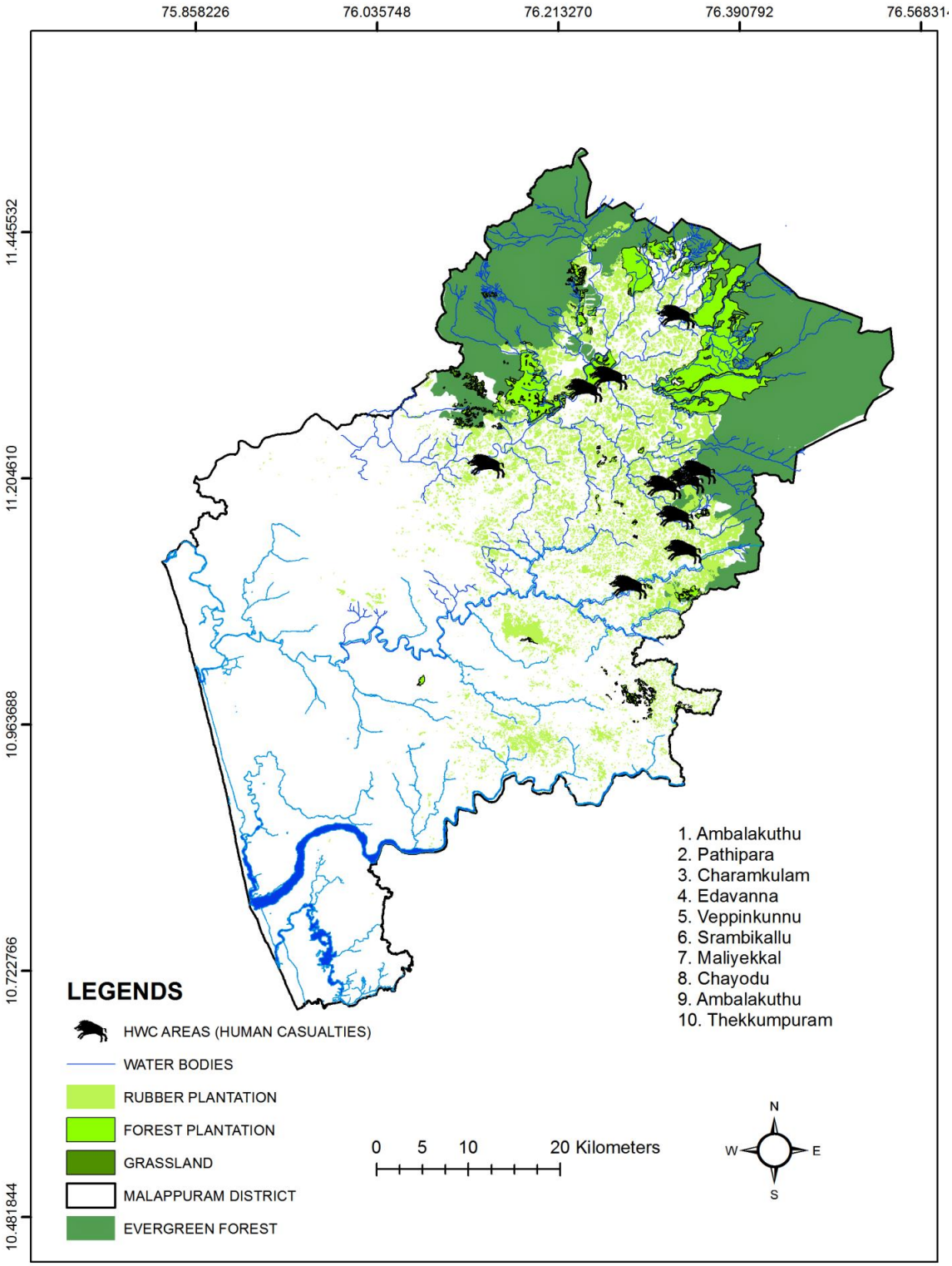

Fig. 18. Location from where human-wild pig encounters recorded

Plate 11. Wild pig bite on the hand

Plate 12. Human Casualty by Wild pig

ultimately caused damage to the wall and door of a house, bike, and cattle pens. It also attacked three local people and one of them was seriously injured and underwent urgent surgery. The gaur used most of its time to stand in front of its domestic partners like cow and buffalo. Due to the presence of crowd around the gaur, the situation became worst and the officials were compelled to shoot the gaur with the help of local police (Plate 13).

3.3.3. Cattle-lifting

Leopard and wild dog were responsible for the six cattle lifting incidences reported from the District. One leopard was trapped from Mulliyarkurussi (76.22841E 11.01403N) by Kerala forest and wildlife department when it was out for cattle-lifting (Plate 14). The five incidences were recorded from Kalikavu and one from Vazhikadavu Forest Ranges (Fig.19) and (Table 18). Cattle lifting and human casualties in Kerala during nineties were reported earlier by Veeramani *et al* (1996).

Table 18. Cattle lifting incidences during the period of study.

Sl. no.	Location	Predator involved	Prey animal	Distance from the forest (m)
1	Kuruniyambalam	Leopard	Calf	350
2	Vallipoola	Leopard	Goat	150
3	Mulliyarkurussi	Leopard	Cattle	13000
4	Arnadampadam	Leopard	Goat	120
5	Kalkundu	Wild dog	Goat	800
6	Venghaparutha	Leopard	Goat	0

3.4. Control measures

Many traditional control measures were used by the people to protect the crop from wildlife damage (Table 19) (Plate 15& 16). An evaluation of crop protection methods employed in Kerala were reported earlier by Veeramani *et al.* (2004 c).

Table 19. 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	Spot light	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

3.4.1. Honey Bee fence

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 (Table 20). In all the other encounters, the elephants tried to avoid the honey bee fence by choosing a different way of entry. Every elephant encounter happened at night, which means the guarding bees were active even at night in the presence of elephants. The buzzing sounds of the bees itself kept the elephant away from the honey bee fence. With the previous experience of honey bee strikes from the forest they avoided the honey bee fence.

Plate 13. Gaur death at Mayilumpara (Karulai Forest Range)

Plate 14. Leopard trapped at Mulliyarkurussi

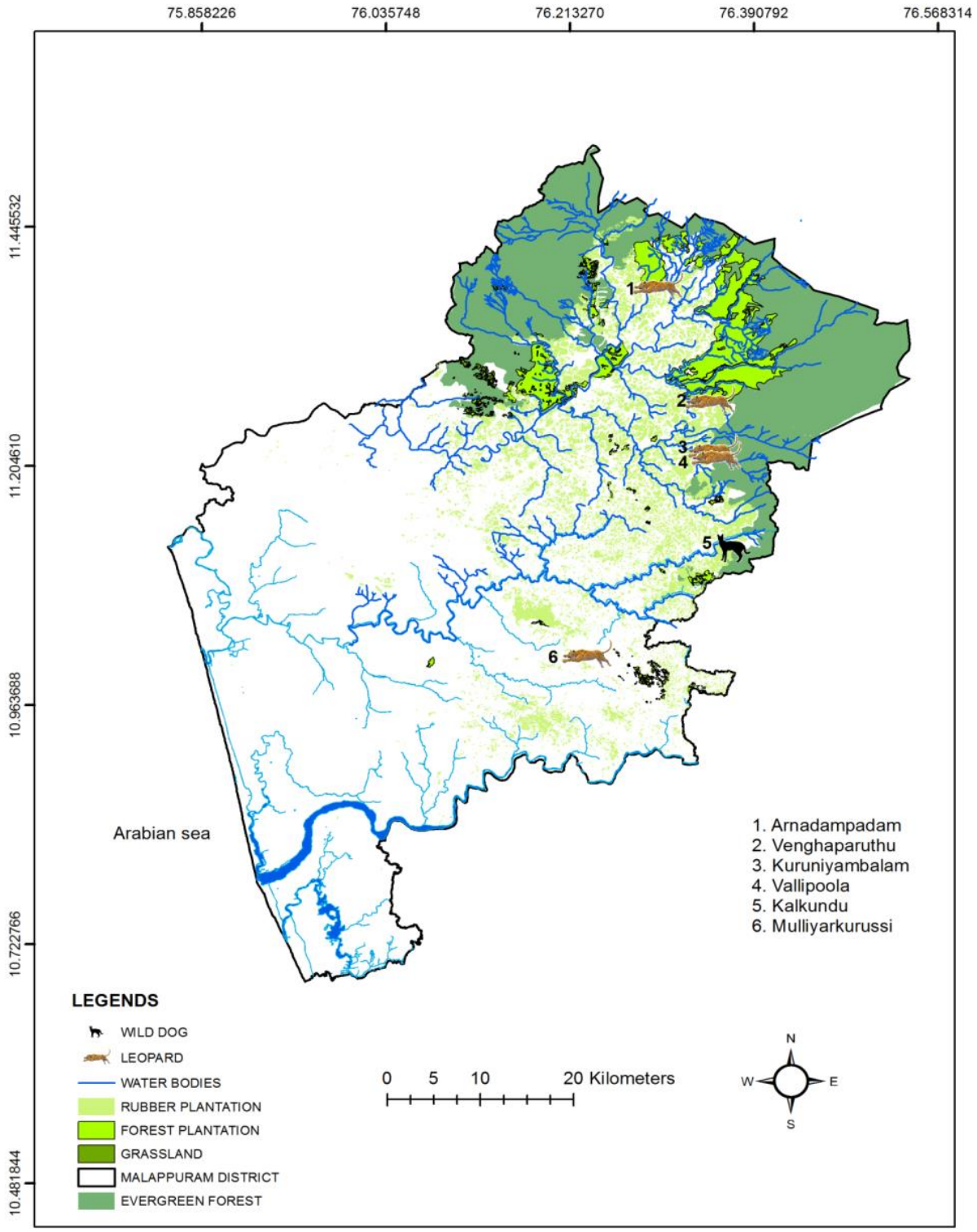

Fig.19. Areas from where cattle-lifting incidences reported

Plate 15. combination of traditional control measures

Plate 16. Plastic cover fence against Wild pig

Seventy per cent of the encounters were made by solitary male elephant, locally called as "Ottakomban", which is a habituated crop raider in the area. No elephant herds were recorded from the area as crop raiders or intruders in to the human habitats.

After three months of installation, beehive fence showed a wide range of acceptance among the farmers living in the forest fringe areas as it is practically applicable and economically beneficial (Plate 17, 18 & 19). Kerala forest and wildlife department also installed another set of beehive fence at Panichola under Karulai Forest Range by using 10 beehives on demand of the people, which was 2 km away from our experimental site. It is an integrated approach, so that honey is extracted and some revenue is available from the sale of honey. Approximately 15 kg of honey was extracted from eighteen beehives in the experimental site at a time (Nair and Jayson, 2016 a).

Table 20. 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	11/9/2014	Non fenced	6	Arecanut , rubber	3	10.00 pm
12	12/9/2014	Non fenced	3	Arecanut , rubber	3	11.00 pm
13	19/10/2014	Fenced	3	Pineapple	1	03.00pm
14	10/11/2014	Fenced	4	Pineapple	4	09.00pm

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 from the beehives by anti-social elements was another management problem and in the rainy months constant attention is needed to provide artificial food at least for twenty days, interval. In the current social scenario of the State, the maintenance of honey bee fences will be difficult.

3.4.2. Yellow colored cloth

Yellow colored cloth is an effective mitigation measure to deter the crop raiding animals like wild pig and Indian crested porcupine (Plate 20)**.** The innovative method was observed as the traditional practice by the farmers in the Kalikavu Forest Range of Nilambur South Forest Division (Plate 21). 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 is protected by the yellow colored cloth.

3.4.3. Bio-repellent (Trump guard)

GCMS analysis of Bio-repellant “Trump guard” extracted in chloroform was found to have 22 volatile compounds. Most of the compounds identified are 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.

കാട്ടാനകളെ തുരത്താൻ കെനിയയിൽ നടപ്പാക്കിയ തേനീച്ചക്കൂട് വേലി സംസ്ഥാനത്തും പരീക്ഷിക്കുന്നു

നിലമ്പൂർ വനമേഖലയിൽ കരുളായിക്കടുത്ത് മൈലംപാറയിൽ തേനീച്ചക്കൂട് വേലി സ്ഥാപിച്ചു

എന്തിനും തയാറായി തേനീച്ചക്കൂട്ടം; ഇനി എന്തു 'കാട്ടാന'...

ജോമിച്ചൻ ജോസ്

Plate 17. Paper news about Beehive- fencing

ആനകളെ തുരത്താൻ തേനീച്ചകളെക്കൊണ്ട് വേലികെട്ട്

മുജീബ് പുള്ളിച്ചോല

Plate 18. News about beehive-fencing

കാട്ടാനയെ അകറ്റാൻ തേനീച്ചക്കൂട് വേലി; പ്രതീക്ഷയോടെ കർഷകർ

Plate 19. News about beehive-fencing

Plate 20. Yellow cloth fence at Kalikavu Forest Range

Plate 21. Yellow cloth fence at Kalikavu Forest Range

The field trail result showed that natural repellent "trump guard" is 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 the all 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.

3.5 Conservation attitudes

The conservation attitude of the farmer community in the Malappuram District was assessed with the help of questionnaires as described in the method. It is very important to understand their opinion and thinking as well as the magnitude of the human-wildlife conflict to solve or mitigate the human- wildlife conflict as it is a social need (Plate 22).

Three hundred households were surveyed from twenty five Panchayaths in the District (Table 21). The maximum 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%) and the remaining (4.67%) were clustered (less than 10 m apart distance).

Table 21. Panchayaths surveyed from different Forest Ranges

Sl.no.	Forest Ranges	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

Demography: Both males and females responded to the structured questionnaire survey and the age limit was between 18-80 years and all of them were permanent residents of the area. Educational status revealed that 10.7 per cent of the respondents attended lower primary school and 31per 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. Ninety five per cent of the respondents depended on open well as their source of drinking water.

Crop damage: Fifty nine per cent of the respondents reported wild pig as the major crop damaging species followed by monkey (8%), elephant (4.3%) and porcupine (3%). Twenty eight per cent reported that they have no damage from wild animals. Forty per cent and above crop damage was reported by 52.1 per cent of the respondents. Most of the respondents (68.3%) were unaware about the ex-gratia paid by the Kerala forest and wildlife department for the crop loss by wild animals and only 3 per cent received any compensation for their crop loss.

Cattle-lifting: Around 43.33 per cent of the respondents had livestock in their house, out of which 28.33 per cent depend 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%) (Plate 23). Leopard attack on cattle was recorded from Kalikavu and Vazhikadavu Forest Ranges. Presence of wild dog as predator was recorded from Kalikavu Forest Range. Two human-casualties by vehicle colliding with wild pig were reported in the questionnaire survey.

Plate 22. Elephant death at Vazhikadavu Forest Range

Plate 23. Leopard attack on goat

4. DISCUSSION AND RECOMMENDATIONS

Five species of wild animals are damaging crops in Malappuram District and they are Asian elephant, wild pig, Indian crested porcupine, bonnet macaque and hanuman langur. Asian elephant did the highest crop damage (Rs.22,17,363.63/-per annum). Wild pig and Indian crested porcupine are distributed in all Forest Ranges. Mean economic loss caused by the above two species is estimated as Rs. Rs.15,793/- per ha per annum and Rs.1322/- per ha per annum respectively. Highest activity of Indian crested porcupine was recorded in Edavanna Forest Range. Bonnet macaque was another major species responsible for huge loss to the coconut farmers in the District and an amount of Rs.12,791.67/- per ha per annum of mean economic loss was estimated from the District.

Beehive fencing is an innovative mitigation measure used against crop raiding elephants which is effectively employed in African countries and it is proved that it is a very good short term control measure in Kerala also. The African bee *Apis mellifera scutellata* is selected for making the beehive fence in the African countries which is more aggressive and venomous than the other bee species and is a subspecies of the Western honey bee and that can be replaced by the indigenous species *Apis cerana* which is less aggressive in nature but commonly used here for apiculture. It is a low cost and more dependable mitigation measure for the farmers in the forest fringes which can yield economic benefit too. Approximately 15 kg of honey was extracted from eighteen beehives in the experimental site at a time and there by the farmers can manage the maintenance of the fence with the generation of an extra income. This innovative method can be popularized with the help of Kerala forest and wildlife department. On social side, the problems faced in managing the honey bee fences are described in the result section.

As the human-wildlife encounters were highly published by the newspapers and visual media, all such incidents occurred were reported prominently with photographs in the newspapers and visual media. Awareness on wildlife laws was excellent among the local people and their attitude towards the wildlife species has changed. Crop damage by wild animals is a reality and humans have to live with this problem as happened in the yester years. Crop damage is happening depending on the crop pattern and the location of the agricultural fields. Accurate population assessment of wild animals like Asian elephant, wild pig, Indian crested porcupine, sambar, gaur, hanuman langur and bonnet macaque is a must to evolve management options. The

mitigation measures are of two ways-short term measures and long term measures. Short term measures include construction of electric fences with energizers in problem areas. Local communities should be advised to avoid planting cash crops in the fringe areas of the forests. Sanctioning of subsidy and bank loans to the farmers for constructing preventive measures against crop raiding animals is to be initiated. Steps must be initiated to release the compensation within a reasonable time limit. Long term measures are (1) relocating the isolated villages within the forest areas to outside (2) Establish corridors for elephant movement.

Compensation for damage due to wildlife is not a permanent solution to the problem. However, timely action for compensating the loss will help in building up support to the conservation efforts.

4.1 Suggestions

1. Continuous monitoring and effective intervention from the Kerala forest and wildlife department is needed to drive away elephants raiding the crops. The places in which the elephant encounters were rampant were marked in the map. This is needed as traditional wisdom and cooperation among the farming community to drive away elephants is not seen in the present generation.
2. The monkey menace in the Kalikavu Forest Range which results in an economic loss of Rs.11,914.61/- per ha per annum should be addressed properly. The mitigation measures like translocation and sterilization of primate population in and around the farmland is urgently needed.
3. Awareness programs and meetings should be conducted by the respective forest ranges at least twice in six months with the participation of Forest officials, farmers and media in the District to increase the communication between them and to encourage a participatory approach in the mitigation of crop raiding animals.
4. Wild pig caused a mean economic loss of Rs.15,793.82/-.per ha per annum and 10 severe human casualties in the District. As the problem is serious, care should be taken to avoid the inhabitance of wild pig outside the forest areas and should be removed.
5. 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 of defence" in the fringe areas.

6. Data from the questionnaire survey revealed that 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.
7. Strict instructions should be given to the farmers 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.
8. Beehive fencing is an innovative mitigation measure used against crop raiding elephants which is effectively employed in African countries and it is proved that it is a very good short term control measure in Kerala also. It 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.
9. Radio collaring of the habitual crop raider (Ottakomban), which is responsible for around 40 per cent of crop loss by elephant in the study area is recommended for the proper monitoring of its movement within and outside the forest areas.
10. Cattle grazing in the forest fringe areas during the evening hours should be avoided and also the cattle should be kept inside the closed cages to reduce the cattle lifting incidences by carnivores in the villages sharing the boundary with forest.
11. Selected locations of the study area where continuous watch and ward monitoring/ electric fence needed to prevent the entry of elephant into the human settlements and crop field are described below.

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

b). **Mayilumpara-Unnikulam** : A six 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 crop lands.

c). **Munadi** : In this location agricultural areas directly shares 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 were high. A stretch of four km defence is essential there to keep the elephant 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 seven km should be kept under watch & ward to restrict the entry of elephants into the agriculture fields.

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7. APPENDICES

Appendix-1 GCMS Result of Trump guar

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

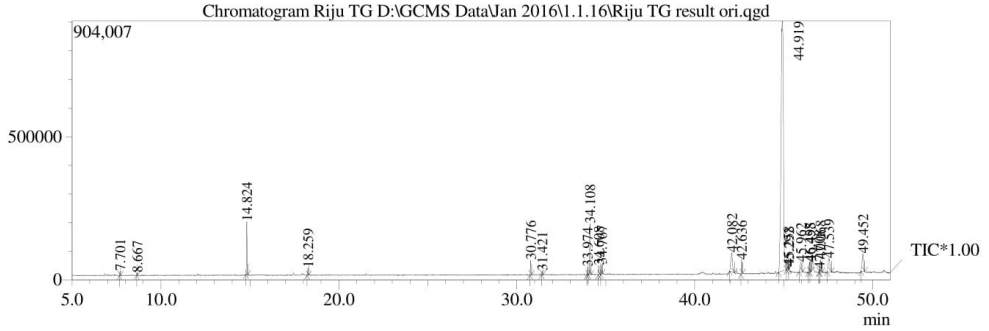
Method

===== 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
If(100.0!=)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	3231947	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	33430	3-OXABICYCLO[5.1.0]OCTANE, 5,5-DIMETHYL-4-(3-METHYL-3-BUTENYLIDENE)-2-METHYLENE-, CIS-(.+-.)-	218.15
46.458	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
	353757	831444		

Appendix-2 Questionnaire 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?