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(FINAL REPORT OF THE RESEARCH PROJECT KFRI/552/08)

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ABSTRACT OF THE PROJECT PROPOSAL

1. Project No. : KFRI/552/08

2. Title of Project : Assessment of crop damage by wild animals in Trichur District, Kerala.

3. Objectives :

   1. To assess and estimate the extent of crop damage by wild animals in the Trichur District.

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

4. Date of commencement : August 2008

5. Scheduled date of completion : March 2012

6. Funding agency : Plan Funds

7. Project Team

   Principal Investigator : Dr. E. A. Jayson

   Associate Investigator : Nil

   Research Fellow : Suresh K. Govind

8. Study area : Trichur District

9. Duration of study : 3 Years

10. Project budget : Rs. 8 Lakhs

CONTENTS

ABSTRACT

A study on assessment of crop damage by wild animals was conducted in Thrissur District, Kerala, India, from April 2009 to March 2012. The objectives of the study were 1. To assess and estimate the extent of crop damage by wild animals in the Trichur District. 2. To suggest suitable remedial measures to reduce and prevent the crop damage by wild animals. Study area consisted of three Forest Divisions and nine Forest Ranges. Methods involved were collection of field data from quadrates, observational studies in the field, field trials of control measures, experimental trials to assess paddy loss, questionnaire survey and collection of data from the records of Kerala Forest Department. Field data was collected using quadrates (10 m x 10 m) taken randomly in the eight Forest Ranges. Crop damage incidences were recorded from quadrates in each month (n=36) and the species of crops damaged was quantified. Enquires were also made among the farmers near the quadrates to confirm the species of crop raiding animals. Case studies were carried out for large herbivores, as they were not recorded from the quadrates. Observational studies were carried out on Indian giant squirrel to quantify the damage to coconuts. A field experiment was carried out at Chulannur, Thrissur to quantify the loss of paddy due to Indian peafowls.

Seven species of wild animals namely Asian elephant (*Elephas maximus*), wild pig (*Sus scrofa*), Indian crested porcupine (*Hystrix indica*), Indian giant squirrel (*Ratufa indica*), Indian peafowl (*Pavo cristatus*), bonnet macaque (*Macaca radiata*) and sambar (*Rusa unicolor*) were damaging the crops. During the study period, Asian elephant did the highest damage (Rs. 17,35,625/- per annum), followed by wild pig (Rs. 3,736/- per ha per annum) and Indian crested porcupine (Rs. 615.47/- per ha per annum). The damage occurred in the immediate fringe areas of the forest (n=9) and up to 100 m from the forest boundary (n=9). The seasonality of elephant raids is found to be coinciding with the period of crop ripening. Wild pig was distributed in all the Forest Ranges and was active in the cultivated land throughout the year. It fed on coconuts (n=296) followed by plantains (n=33) and tubers. Indian crested porcupine consumed coconuts (n=150) and debarked the basal portion of the coconut trees and this damage was highest in Vellikulangara Forest Range.

Feeding of Indian giant squirrel on coconut is reported for the first time and this behaviour was recorded in the Forest Ranges adjacent to Wildlife Sanctuaries. Highest damage was documented in the Peechi Forest Range (Rs. 3,528/- per annum), followed by Machad (Rs.

3,009/- per annum) and Palapilly (Rs. 205/- per annum). Mean economic loss per annum was estimated as Rs. 2,247/-. Though the availability of food within the forest was sufficient, coconut trees in the forest fringes lured this species to coconut plantations. The mode of consumption of coconut was by making a hole into the endocarp after removing the mesocarp. The opening had a circumference in the range of 19±4 cm (n=150). Consumption of coconuts was highest in the Peechi Forest Range (4.6±2.2nuts/tree/month) followed by Machad (2±1.02nuts/tree/month) and Palappilly (0.46±0.44nuts/tree/month) Forest Ranges. Indian peafowl did extensive damage on the paddy near the Chulannur Peafowl Sanctuary. Loss of paddy was estimated as Rs. 16,615.45/- per ha. The species preferred paddy followed by vegetables and its presence in the crop field was reported only from Wadakkencherry Forest Range. Consumption of paddy (1466.5±247.31 kg/ha) reached high near the Sanctuary area.

Solar electric fence is a good control measure for all herbivores, if it is properly maintained. Yellow-coloured plastic sheet is an innovative control measure for the frequent crop raiders like wild pig, Indian crested porcupine and sambar. Efficacy of the chilli-rope and chilli-brick were evaluated, which were already proved successful in African conditions. Chilli-rope is found to be an effective short term remedial measure to prevent elephants from entering crop fields in the tropical monsoon condition. Burning of chilli-brick was not an effective control measure due to the unexpected encounter of elephants in the crop field. Marginal farmers are facing severe economic loss due to crop damage by wild animals in the District. Asian elephants did the crop damage in different grama panchayaths namely Athirapilly (51.2%), Kodassery (18.4%), Panacherry (11.7%), Varandharapilly (10.6%) and Puthur (7.9%). Wild pig was rampant in the crop fields and the raiding of crops was reported high in different grama panchayaths namely Panacherry (41%), followed by Thekkumkara (12%), Chelakkara (11%) and Madakkathara (9%) grama panchayaths. Highest crop damage by Indian crested porcupine was recorded from Mattathur grama panchayath (34%), followed by Kondazhy (23%), Erumapetty (21%) and Kodassery (17%) grama panchayaths.

As the market price of the rubber increased, farmers were trying to cultivate even in the remote areas with rubber, intermixed with plantains. This has put considerable pressure on wild areas lying adjacent to forest and the tendency to encroach the forest land was severe. This trend is triggering increased human-elephant interaction in the District.

1. INTRODUCTION

Human-wildlife conflict (HWC) is creating growing concern in the Western Ghats of Kerala as in other parts of the country and in other countries. Human-wildlife conflict is attracting greater attention in recent days due to the straying of wild elephants to crop fields and human casualties due to leopards and elephants. Agriculture crop damage by wild animals, injury and human casualties caused by them are considered as human–wildlife conflict for the purpose of this study. Human-wildlife conflict has been investigated in Kerala by the scientists of KFRI earlier. Mitigation measures, which are developed in other countries, need to be evaluated in the local conditions and new methods to be developed, which will be appropriate for local environmental and social conditions.

The forest in Kerala is extremely fragmented due to settlements and agriculture. Crop damage by wild animals in agricultural fields, adjoining the forest areas is severe. This is primarily due to the straying of wild animals such as wild pig, Asian elephant, Indian porcupine and deer from the forest to the homesteads and plantations. Consequent to this, conflict between wild animals and farmers in the fringe areas of the forests and protected areas are rising. Wild animals are protected against poaching. Census figures show that, majority of these animals are stable or growing in number over the years. Especially the population of sambar, wild pig and elephant is growing. In addition to these, past activities like, large-scale conversion of forests into monoculture plantations of teak and eucalyptus, shifting cultivation, hydroelectric projects and organised encroachments reduced the accessible habitat of wild animals in Kerala. This scenario is leading to human - wildlife conflict in several places. In order to ameliorate the deteriorating situation, Forest Department pay compensation for crop damage, cattle lifting and human casualties.

Wild animals in Kerala destroyed forty five species of crops and most important among them were paddy (*Oryza sativa*), coconut palm (*Cocos nucifera*), plantains (*Musa* sp.), cassava (*Manihot esculenta*), areca nut (*Areca catechu*), coffee (*Coffea arabica*), oil palm (*Elaeis guineensis*), pepper (*Piper nigrum*), jack tree (*Artocarpus heterophyllus*), mulberry (*Morus alba*) and mango (*Mangifera indica*) (Jayson and Veeramani, 1995). The main animals involved in crop damage were elephant (*Elephas maximus*), gaur (*Bos gaurus*), sambar (*Rusa unicolor*), wild pig (*Sus scrofa*), bonnet macaque (*Macaca radiata*), common langur (*Presbytis entellus*), blacknaped hare (*Lepus nigricollis*) and pea fowl (*Pavo cristatus*). Among these, elephant and wild pig did highest damage. Of the total compensation claimed by the farmers only 8.2 % was sanctioned by the Kerala Forest Department (Jayson, 1999).

For managing the human - wildlife conflict, scientific data is essential from all over the State in detail. Human-wildlife conflict is creating an adverse impact on the conservation activities in several fringe areas of the forest and this is adversely affecting the conservation of biodiversity. Previous studies in the Institute showed that the crop damage is largely affecting the marginal farmers (Veeramani *et al*., 2004). 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 (Veeramani *et al*., 2004). Detailed and site specific studies are required to formulate integrated management strategies for mitigating human-wildlife conflict in the State. This study to estimate crop damage by wild animals in the Trichur District is carried out with this background.

Human-wildlife conflict occurs "*when the needs and behaviour of wildlife impact negatively on the goals of humans, or when the goals of humans negatively impact the needs of wildlife*" (IUCN World Parks Congress Recommendation). This global issue is worsened when the local people feel that, the needs or values of wildlife are given priority over their own needs. The negative interactions may result (a) crop damage by wild animals, (b) cattle-lifting, (c) human casualties and (d) household damage (Conover, 2002). The expansion of human population, land area conversion, encroachment, developmental activities near the marginal areas and fragmentation of the forest habitat are the main causes for increasing human-wildlife conflicts (Romanach *et al*., 2007; Sharma *et al*., 2011). Co-existence between humans and wildlife is inevitable for enhancing the survival of wildlife species in the forest habitat (Madden, 2004). As the wildlife species do easily habituate to the traditional control measures to prevent their encounter in the human habitations, practising of innovative methods will minimize the occurrence of negative interactions (Jorgenson *et al*., 1978; Tuyttens and Macdonald, 2000; Woodroffe and Frank, 2005). Immediate verification of damage and compensation schemes with strong institutional support will reduce the severity (Nyhus *et al*., 2003). Education and information in general can improve the tolerance among the local people, which decrease the frequency of conflicts (Sutherland, 2000; Mishra *et al*., 2003). Human-wildlife conflict is attracting greater attention in recent years in Kerala, due to the frequent encounter of wild animals in the crop fields incurring huge economic loss to the marginal farmers. Even though information on human-wildlife conflict is available at the State level, area specific information is lacking. Site specific data is a must for any

management intervention. Mitigation measures to prevent crop damage were also evaluated in this study.

The objectives of the study were 1. To assess and estimate the extent of crop damage by wild animals in the Trichur District. 2. To suggest suitable remedial measures to reduce and prevent the crop damage by wild animals.

1.1. Review of literature

1.1.1. Crop damage

Numerous studies were conducted outside the country on crop damage by elephants. Crop damage is found to be linked with cropping pattern and location of the agricultural field. Several studies have been conducted on human-wildlife conflict and its impact on agriculture (Dublin and Hoare, 2004; Anthony *et al*., 2010). They reported that, large mammals such as elephant, tiger, wild boar and monkeys often come into conflict with people by destroying agricultural crops and even killing people, thus providing a deterrent to conservation efforts. O'Connell-Rodwell *et al*. (2000) studied the economic impacts of elephants and tested the efficiency of methods to mitigate human-wildlife conflict where the study revealed that electric fence reduced the crop damage by elephants, but deterrent efforts helped to improve the relationships between communities and conservationists. 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.

Zhang and Wang (2003) studied the impact of Asian elephant on the rural agricultural economy. Attempts were made to reduce the conflict by building artificial salt ponds in the forest and digging trenches to protect farmland and to improve governmental compensation. Parker and Osborn (2006) assessed the palatability of chilly plant for elephants and economic returns of the farmers in Zimbabwe. The results revealed that the chilly was less palatable to wildlife and it was an economically viable crop to grow in this region. Kioko *et al.* (2008) assessed the performance of electric fence as a barrier against the crop raiding elephants in Kenya. Location of the fences in relation to the landscape factors, maintenance of the effective non-electrified fences and proximity of the fences to the areas of high elephant concentration were stated as significant determinants. Osei-Owusu and Bakker (2008) introduced the chilly-dung brick for deterring the elephants from cultivatable land areas in

Africa. The noxious smell formed by burning of dried chilly-dung brick irritated the elephants and prevented its entry into crop field, when it was burned near the farm. Rood *et al*. (2008) found that intermediate habitat fragmentation did not create any elephant movement from their natural ranges but secondary forests and agricultural areas near to the primary forest provided suitable habitat for elephants. The availability of resources itself was not an observation tool for the distribution of elephants, but it was accompanied with historic ranges and movements.

Schley *et al.* (2003 & 2008) reviewed the diet of wild pig in Western Europe, paying particular attention to the consumption of agricultural crops and it was implicated on the basis of crop damage. Vegetable food was more selective than animal food for diet and the dependence of energy-rich plant material led to significant agricultural damage. The study on the patterns of crop damage by wild boar revealed that permanent grassland was damaged more frequently than annual crop, but seasonal damage was based on the type of crops cultivated. Geisser *et al.* (2004) reviewed the efficiency of remedial measures like hunting, feeding and fencing to reduce the crop damage by wild boar. The result showed that hunting obviously reduced the conflict between humans and wild boar. New harvest models to be introduced among the local hunting teams were also suggested.

Vercauteren *et al.* (2006) conducted a management study on White-tailed deer (*Odocoileus virginianus*). The study covered mainly on crop damage, automobile and aviation collisions, disease transmission, environmental degradation and destruction of ornamental plantations. Efficiency of exclusionary fences was tested and improvements in fence technology were also suggested in the study. Crop raiding by wild boar (*Sus scrofa*) is found to be severe in other countries also (Geisser and Reyer, 2004; Wang *et al*., 2006; Schley *et al.*, 2008; Cai *et al*., 2008; Amici *et al*., 2011) as in India (Sekhar, 1998). Indian crested Porcupine (*Hystrix indica*) is also a crop raider next to elephants and wild boar. It makes severe damage to traditional as well as non-traditional crops (Hafeez *et al*., 2012), fruit orchads and vegetables (Alkon and Saltz., 1985).

The damage by deer is a general problem. Damages include crop loss, automobile collisions (Vercauteren *et al.*, 2006) and destruction to ornamental gardening (Nolte**,** 1998). Browsing, bark stripping and fraying are the damages to the crops made by deer (Gill, 1992). In order to prevent the entry of deer into the farmlands, deer guards and bump gates, Big Game Repellent-Powder (BGR) and Deer Stopper (DST**)** (Nolte, 1998) was adopted in other countries.

Crop damage by primates is yet another burgeoning issue to common man. Across Asia primates, especially macaques tend to be the habitual crop raider (Hill, 1997; Pienkowski *et al*., 1998; Twehevo *et al*., 2005; Marchal and Hill, 2009; Smith *et al*., 2010). Comparing the severity of crop damage with other countries, we have only minor loss caused by *Macaca radiata.* Government pay compensation for damages caused by wild animals. But compensating pastoralists and farmers will have a negative impact in the near future (Bulte and Rondeau, 2005). Again, inadequate remuneration, processing delays and corruption are the key problems related to compensation (Ogra and Badola, 2008).

1.1.2. National

Studies on crop damage by Asian elephants were carried out in India also. Elephants forage more 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). In Rajaji National Park, the adult males that raids crops had large home ranges and elephants raid crops after dawn and get back to their forest before dawn (Williams *et al*., 2001; Joshi and Singh, 2007). The seasonality of elephant raids is found to be coinciding with the period of crop ripening (Roy *et al.,* 2009; Gubbi, 2012). Studies conducted in Peppara Wildlife sanctuary showed that substantial amount of crop was damaged as compared to what was consumed by wild animals (Jayson *et al*., 2008). Prasad *et al*., (2011) reported GIS based spatial prediction model for human-elephant conflicts. Short term mitigation measures showed superior efficacy against habitual raiders, for eg. slippery bed (Kannan, 2007) and chilli-based repellents (Chelliah *et al.,* 2010).

Nigam (2002) mentioned the levels of damage caused by a small group of elephant in Jharkhand as the habitat degradation led to human-wildlife conflict. Prasad and Reddy (2002) reported suggestions to alleviate human-elephant conflict, when elephants were returned to the areas of former habitat. Chelliah *et al.* (2010) analyzed the efficiency of chilly-tobacco rope against the crop raiding elephants in Karnataka and it was proved that the method was significantly better in low-rainfall seasons than medium and high-rainfall regimes. Chauhan *et al.* (2009) investigated the agricultural crop depredation and attacks on humans by wild pig in 5 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.

Srivastava (2000) conducted a study on the consumption of 19 varieties of sugarcane by Indian crested porcupine in Lucknow, Uttar Pradesh. The result revealed that 31.68 % of damage was done to the clumps and in damaged clumps, 49.76 % of internode was eaten up by porcupines. Damaged canes suffered weight loss of 30 % on an average. Different climatic zones with complex tropical patterns and crop practices were the main cause for increasing the vertebrate pests. 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 behavior. Thyagaraj *et al.* (2006) reported the consumption of fallen coconut and areca nut and debarking behavior of palm by Indian crested porcupine. Seedlings of the mature coconut palm (less than two years old) were preferred for consumption. Different varieties of plant species damaged by porcupine were also mentioned in the study. Debarking was the major damage in forest nurseries of Rajasthan and coconut palms in Karnataka (Chakravarthy *et al*., 2006). According to Thyagaraj *et al*., (2006) coconut and areca nut palms less than 20 years are more prone to damage. Srivasthava (2000) reported sugar cane damage from the farm of Indian Institute of Sugarcane Research.

1.1.3. Studies from Kerala

Number of studies on human-wildlife conflict were conducted in KFRI (Jayson, 1999). One study covered the whole State of Kerala and other studies were in the Peppara Wildlife Sanctuary and Wayanad Wildlife Sanctuary. Several incidence of crop damage were not reported to the forest offices by the cultivators as no compensation was offered for the damage by wild boar. At Marayur Range, 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 vulnerable to the attack of wild animals 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, wild boar etc. These animals were recorded as destructive to mulberry, plantains, paddy followed by sugar cane (*Saccharum officiniarum*). In Peppara Wildlife Sanctuary, five species of animals were recorded as destructive to 17 crops. But wild boar did the most damage followed by 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. Awareness about crop damage compensation is very low and those, who are aware about compensation, lose their interest due to the formalities and long process involved in obtaining payment. In Wayanad Wildlife Sanctuary, elephants did damage to a total of 97 species of plants belonging to 34 families. Studies on food availability indicated that low grass biomass in areas surrounding the settlements, increased elephant population and local over abundance result in habitat degradation leading to crop raiding. The movement of people during the day time forces the elephants to confine themselves to smaller undisturbed patches and put them under stress and strain.

For controlling the crop damage, 15 indigenous methods had been identified. They are watch and ward, line fence with different materials, sound from metallic parts, fire, dogs, stone wall, bar soap, bamboo fence, bush fence, reed line, cracker line, cable, kerosene, plastic bags and cloths. Human dummies, areca nut sheaths and different types of traps like mouse trap, pit trap, deadfall trap, tree trap and pellet bow are used in many areas. Trenches and stone walls are employed in many parts of Kerala to keep away the wild animals from settlements and agriculture. In order to reduce the animosity towards wild animals, solar electric fence using the energizer is used and very effective. Experiment of solar electric fence showed effectiveness in preventing the intrusion of elephants and other larger animals. Yet, it is not effective against wild pigs and other smaller animals. Technical problems, high rainfall and rapid regeneration of under growth altogether demand high maintenance for adequate functioning. Continuous co-operation of the inhabitants is also essential for keeping the fence in an effective condition. Veeramani *et al.* (2004) 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, 2011). 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, biological fences like agave, cacti and psychological fence like electric fence are the protective methods used to mitigate the human-wildlife conflict (Veeramani *et al*., 2004; Fernando *et al*., 2008).

1.2. STUDY AREA

1.2.1. Location

The study was carried out in Thrissur District, Kerala, India. Thrissur District (10^0 46' to 10^0 7' N and 75^0 57' to 76^0 55' E) is the central part of Kerala State, spanning an area of about 3,032 sq. km (Fig.1). The District has a tropical humid climate and plentiful seasonal rainfall. Different varieties of soil namely laterite, sandy loam, alluvial, clayey and black are found. Presently, the effective forest area in Kerala State is around 9400 km^2. The study area is comprised of 11 Forest Ranges within 3 Forest Divisions namely, Thrissur (210.64 km^2), Chalakudy (279.71 km^2) and Vazhachal (413.94 km^2) and 2 Wildlife Sanctuaries (210 km^2) and 1 Peafowl Sanctuary (3.44 km^2). The forest area include different vegetation types namely moist deciduous, evergreen and semi-evergreen, grassland and forest plantation. Asian elephant, wild pig, porcupine, sambar, leopard, wild dog and Indian giant squirrel are the major animals found in the forests. Agriculture is the main livelihood in the forest fringes. Coconut (*Cocos nucifera*), rubber (*Hevea brasiliensis*), paddy (*Oryza sativa*) and plantain (*Musa paradisiaca*) are the major cash crops cultivated by the farmers.

1.2.2. Protected areas of Thrissur District

Thrissur District is having three Wildlife Sanctuaries namely Peechi-Vazhani and Chimmony and one Peafowl Sanctuary at Chulannur, which is in the border region of Thrissur and Palghat Districts (Fig. 1).

Peechi-Vazhani Wildlife Sanctuary

This sanctuary was established in 1958 with an extent of 125 km^2. It lies between 10^0 28' - 10^0 38' N and 76^0 18' - 76^0 28' E, in which the terrain has varying elevation from 45 to 900 m. The area includes two reservoirs namely Peechi and Vazhani, having an area of 12.95 km^2 and 1.843 km^2 respectively. The forest areas of the Sanctuary are connected with Palappilly Forest Range, Nelliampathy Reserves and Chimmony Wildlife Sanctuary. The NH-47 (from Ernakulam to Coimbatore) stopped the free movement of animals from Peechi and Vazhani forests. The vegetation is dominated by the tropical moist deciduous forest and semi-evergreen forests, which are confined to the upper region.

Chimmony Wildlife Sanctuary

It lies within the geographical extremes of latitudes 10^0 22' – 10^0 26' N and longitudes 76^0 31' – 76^0 39'E on the western slopes of Nelliampathy forests. The reservoir

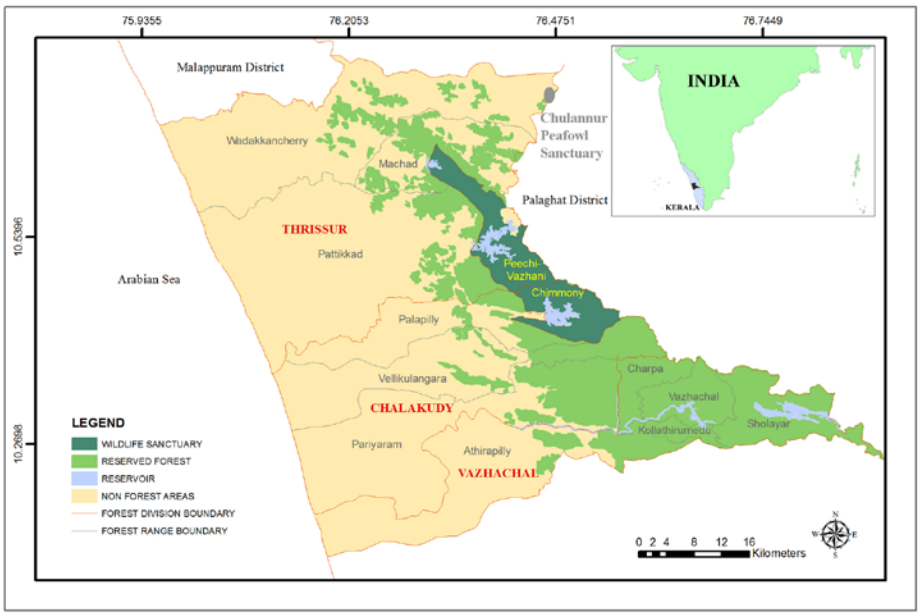


Fig. 1. Intensive study area, Thrissur District, central Kerala, India.

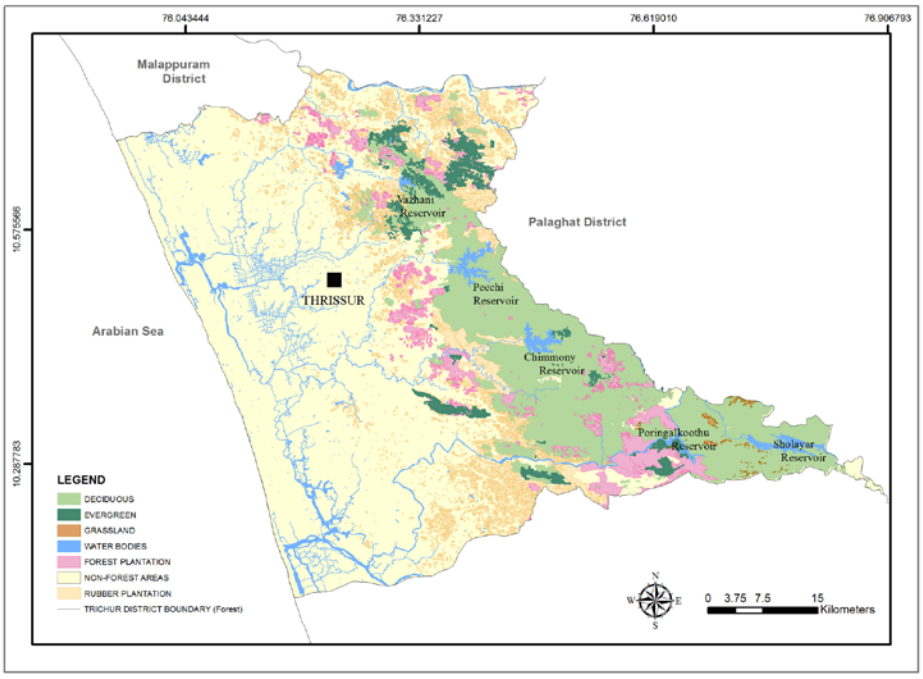


Fig. 2. Vegetation map of Thrissur District.

occupies 5.68 % of the total area of this Sanctuary (85.067 km^2) and the elevation of the terrain varies from 350 m to 750 m above msl. The vegetation includes tropical wet evergreen forests at higher altitude, semi-evergreen forests and moist deciduous forests. The Sanctuary is connected with Parambikulam and Peechi-Vazhani Wildlife Sanctuary where the status and habitat utilization of larger mammals in the area is very high.

Chulannur Peafowl Sanctuary

Chulannur Peafowl Sanctuary (10^0 42' 51.9" N & 76^0 28' 21.05" E) is located near Thiruvillamala and it consists of 342 hectares of vested forests spread over in the districts of Thrissur and Palakkad. The area was declared as a sanctuary in 2007, for ensuring the long-term protection of Peafowl. In 2008, it was renamed as "Chulannur Peafowl Sanctuary" dedicated to the memory of Sri. K.K. Neelakantan, a famous ornithologist of Kerala and the author of the book entitled, "Keralathile Pakshikal", who hailed from Kavassery near the Sanctuary. The deciduous forests of the sanctuary with open patches and rocky areas offer an ideal habitat for peafowl. A sizeable population of peafowl occurring in these forests offers scope for effective long term conservation of the species. It also supports a rich variety of other species of birds.

1.2.3. Climate

The District fall in the tropical zone. Moderate rainfall and humid atmosphere is found for the major part of the year. Comparison of the rainfall and temperature shows that the driest period extends for nearly four months, which starts from December and ends by March/April. The high rainfall supports a wide range of vegetation types (Fig. 3,4 and 5).

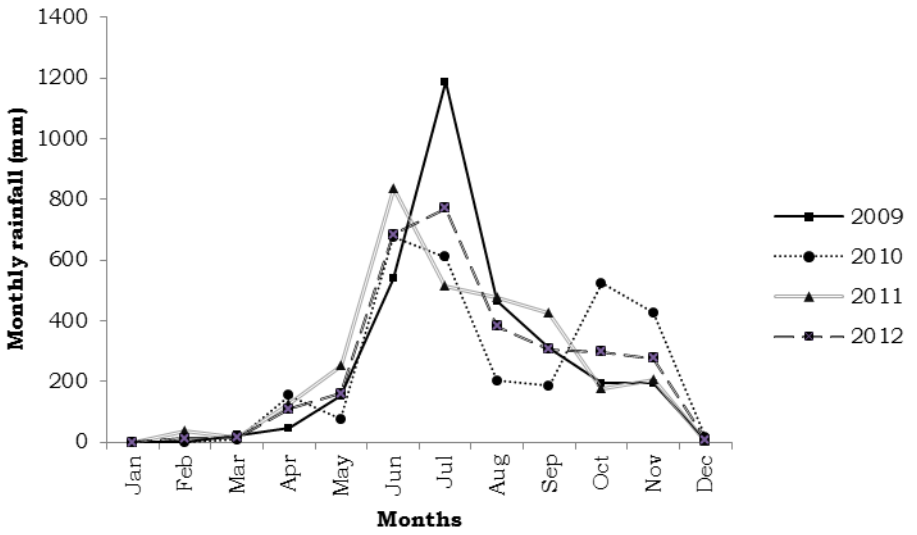


Fig. 3. Monthly rainfall (mm) in Thrissur District, Kerala (Source - KFRI, Peechi)

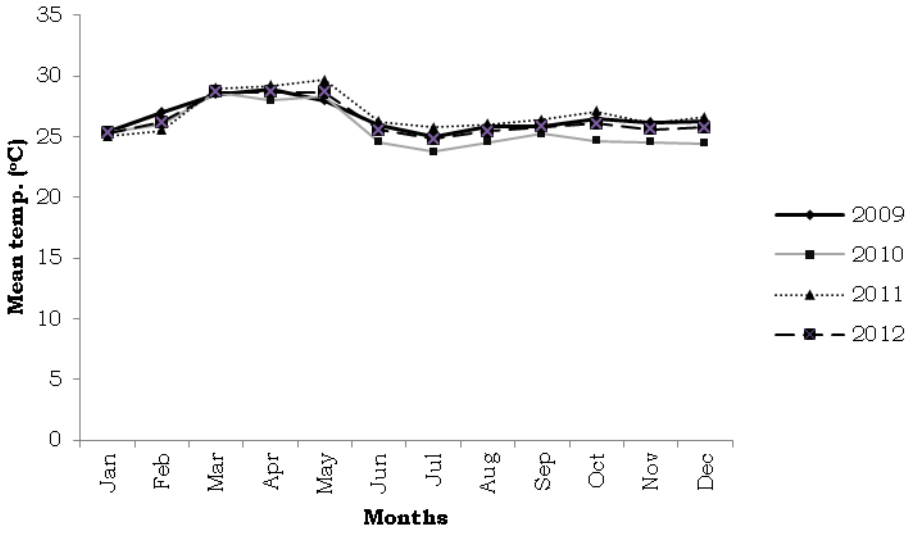


Fig. 4. Mean temperature (^{o}C) in Thrissur District, Kerala (Source - KFRI, Peechi)

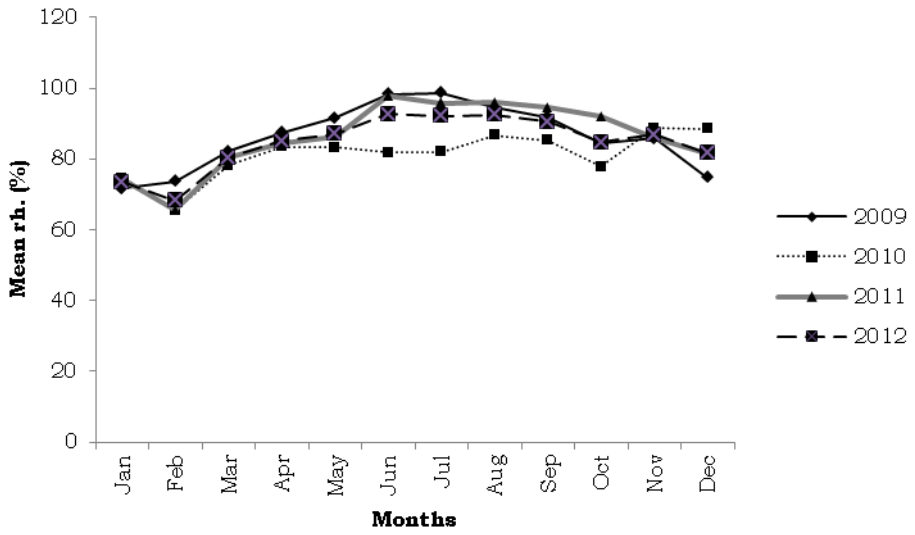


Fig. 5. Mean relative humidity (%) in Thrissur District, Kerala (Source - KFRI, Peechi)

1.2.4. Vegetation types

Based on the Revised Forest Types of India by Champion and Seth (1968), the following type of forests are seen in Thrissur District and they are

1. Tropical Wet evergreen forests
2. Tropical semi-evergreen forests
3. Tropical moist deciduous forests
4. Plantations

Floristic Composition

Common tree species in the District are *Albizzia odoratissima, Alstonia scholaris, Bombax malabaricum, Grewia tiliifolia, Miliusa tomentosa, Terminalia crenulata, Xylia xylocarpa, Palaquium ellipticum, Cullenia exarillata, Mesua ferrea, Vateria indica, Calophyllum, Lophopetalum wightianum, Holigarna ferruginea, Artocarpus heterophyllus, Dysoxylum malabaricum, Calophyllum polyanthum, Dysoxylum malabaricum, Myristica dactyloides, Vateria indica, Dipterocarpus indicus, Kingiodendron pinnatum, Pterygota alata, Gymnacranthera canarica, Mangifera indica, Ormosia travancorica, Meliosma simplicifolia, Hydnocarpus macrocarpus, Myristica dactyloides, Bhesa indica, Aglaia lawii, Neloamarkia cadamba (Anthocephalus cadamba), Semecarpus travancorica, Vepris bilocularis, Melicope lunu-ankenda, Drypetes elata, Canarium strictum, Toona ciliata, Carallia brachiata, Polyalthia fragrans, Elaeocarpus tuberculatus, Elaeocarpus glandulosus, Garcinia morella, Humboldtia vahliana, Holigarna grahamii, Atuna travancorica, Euphoria longan, Vepris bilocularis, Hydnocarpus pentandra, Litsea coriacea, Aporusa lindleyana,*

Knema attenuata, Walsura trijuga, Vernonia arborea, Bridelia retusa, Careya arborea, Cassia fistula, etc. Acacia sinuata, Caesalpinia bonducella, Ardisia pauciflora, Symplocos laurina, Litsea floribunda, Litsea bourdillonii, Aporusa acuminata, Glochidion ellipticum, Clausena indica, Atalantia racemosa, Agrostistachys borneensis, Phoebe lanceolata, Drypetes oblongifolia, Callicarpa tomentosa, Ixora arborea, Xanthophyllum arnottianum, Blepharistemma serratum, Orophea uniflora, Alangium salvifolium, Glochidion zeylanicum, Meiogyne ramarowii, Hunteria zeylanica, Isonandra Ianceolata, Symplocos macrocarpa etc. The under growth consists of *Amomum muricatum, Glycosmis pentaphylla, Laportea crenulata, Thottea siliquosa, Schumannianthus virgatus, Pellionia heyneana etc. The common climbers are Caesalpinia cucullata, Entada rheedei, Ventelago bombaiensis, Ancistorcladus heyneanus, Bauhinia phoenicea, Chilocarpus denudatus, Derris brevipes, Artabotrys zeyleanicus,* etc.

Riparian Forests

The riparian vegetation along the Chalakudy river system offers a unique ecosystem. Further, it serves as a link between the varied habitats at lower and higher elevations. Healthy riparian zones maintain the channel form and serve as important filters of light, nutrient and sediment which provide habitats for fish and other riverine organisms, function as corridors for their movement, control river temperatures and maintain bank stability. The riparian forests of the Chalakudy River have revealed the existence of a thick riparian vegetation of more than 10 m width for a distance of 10.5 km downstream from Poringalkuthu, covering an area of 58.5 hectares. Out of this, 26.4 hectares lie within the Vazhachal area, including three large islands densely covered by riparian forests. The zone starting from just below the Poringalkuthu Dam (400m above M.S.L.) up to the Athirappally waterfalls represents rich low altitude riparian wet evergreen forests. The continuous stretch of riparian vegetation, the river and the Vazhachal and Athirappally waterfalls makes this zone one of the most beautiful places in South India which attracts lakhs of visitors every year. At Vazhachal there are no residential areas except two Kadar tribal colonies and Forest Department staff quarters. Hence disturbance in this zone is comparatively less. The main disturbance is from tourism activities and is due to the Anamala road passing through the area. Tourism and allied activities are mainly located at Athirappally, Charpa and Vazhachal waterfalls and hence other areas in this zone are kept comparatively undisturbed. Presently, the intrusion of tourists to the nearby forest areas and riparian zone has been reported. The vegetation cover adjoining the riparian forests in this area consists mainly of deciduous forests and plantations

of teak and Bombax. The adjoining land cover of the Charpa area is mainly evergreen and semi- evergreen forest. The deciduous patches were also found downstream to Charpa. The characteristics of the land adjoining the riparian area are significant and exert great influence on the riparian vegetation of that area. Small patches of reed brakes are seen near Charpa before the Athirappally waterfalls. From Athirappally waterfalls up to Thumboormuzhi (120-50 M.S.L) the continuity of the riparian forests has been lost due to disturbances. Oil palm, rubber and other plantations of Plantation Corporation of Kerala, tourism activities in the Government and private sector and the activities of the local people have contributed to the depletion and loss of continuity of the vegetation. The riparian vegetation, especially in the river margins is highly reduced and is mainly due to the rubber and oil palm plantations. A number of small islets are present up to and just after Thumboormuzhi. These islets have good stretch of riparian vegetation. The riparian forest in these islets is also a unique feature of the Chalakudy River.

Dominant species in the riparian zone

The riparian vegetation is dominated by species *like Syzigium occidentale, Barringtonia acutangula, Madhuca neriifolia, Humboldtia vahliana, Mallotus aureo-punctatus, Homonoia riparia, Hopea Sp., Ochlandra Sp., Bambusa Sp., Vateria* and *Ficus Sp.*. These plants are evergreen species and the first six species are endemic to the riparian habitat. The dominant evergreen and semi - evergreen species found in these zones are *Humboldtia vahliana, Barringtonia acutangula, Syzygium occidentale, Homonoia riparia, Madhuca neriifolia, Hopea parviflora, Vateria indica, Xanthophyllum flavescens, Elaeocarpus aporusa lindleyana, Xylia xylocarpa, Hydnocarpus alpina, Baccaurea courtallensi and Olea dioica.* Of these, most of the species are typical West coast evergreen and semi-evergreen elements and some plants are typical riparian components. The elements also represent various seral and edaphic communities of the west coast evergreen forests. The species like *Ochlandra, Bambusa* and *Macranga peltata* and some deciduous elements and the presence of weeds indicate the disturbances in the riparian forests. The vegetation above 50m altitude was found to possess this type of vegetation.

Fauna

Thrissur District is very rich in fauna, which is constituted by a large variety of mammals, birds, reptiles, amphibians, aquatic fauna, butterflies and other insects as well as micro-organisms. Faunal diversity is stated as follows –

Important mammals include lion-tailed macaque (*Macaca silenus*), bonnet macaque (*Macaca radiata*), Nilgiri tahr (*Nilgiritragus hylocrius*), Asian elephant (*Elephas maximus*), tiger (*Panthera tigris*), leopard (*Panthera pardus*), wild pig (*Sus scrofa*), barking deer (*Muntiacus muntjak*), sambar (*Rusa unicolor*), spotted deer (*Axis axis*), mouse deer (*Moschiola indica*), Nilgiri langur (*Semnopithecus johnii*), sloth bear (*Melursus ursinus*), Indian giant squirrel (*Ratufa indica*), Indian giant flying squirrel (*Petaurista philippensis*), gaur (*Bos gaurus*), etc. The main reptiles found in the District include - Indian cobra (*Naja naja*), king cobra (*Ophiophagus hannah*), Russell's viper (*Daboia russelii*), saw-scaled viper (*Echis carinatus*), Indian python (*Python molurus*), common rat snake (*Ptyas mucosa*), common green whip snake (*Ahaetulla nasuta*), common Indian krait (*Bungarus caeruleus*), Cochin cane turtle (*Vijayachelys silvatica*), Travancore tortoise (*Indotestudo travancorica*) and Western Ghats flying lizard (*Draco dussumieri*). Other Important reptiles are south Indian rock lizard (*Psammophilus dorsalis*), common Indian monitor (*Varanus bengalensis*), and terrapin (*Melanochelys trijuga*).

The District has good avian diversity. Important birds include Malabar pied hornbill (*Anthracoceros coronatus*), Great pied hornbill (*Buceros bicornis*), red spurfowl (*Galloperdix spadicea*), Malabar trogon (*Harpactes fasciatus*), blue-bearded bee-eater (*Nyctyornis athertoni*), black-naped oriole (*Oriolus chinesis*), crested tree swift (*Hemiprocne coronata*), brown fish-owl (*Ketupa zeylonensis*), lesser fish eagle (*Ichthyophaga humilis*), blue-headed rock-thrush (*Monticola cinclorhynchus*), Eurasian black-bird (*Turdus merula*), brown-breasted flycatcher (*Muscicapa muttui*), large-billed leaf warbler (*Phylloscopus magnirostris*), little spiderhunter (*Arachnothera longirostris*), great eared-nightjar (*Eurostopodus macrotis*), Malabar parakeet (*Psittacula columboides*), white-bellied treepie (*Dendrocitta leucogastra*), white-bellied blue flycatcher (*Cyornis pallipes*), small sunbird (*Nectarinia minima*), Nilgiri pipit (*Anthus nilghiriensis*), Nilgiri wood pigeon (*Columba elphinstonii*), grey-headed bulbul (*Pycnonotus priocephalus*), Nilgiri flycatcher (*Eumyias albicaudata*), large hawk cuckoo (*Hierococcyx sparverioides*), lesser adjutant stork (*Leptoptilos javanicus*), grey-headed fish-eagle (*Ichthyophaga ichthyaetus*), peninsular bay owl (*Phodilus badius*), oriental broad-billed roller (*Eurystomus orientalis*), darter (*Anhinga melanogaster*), little cormorant (*Phalacrocorax niger*), black eagle (*Ictinaetus malayensis*), black-capped kingfisher (*Halcyon pileata*) and black woodpecker (*Dryocopus javensis*).

Plate 1. Study area at Randukai, Pariyaram Forest Range

Plate 2. Study area at Wadakkancherry Forest Range

1.2.5. Human settlements within the forest limits

Two tribal communities were seen in the District and they are 1. Malayan and 2. Kadar.

Malayan The Malayans are the scheduled tribe found in the hill regions of Thrissur District. The word 'Malayan' indicates that 'one who resides in the hill'. They are dark to dark brown in complexion, short in stature, flat nose and thick lips. Nowadays, many of them are settled in colonies in the plains, mixing with non-tribal population. They are non-vegetarians and their main dish is 'kanji' (gruel). They cultivate roots, tubers and vegetables and collect medicinal plants from the core portion of forest limits.

Kadar Kadar is considered as the best representative of the integrated food gathering tribes of South India. The word 'Kadan' (plural – Kadar) in Malayalam means 'the dweller in the forest'. Both women and men are of dark complexion. According to the data collected from the Forest Department, the Kadar settlements were recorded in the District from Vazhachal (Charpa Forest Range), Pokayilappara (Vazhachal Forest Range), Poringalkoothu (Vazhachal Forest Range), Vachumaram (Kollathirumedu Forest Range), Chandanthodu (Sholayar Forest Range), Malakkapara (Sholayar Forest Range) and Anapantham (Vellikulangara Forest Range). Their staple food is rice, supplemented with roots and tubers. They developed appropriate technology for the collection of honey. Fishing is usually their part-time activity and they are not fond of any ornaments. They are the expert trackers and the Forest Department depends on them for all activities.

2. METHODOLOGY

The whole area was surveyed on foot and vehicle for a reconnaissance survey. Observational methods were used for the study. Field data were collected from April 2009 to March 2012.

2.1. Crop damage by wild animals

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

In order to quantify the crops damaged by wild animals, the study locations were selected by a field survey. As information about the study was published in newspapers and visual media, several farmers in the forest fringes responded with information. From each Forest Range, two locations were selected randomly and the permanent quadrats were laid in their farms. Permanent quadrats of 10 m x 10 m were taken in the fringe areas of the Forest Ranges. Four quadrats (sample plots) in the mixed crop farms and one quadrat (control plot) in the Reserve Forest near the sample plots were taken from each location. Two more quadrats were also laid in the cultivated lands of each Forest Range, which were blocked or fenced to prevent the entry of wild animals, for quantifying the yield of major crops damaged. Each plot was demarcated and marked using ribbon. Forest Ranges with negligible cultivation of crops were omitted from quadrats, but case studies were conducted from such Ranges. Crop damage incidences were recorded from quadrats in each month (n=36) and the species of crops damaged was quantified. In order to quantify the consumption of tubers, estimates were taken after discussing with the farmer of the respective land. Following details were collected from each quadrat.

- Number of trees or plants damaged and undamaged
- Number of coconuts damaged in each month
- Number of indirect evidences of wild animals in each month
- Damage in the nearby areas to the quadrats

Enquires were also made among the farmers near the quadrats to confirm the crop raiding species and the quantity of crops damaged. Case studies were carried out for large herbivores, as they were not recorded from the quadrats. In such cases, emphasis was given to record the place and time of encounter, distance from the forest, age of the crops damaged

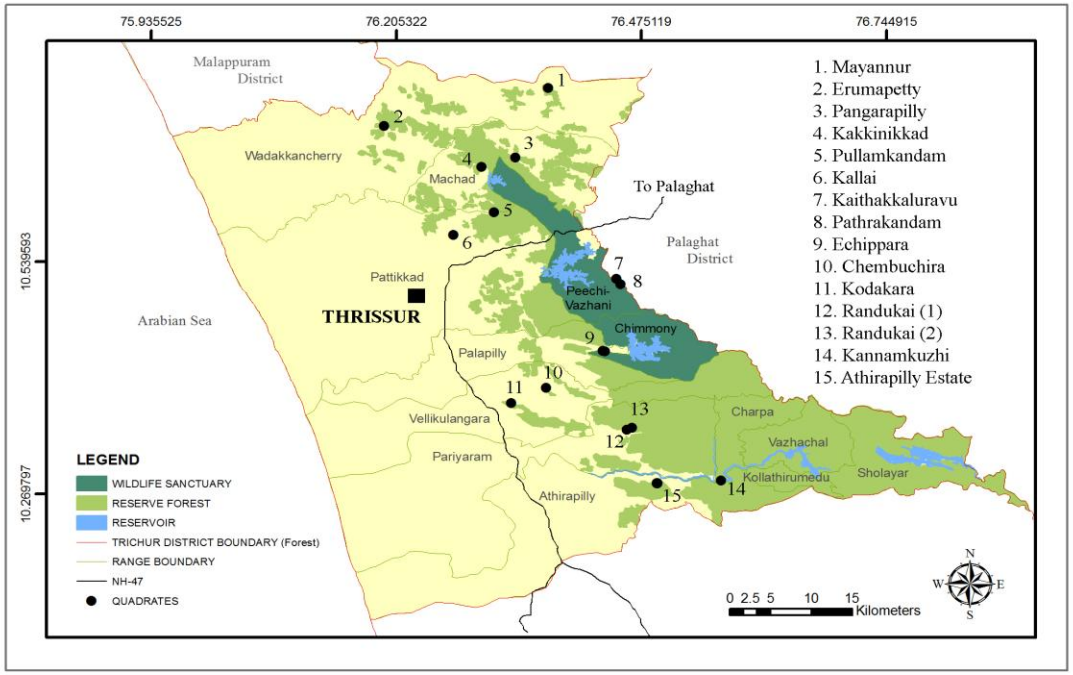


Fig. 6. Location of the permanent quadrates in the Forest Ranges of Thrissur District, Kerala.

and the mode of attack. Damaged and undamaged crops were quantified by running quadrats (10 m x 10 m) from the site of damage. 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.

The presence/absence data of animals were entered in data sheets. For each plot, details of the crop species, age of crop plant, number of damaged and undamaged plants, vegetation type, animal causing the damage, nature of damage and the cost and efficacy of the protection methods employed at the time of visit, were also recorded. Enquiries were also made with the cultivators in the area to confirm the species involved in the raids, frequency of raiding and other details such as the date and time of the raids. From these quadrats, indirect evidences left by the wild animals such as scats, droppings, diggings, feeding signs and scratching marks were identified.

A total of 103 permanent quadrats were taken from the Forest Ranges namely Wadakkencherry, Machad, Pattikkad, Peechi, Palappilly, Vellikulangara, Pariyaram, Charpa and Athirappally (Table 1). Forest Ranges with negligible cultivation of crops were not sampled and they were Vazhachal, Kollathirumedu and Sholayar. As the crop damage by wild animals was less in the Peechi-Vazhani Wildlife Sanctuary, Peechi Forest Range was not included in the initial observations. Later, it was found that, an arboreal mammal did huge economic loss to the farmers in this Range. Consequently, quadrats were laid in the enclosures namely Kaithakkaluravu and Pathrakandam on September 2009. Quadrats taken from Athirappally Forest Range (n=7) were omitted after 9 months of routine observation, because, no herbivores were recorded within the sample plots and in the nearby areas. As the Palappilly Forest Range of Chalakudy Forest Division and Charpa Forest Range of Vazhachal Forest Division were also occupied with monoculture plantations, all quadrats were taken from the same location, where the mixed cultivation was seen as in the form of a cluster in Echippara, near Chimmony Wildlife Sanctuary and Kannankuzhi near Athirappally water-falls. Apart from the permanent quadrats, a total of 238 running quadrats were taken from different Forest Ranges namely Pattikkad, Peechi, Palappilly, Pariyaram, Vellikulangara, Athirappally and Charpa, as a part of case studies. These quadrats were laid after getting information from the farmers during the field visit and based on newspaper reports on damaging the crops by wild animals.

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

Forest Division	Forest Range	Location	Latitude & Longitude	Number of samples
		Location of permanent quadrats		
Thrissur	Wadakkencherry	Mayannur	$10^0$44’27.6”N $76^0$22’22.8”E	5
		Erumappetty	$10^0$41’49.2”N $76^0$11’32.28”E	7
	Machad	Pangarapilly	$10^0$39’38.52”N $76^0$20’12.84”E	5
		Kakkinikkad	$10^0$38’59.64”N $76^0$17’57.12”E	7
	Pattikkad	Pullamkandam	$10^0$35’47.76”N $76^0$18’47.88”E	7
		Kallai	$10^0$34’13.08”N $76^0$16’6.6”E	5
Peechi-Vazhani Wildlife Sanctuary	Peechi	Kaithakkaluravu	$10^0$30’47.16”N $76^0$27’8.64”E	5
		Pathrakandam	$10^0$30’47.49”N $76^0$27’8.81”E	7
Chalakudy	Palappilly	Echippara	$10^0$26’6.36”N $76^0$26’7.8”E	12
	Vellikulangara	Chembuchira	$10^0$23’33.36”N $76^0$22’14.52”E	5
		Kodakara	$10^0$22’29.64”N $76^0$19’55.92”E	7
	Pariyaram	Randukai (1)	$10^0$20’38.84”N $76^0$27’34.2”E	5
		Randukai (2)	$10^0$20’46.68”N $76^0$27’54”E	7
Vazhachal	Charpa	Kannankuzhi	$10^0$17’6.72”N $76^0$33’47.52”E	12
	Athirappally	Athirappally Estate	$10^0$17’1.68”N $76^0$30’2.52”E	7
		Total		**103**

2.1.2. Factors affecting the human-elephant conflict

For identifying the variables associated in the occurrence of human-elephant conflict, binary logistic regression was carried out. The intensive study area was divided into grid cells with a size of 2 km x 2 km. To facilitate the data analysis, all the independent variables were superimposed on to the grid cells, which covered the range of elephants. The grid cell containing the HEC locations was taken as a conflict cell. The non-conflict cells were selected by simple random method and four locations within each cell were selected non-randomly. The values of environmental variable were recorded from the locations and its mean value was taken for the analysis. As the human-elephant interaction was absent in the

western side of the District, cells with non-forest areas were omitted. The entry and exit of environmental variables were determined by Wald Statistic with *P*-values of 0.05 and 0.1 respectively. Spearman's rank correlation (r_s) was used to observe the association between predicted probabilities of the occurrence of crop damage from the logistic model and number of crop raiding incidents in the grid cells.

2.1.3. Consumption of coconut by Indian giant squirrel

The consumption of coconut by Indian giant squirrel was quantified by taking quadrats of 10 m x 10 m systematically in the fringe areas of the three Forest Ranges, where this behaviour was observed. Six quadrats with 20 coconut trees were marked in the Machad Forest Range, three quadrats with 6 coconut trees in Palappilly Forest Range and three quadrats with 10 coconut trees observed in Peechi Forest Range of Peechi-Vazhani Wildlife Sanctuary. As the forest fringes of Palappilly Forest Range was extensively occupied with rubber plantation, all quadrats were laid in the same location. Data were collected from April 2009 to March 2012 and the coconuts consumed per tree were recorded in each month (n=36) from the quadrats. Feeding behaviour of the species was quantified using Altman's sequence sampling method (Altman, 1974), in which, the time of encounter and duration for consuming single coconut were documented with a stop watch. Seven observations were recorded from Machad Forest Range and one was from Peechi Forest Range and total time of observation was 19 hours.

2.1.4. Estimating the availability of food for Indian giant squirrel

Availability of natural food within the Reserve Forest was estimated by employing Point centered quarter method. 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. 7). 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. Distance to the nearest trees was estimated in all the four quarters. The trees were identified with the help of experts in KFRI. The identity of trees inside the control plots was identified and their diameter at breast height (DBH) was measured using a tape.

2.1.5. Assessment of paddy damage

Peafowl and other birds made extensive damage on paddy and vegetables in Wadakkencherry Forest Range of Thrissur Forest Division. Paddy damage by peafowl and other birds was assessed by enclosure experiment, which was conducted near Chulannur Peafowl Sanctuary ($10^0$43'55.2"N & $76^0$19'54.48"E), Chulannur (Plate 3). Plots of paddy field were protected with metallic frames and plastic nets (10 m x 10 m) to prevent the consumption of paddy by peafowl and other birds. They functioned as control plots. Consumption of paddy was estimated by comparing the yield of paddy from the control plots and the sample plots. Four plots (2 control and 2 experimental) were monitored in four seasons (December 2009, September 2010, December 2010 and September 2011).

2.1.6. 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 (n=36), the price of commodities in central Kerala for 3 days were selected, with a gap of 10 days. Economic loss was calculated by multiplying the average market price of the commodities and the quantity of crops damaged from the quadrats. For estimating the potential loss of perennial crops, initially, its economic life period was divided into immature phase and productive phase. If a crop 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 having serious damage by wild animals (partial damage was not considered) and the species of crops damaged not less 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.

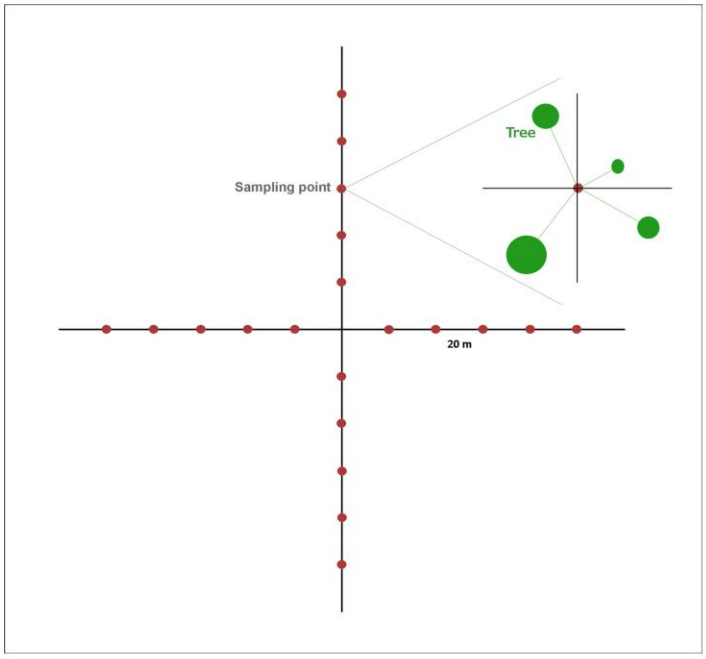


Fig. 7. Pictorial representation of Point Centered Quarter (PCQ) method.

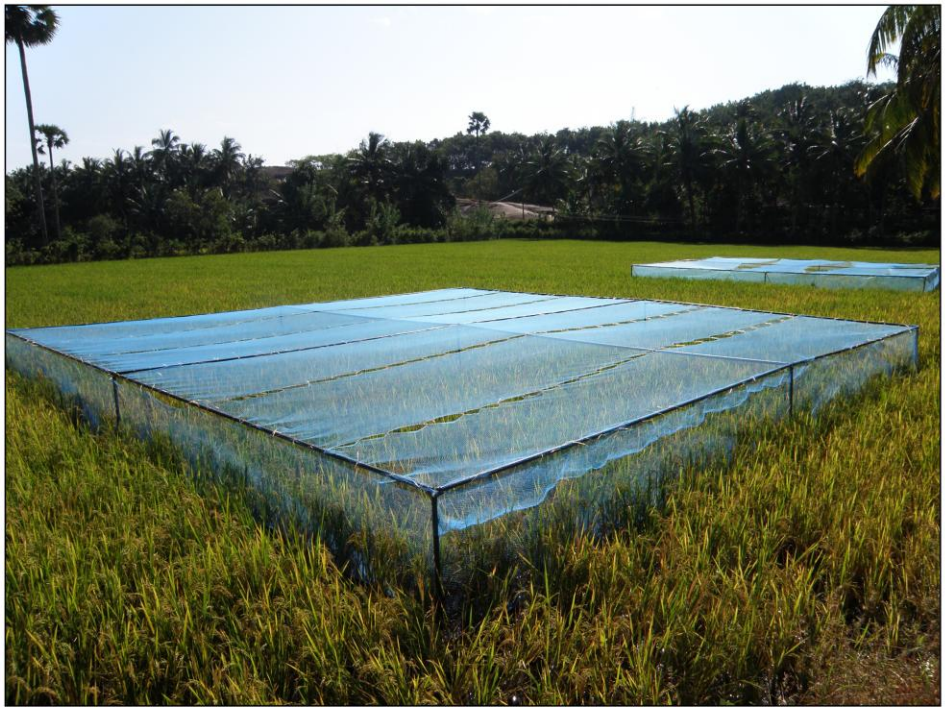


Plate 3. Paddy enclosure experiment conducted in the paddy field near Chulannur Peafowl Sanctuary, central Kerala.

2.2. Control measures

2.2.1. Chilli-rope and chilli-dung brick

Chilli powder makes irritation to elephants. In chilli-rope method, coir rope was saturated with the mixture of chilli powder and used engine oil and it was positioned around the cultivation (Chelliah *et al*., 2010). This will produce burning sensation to the elephants. Two places namely Athirappally ($10^0$17'15"N & $76^0$33'50.4"E) of Charpa Forest Range and Ayyampuzha ($10^0$16'17.4"N & $76^0$27'31.32"E) of Athirappally Forest Range were selected for chilli-rope experiment. Chilli-rope was prepared by smearing the coir rope (5 cm circumference) with a mixture of chilli powder (*Capsicum* sp.) and used engine oil in the ratio of 1:2 (3 L engine oil:1.5 kg chilli powder). Engine oil helps to stick the chilli powder on the coir even in heavy rain. Chilli-rope was tied along the boundary of the forest, where in adjacent private lands were planted with jackfruit (*Artocarpus heterophyllus*), arecanut (*Areca catechu*), coconut and plantain (*Musa paradisiaca*). The entry points of elephants were identified and monitored before installing the chilli-ropes. The coir-rope was 150 m in length and fixed at 2 m above the ground level, where in the adult elephants would get a chance to touch the rope just below the eye level. For smearing the entire coir rope with the mixture, 4 L of engine oil were used. The mixture was applied 9 times on the coir rope after examining the presence of chilli on the rope. The encounter of elephants with the chilli-rope and its efficiency were monitored on each day.

Chilli-dung brick was prepared by mixing the chilli powder and elephant-dung and allowing it to dry and this was burned near the crop field. The noxious smell emanating from the chilli-dung brick will disturb the elephants, producing sneezing or burning sensation (Osei-Owusu *et al*., 2008). Chilli-dung brick experiment was conducted at Athirappally ($10^0$17'15"N & $76^0$33'50.4"E) of Charpa Forest Range, where the presence of elephant was frequent in the crop field. Chilli-dung brick was produced by mixing chilli powder with fresh cow-dung, initially in the ratio 1:5 (1 kg chilli powder : 5 kg cow-dung) and later 1:1 and allowing it to dry keeping in a mould with a dimension of 15 cm x 15 cm x 15 cm. Cow-dung was used due to the shortage of elephant-dung near the locality. Moreover, discussion was made with African researchers on the ratio of chilli powder and cow-dung and confirmed that, 1:5 ratio is sufficient to deter wild elephants under African conditions. This dried mixture (Chilli-dung brick) was then burned in the field after getting information from the local people about the presence of elephants or the sound of elephants in the nearby Reserve Forest. The entire study area (1000 m^2) was planted with edible crops for elephants like jack

tree and cash crops such as coconut tree, areca nut tree and rubber. In each case, 2 chilli-bricks were burned in the plot with a gap of 100 m. Efficiency of chilli-brick was evaluated from May 2010 to November 2010 and observations were recorded on encounter of elephants in the area or the attempt of elephants to enter the crop fields.

2.2.2. Yellow-coloured plastic sheet fence

During the field survey, application of yellow plastic sheet as fence in Pariyaram Forest Range was recorded in a newly planted rubber plantation, for deterring the herbivores (wild pig and sambar). This innovative remedial measure was known to prevent the entry of wild animals to the crop field and its efficiency was evaluated in Randukai ($10^0$20'38.4"N & $76^0$27'34.2"E) of Pariyaram Forest Range. The study area was selected in a private land (fringe area of the forest) having mixed cultivation. Yellow plastic sheet (6 feet height) was fixed in the boundary of this farm spanning an area of 16,000 m^2. Overall expenditure of the experiment, including the cost of sheet and its installation was around Rs. 15,000/-, which was invested by the farmers. A total of 12 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). Two more quadrats were also taken in the Reserve Forest as control plots. All the quadrats were laid within a km^2. Month-wise observation was recorded from the quadrats and the per cent of encounter was documented from April 2010 to March 2011 (n=12).

2.2.3. Solar electric fence

Twelve quadrats (10 m x 10 m) were laid in two locations for evaluating the efficiency of this method. Six quadrats were taken within the crop field, protected by solar electric fence and 6 quadrats in the Reserve Forest. All the quadrats were laid within 250 m^2. Month-wise observation was recorded from the quadrats and the per cent of encounter was documented from April 2010 to March 2011 (n=12) in the Palappilly Forest Range; whereas, in the Peechi Forest Range, it was recorded in each week from January 2012 to December 2012 (n=12).

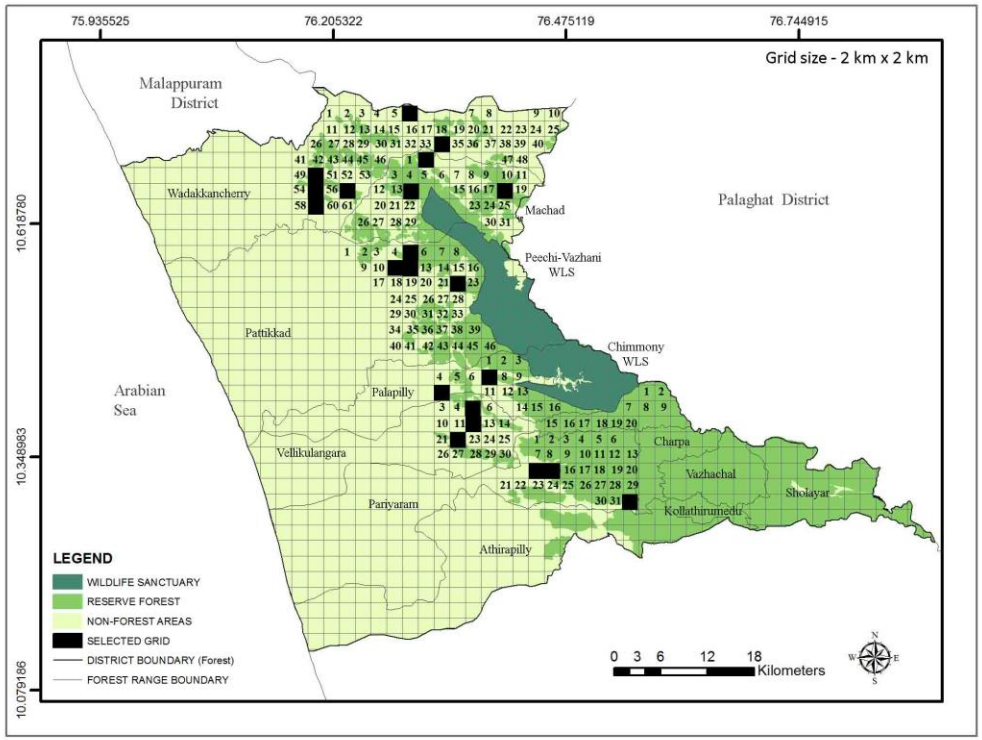


Fig. 8. Locations selected for focus group discussion in Thrissur District.

2.3. Conservation attitudes

Structured questionnaire survey was carried out in the Forest Ranges of Thrissur District 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 (Fig. 8). Non-forest areas towards the western side of the District and wildlife sanctuaries were omitted from the grids, as the human-wildlife interaction in the non-forest areas and human habitations within the wildlife sanctuary were negligible. Grids were selected using simple random method for the survey. From each Forest Range, 10 % of the total grids were selected randomly and the houses within the grids were selected non-randomly (Table 2). Ten houses were selected for the survey from each grid. Sixty questions were included in the questionnaire proforma, mainly focusing on details of the area, cultivation, crop damage, lifting of livestock, human casualties and social dimension. Emphasis was also 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. Interviewees were made in the homes and roughly 15 to 20 minutes was utilised 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 and nearby vegetation.

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 2. Grids selected using simple random method

Sl. no.	Forest Ranges	Total grids	Grids selected using random table	Number of houses surveyed
1	Wadakkencherry	63	6, 34, 50, 55, 57, 59	60
2	Machad	31	2, 14, 18	30
3	Pattikkad	46	5, 11, 12, 22	40
4	Palappilly	16	7, 10	20
5	Vellikulangara	30	5, 12, 22	30
6	Pariyaram	32	14, 15, 32	30
Total				**210**

A total of 210 houses were surveyed from 6 Forest Ranges namely Wadakkencherry, Machad, Pattikkad, Palappilly, Vellikulangara and Pariyaram (Table 2). Other Forest Ranges namely Athirappally, Charpa, Vazhachal, Kollathirumedu and Sholayar of Vazhachal Forest Division were omitted from the survey, as the cultivation of crops was negligible in these Ranges.

2.3.1. Predicting the potential areas of crop loss

Nineteen grama panchayaths are facing serious crop damage in the District and 60 % of the affected grama panchayaths (Table 20) were selected for predicting the potential areas. Different candidate models were prepared based on the variables of questionnaire survey and the top model was selected for identifying the factors associated in the prediction (Karanth *et al*., 2012; Karanth *et al*., 2013). Various hypotheses about the characteristics of crop damage reported in the focus group discussion were used for representing the models. The Pearson's correlation coefficients were calculated to find the colinearity of variables involved in each

model. The Corrected Akaike's Information Criterion (AIC_c) was used for defining the models, evaluating the model fit and recognizing the variables of crop damage. The best models (cumulative weight>0.95) were selected to estimate the probabilities of crop loss (Burnham and Anderson, 2002) and their weighted estimated probability at each sampled location was provided to produce the posterior probability map. Ordinary kriging (spherical model) in the spatial analyst tool of Arc Map v.9 GIS Software Package was used to fit the weighted estimated probability.

2.3.2. Analysis of newspaper media reports

Reports on human-wildlife conflict in the newspapers were collected during the study period and analysed. The newspapers were 1. The Hindu, 2. New Indian Express, 3.Decan Chronicle (Kochi Edition), 4. Mathrubhumi, 5. Malayala Manorama, 6. Maadhyamam (Thrissur Edition) and 7. Chandrika (Malappuram Edition).

3. RESULTS

3.1. Crop damage

Animals involved in crop damage in Thrissur District were Wild pig (*Sus scrofa*), Indian elephant (*Elephas maximus*), Indian crested porcupine (*Hystrix indica*), Indian pea fowl (*Pavo cristatus*), Indian giant squirrel (*Ratufa indica*), giant flying squirrel (*Petaurista philippensis*), spotted deer (*Axis axis*) and sambar (*Rusa unicolor*). Most important crops damaged were coconut, plantain, rubber, paddy and underground tubers like yam, colocasia, sweet potato, tapioca and vegetables like pea, cucumber, pumpkin, ash gourd and brinjal. Number of plants damaged by wild animals in the permanent quadrates is given in the Table 3.

Table 3. Number of plants damaged by wild animals in the permanent quadrates in the study area.

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		
Wadakkencherry Forest Range					
1	Rubber	12	-	10	115
2	Plantain	8	-		
3	Turmeric	8	-		
4	Tapioca	150	21		
Machad Forest Range					
1	Rubber	13	-	20	1467
2	Plantain	38	6		
3	Tapioca	20	-		
4	Colacasia	2	2		
Pattikkad Forest Range					
1	Rubber	35	-	10	8
2	Plantain	108	24		
Peechi Forest Range					
1	Rubber	21	-	10	1429
2	Areca nut	14	-		
3	Plantain	52	-		
4	Capsicum	8	-		
Palappilly Forest Range					
1	Areca nut	28	-	6	203
2	Tapioca	210	28		
3	Nutmeg	8	-		

Vellikulangara Forest Range					
1	Rubber	16	-	9	91
2	Areca nut	7	-		
3	Plantain	25	-		
4	Elephant yam	3	-		
Pariyaram Forest Range					
1	Areca nut	8	-	9	60
2	Plantain	74	3		
3	Elephant yam	9	6		
4	Colacasia	4	4		
5	Nutmeg	1	-		
6	Rubber	8	-		
Charpa Forest Range					
1	Rubber	25	-	11	0
2	Colacasia	8	8		
3	Elephant yam	2	2		

3.1.1. Asian elephant (*Elephas maximus*)

This species comes under Schedule I of the Wildlife Protection Act and listed as endangered species by IUCN due to poaching, habitat loss, degradation and fragmentation. It inhabits grasslands, dry deciduous, moist deciduous, evergreen and semi-evergreen forests.

Asian elephants are in conflict with people at Malakkappara the eastern most part of the District. Cash crops damaged by elephants in the District were plantain (*Musa paradisica*), coconut (*Cocos nucifera*), arecanut (*Areca catechu*), oil palm (*Elaeis guineensis)*, rubber (*Hevea braziliensis*), cocoa (*Theobroma cacao*), turmeric (*Curcuma longa*) and nutmeg (*Myristica fragrans*). Human-elephant conflict was reported from Thekkumpadam, Mayiladumpara, Vazhakkumpara, Chelikkuzhi, Jandamukku, Thamaravellachal, Edasserymukku, Marottichal and Vallore of Pattikkad Forest Range; Olakara of Peechi Forest Range; Echippara and Elikode of Palappilly Forest Range; Nayattukundu, Vellikulangara, Kormala, Randukai and Peelarmuzhi of Pariyaram Forest Range; Ayyampuzha of Athirappally Forest Range; Athirappally of Charpa Forest Range; Vachumaram of Kollathirumedu Forest Range and Malakkappara of Sholayar Forest Range (Fig. 9). Vellikulangara, Vazhachal, Kollathirumedu and Sholayar Forest Ranges were not experiencing elephant raids. Damage to human property and houses was serious in the above Ranges.

Intensive crop damage was not reported from Peechi, Vellikulangara, Vazhachal, Kollathirumedu and Sholayar Forest Ranges. Damage to property and houses was a grave problem in the above Ranges. Pattikkad, Palappilly and Pariyaram Forest Ranges were facing severe crop damage due to elephants. The NH-47 from Ernakulam to Coimbatore and passing

through the Peechi-Vazhani Wildlife Sanctuary blocks the movement of elephants to the northern portions of the District like Machad and Wadakkencherry Forest Ranges (Fig. 9). But it was recorded that, elephants do come up to 2 km near the NH-47, at Kuthiran Mala. Elephants were frequent crop raiders in the eastern part of the District and the financial loss due to a single raid is also very high. Early midnight was the preferred time for crop raids (n=16). As more and more people are putting pressure on the forest areas of the eastern side of the District, human-elephant conflict is also growing.

Farmers in the fringe areas of the forest encourage 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 and coconut. Rubber, nutmeg and cocoa were also damaged as they were planted as intercrop in the plantations. In the plantations of Plantation Corporation of Kerala (PCK) in the Athirappally Forest Range, oil palms were damaged and the emerging shoots were consumed. Elephants raided up to 400 m inside the cultivated crops. While raiding crops, on an average 5.42±1.68 elephants were recorded per herd and 65% of herds had juveniles. Highest crop damage was reported during the months of September and October (Fig. 10).

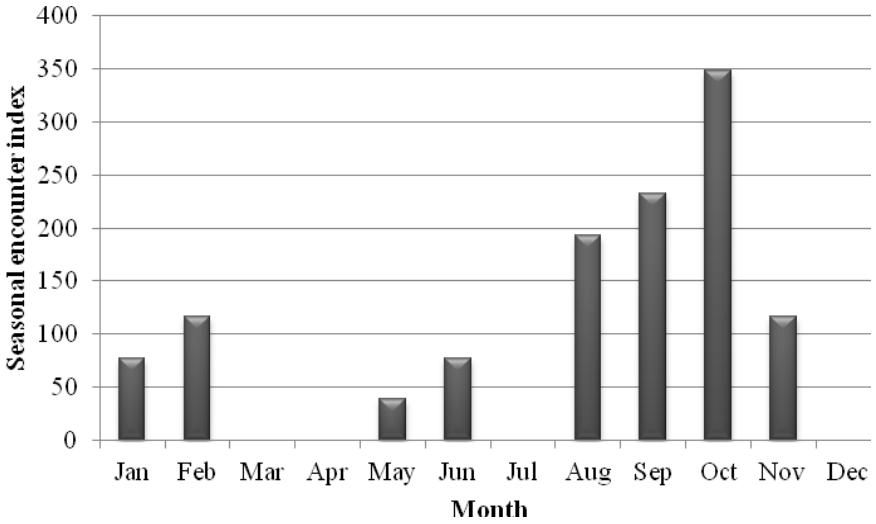


Fig. 10. Seasonal variation in crops damaged by Asian elephants in Thrissur District (April 2009 – March 2012).

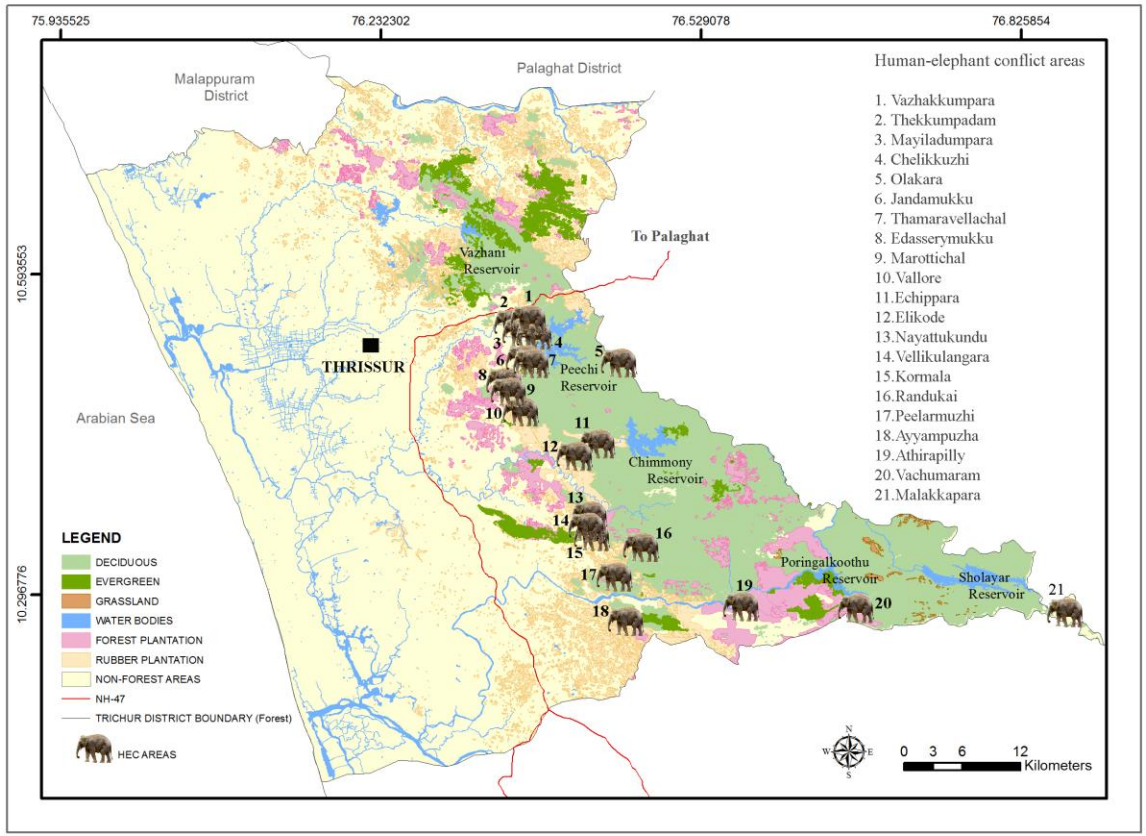


Fig. 9. Locations of human-elephant conflict (HEC) in Thrissur District.

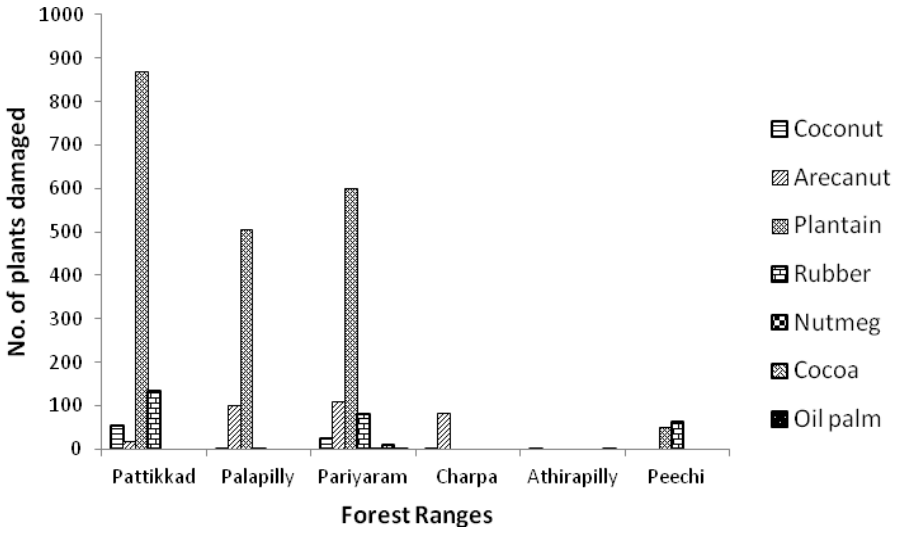


Fig.11. Crops damaged by Asian elephants in different Forest Ranges (April 2009 – March 2012).

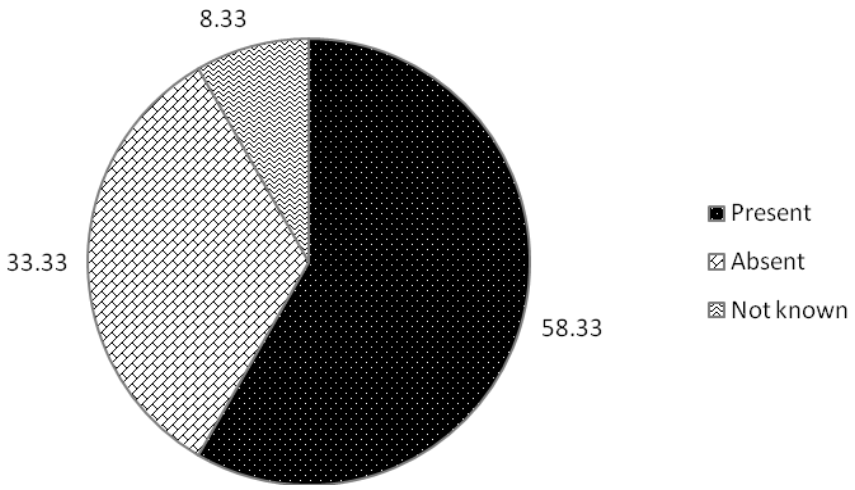


Fig. 12. Percentage of juveniles in a herd while damaging crops (n=24).

Thirty one cases of encounters in crop fields were reported during the period. Pariyaram Forest Range, followed by Palappilly and Pattikkad were facing serious crop damage. Most of the encounter (83.87%) was recorded in the early mid night (2000 hrs – 0000 hrs) and diurnal feeding (1500 hrs) was reported from Vallore of Pattikkad Forest Range. Seventy four per cent of the total encounters occurred during the north-east monsoon season (September – December).

Elephants mostly damaged plantain (74.11%), followed by areca nut tree (11.38%) and coconut tree (3.37%). Rubber tree (10.44%), nutmeg plant (0.14%), oil palm (0.18%) and cocoa plants (0.37%) were also destroyed, as they were planted as intercrop in the

plantations. Farmers cultivated plantains in the initial stages of newly planted rubber. While consuming plantains, the unpalatable rubber plants were destroyed. This inter-crop pattern was found in 30 % of total area raided, namely Pattikkad (43.43%), Palapilly (27.91%), Pariyaram (23.21%) and Peechi (22.22%) (Table 4). No rubber plants were destroyed in Palappilly Forest Range, because, the age of the plants exceeded more than 3 years and all immature trees were survived while consuming plantains. The pseudo-stem of the plantain was preferred as staple food, but the unripe fruit was left behind. All the plants were destroyed during the same period. Forty nine per cent of areca nut trees were trampled during the immature phase and the remaining occurred in the productive phase. Most of the coconut trees were also uprooted during the productive phase (76.09%) and the fresh leaves of the trees were consumed.

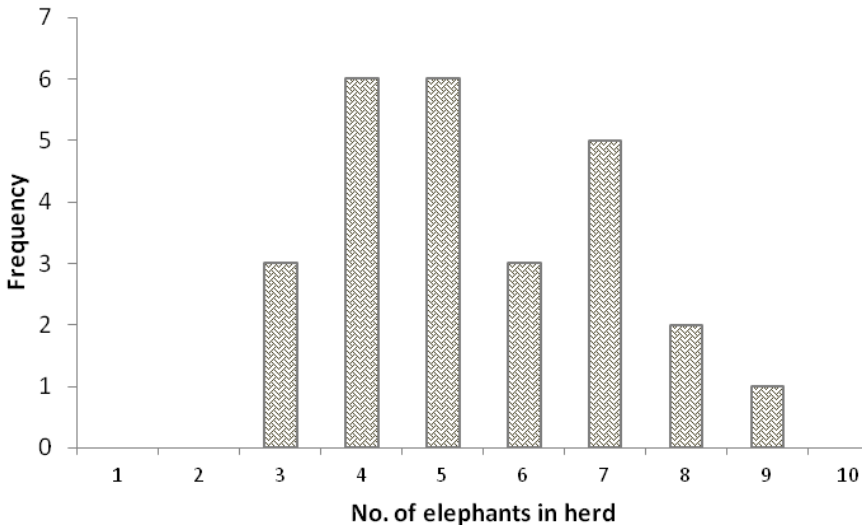


Fig. 13. Group composition of Asian elephants engaged in crop damage in Thrissur District (n=26).

Plate 4. Inter-crop pattern was seen in the marginal areas.

Plate 5. Coconut and arecanut trees were uprooted at Charpa Forest Range.

Plate 6. Oil palm was uprooted at Athirapilly Forest Range.

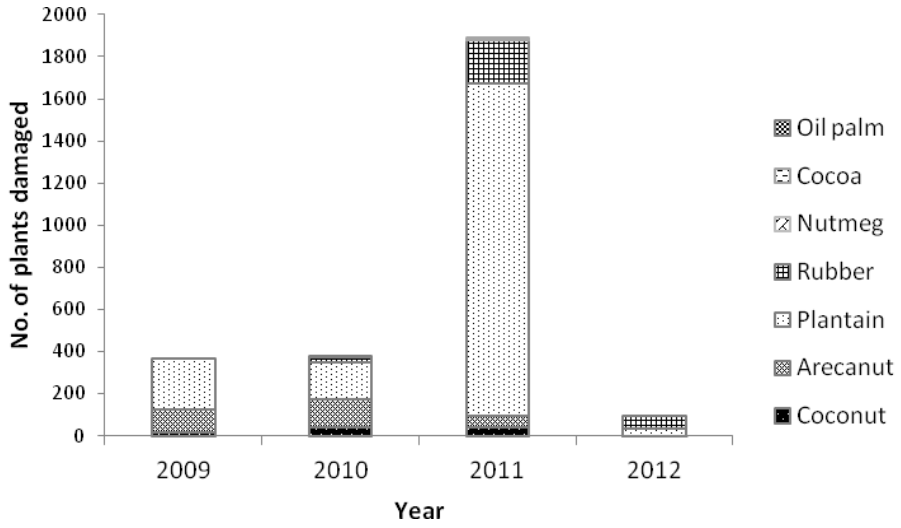


Fig. 14. Incidence of crop damage by Asian elephant in Thrissur District (April 2009 – March 2012).

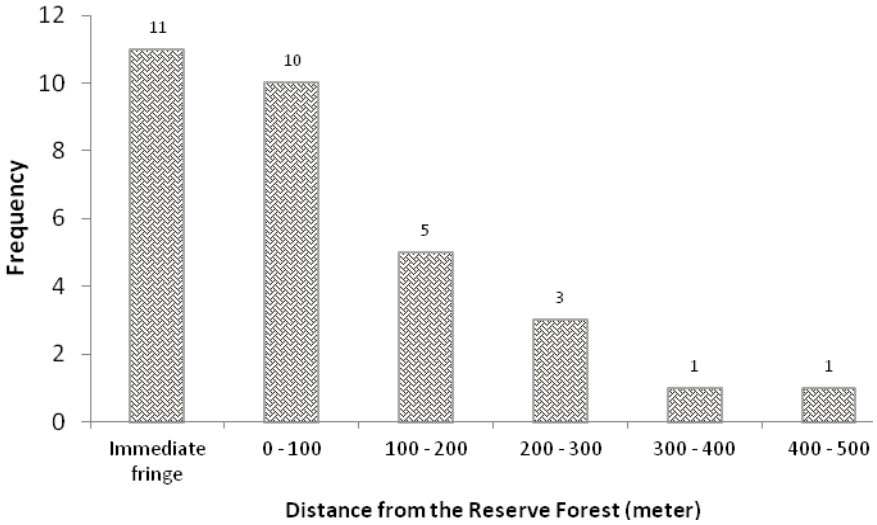


Fig. 15. Distance from Reserve Forest to the crop fields (n=31).

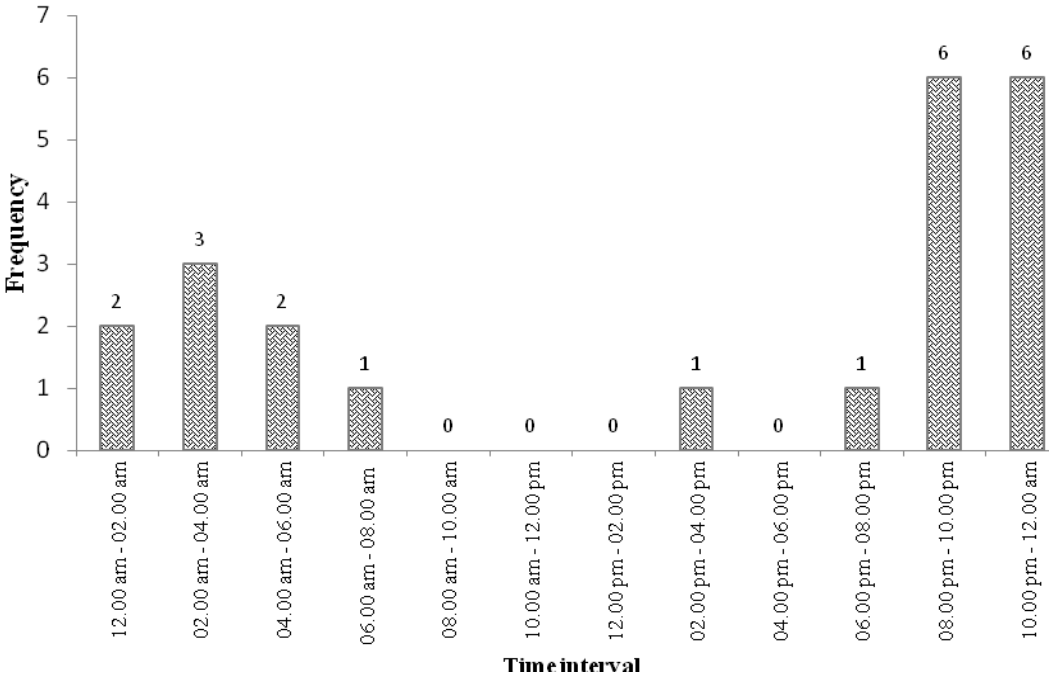


Fig. 16. Time of crop damage by Asian elephants
in Thrissur District (n=22).

Table 4. Locations of elephant damage in the Forest Ranges of Thrissur District (n=238).

Forest Ranges	**Total area of crops damaged (ha)**	**Damaged area with inter-crops (ha)**
Pattikkad	0.99	0.43
Palapilly	0.43	0.12
Pariyaram	0.56	0.13
Charpa	0.18	0
Athirapilly	0.04	0
Peechi	0.18	0.04
Total	**2.38**	**0.72**

The negative interaction between humans and elephants in Thrissur District was linked to the attitudes and activities of humans. 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. In Thrissur District, the fringe areas of the Forest Ranges namely Pattikkad, Palappilly, Pariyaram and Peechi are not recorded as core range of elephants earlier. Planting of cash crops in the immediate fringe areas of the forest attracted elephants to human habitations. During the encounter, elephants preferred mature plantains and consumed the pseudo-stem of the plants. Inter-crop pattern was seen maximum at Pattikkad Forest Range in the raided areas, followed by Pariyaram and Peechi Forest Ranges (Table 4). Inter-crop pattern in the fringe areas fuelled human-elephant interactions. Yielding of plantains during the north-east monsoon, season also boosted the human-elephant conflict, because, the movement of elephants to low elevation area is frequent during this period. As the market price of rubber is high compared to other crops, the farmers are not ready to bear the damage due to the Asian elephants.

3.1.2. Wild pig (*Sus scrofa* Linnaeus)

The species is distributed in all the Forest Ranges in the District, including different type of plantations. It is a nocturnal feeder and chooses tubers among the crops. Damage to crops was reported from the Forest Ranges namely Pattikkad, Peechi, Wadakkencherry, Machad, Palappilly, Pariyaram, Vellikulangara and Charpa. Highest crop damage was reported from Wadakkencherry followed by Pariyaram and Machad. As the cultivation of crops was negligible in Athirappally, Vazhachal, Kollathirumedu and Sholayar forest ranges, crop damage due to wild pig was not recorded from these Ranges. It mainly consumed fallen coconuts in the fringe areas of the forest followed by tubers and plantains. Coconuts were consumed by removing the mesocarp and endocarp and feeding the endosperm. Occasionally, coconuts were carried to the forest and consumed there. Banana, rhizome of the plantain and tubers like tapioca, Colocasia etc. were preferred items as food. As this species belongs to the omnivore category, soil organisms were also fed by grubbing the soil and this mode of attack was recorded from the paddy fields while searching the earthworms, which ultimately damaged the paddy also.

Table 5. Presence of wild pig recorded from different Forest Ranges in different months

Years	Months	Forest Ranges*							
		Mac	Wad	Pal	Par	Vel	Pat	Pee	Cha
2009	Apr	-	-	-	+	-	+	+	-
	May	-	-	-	+	-	+	-	-
	Jun	+	-	-	+	+	-	-	-
	Jul	-	-	-	+	-	+	-	+

	Aug	+	-	-	-	+	-	-	-
	Sep	+	+	+	-	+	-	-	-
	Oct	+	+	-	-	+	-	+	-
	Nov	+	+	+	+	-	+	+	+
	Dec	+	+	-	+	-	+	+	+
2010	Jan	+	+	-	-	-	-	+	+
	Feb	-	+	-	-	+	-	-	+
	Mar	-	+	+	+	+	-	+	+
	Apr	+	+	-	-	-	-	-	-
	May	-	-	+	-	-	-	-	-
	Jun	-	-	-	+	+	+	-	+
	Jul	-	+	-	-	+	-	-	+
	Aug	+	+	-	+	+	-	+	-
	Sep	+	+	-	+	+	+	+	-
	Oct	+	+	+	+	+	+	+	-
	Nov	+	+	+	+	+	+	+	+
	Dec	+	+	-	+	-	+	+	+
2011	Jan	+	+	-	+	-	+	+	-
	Feb	-	+	-	+	-	-	+	-
	Mar	+	+	-	-	-	+	-	+
	Apr	-	-	-	+	-	+	+	+
	May	-	+	+	-	-	-	-	-
	Jun	-	+	-	+	+	+	-	+
	Jul	-	-	-	-	+	-	-	+
	Aug	+	+	-	-	+	-	+	-
	Sep	+	+	-	-	+	+	+	-
	Oct	+	+	+	+	+	+	+	-
	Nov	+	+	+	+	+	+	+	+
	Dec	+	+	-	+	-	+	+	+
2012	Jan	+	+	+	+	+	+	+	-
	Feb	-	+	+	+	+	+	-	+
	Mar	-	+	-	+	+	+	+	+

+ Presence reported
- Absent

***Forest Ranges**

Mac - Machad
Wad - Wadakkancherry
Pal - Palapilly
Par - Pariyaram
Vel - Vellikulangara
Pat - Pattikkad
Pee - Peechi
Cha - Charpa

Plate 7. Plantain was damaged by wild pig at Machad Forest Range

Plate 8. Colocasia was damaged by wild pig at Vellikulangara Forest Range

Plate 9. Paddy field was damaged at Wadakkancherry Forest Range

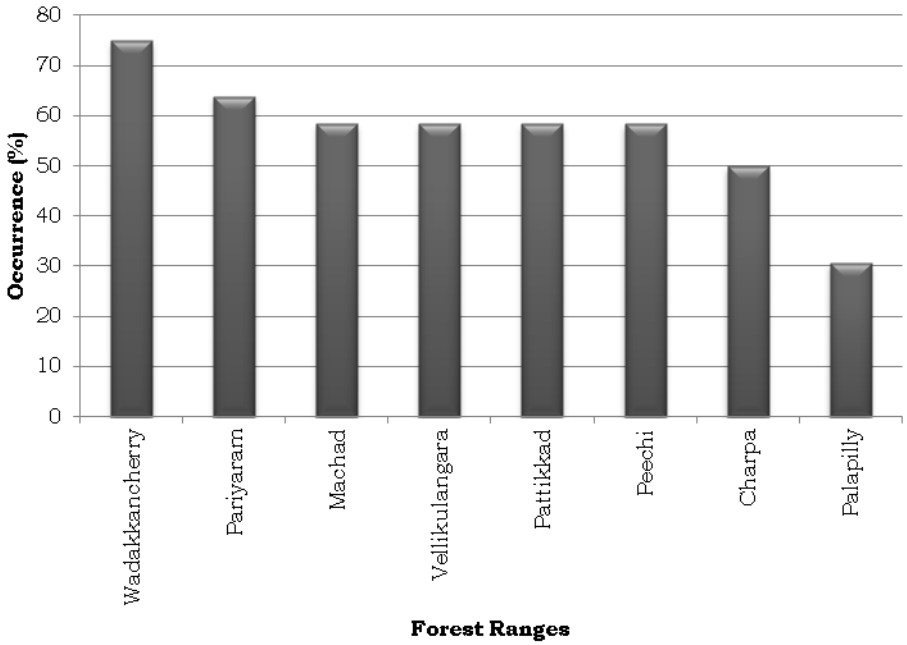


Fig. 17. Percentage occurrence of wild pig in the fringe areas of different Forest Ranges in Thrissur District (n=36).

3.1.3. Indian crested porcupine (*Hystrix indica* Kerr)

It is the largest rodent in India, reported from all the Forest Ranges, but crop damage was recorded from Pattikkad, Peechi, Wadakkencherry, Machad, Palappilly, Pariyaram, Vellikulangara and Charpa Forest Ranges. It consumed fallen coconuts on the ground and debarked the basal portion of coconut trees in the forest fringes. Damage to crops was highest in Vellikulangara Forest Range. Like wild pig, coconuts were consumed by removing the mesocarp and endocarp and then consuming the endosperm. But the method of consumption was different from wild pig and in this species; they removed mesocarp by sharp edges with uniform size (Plate 12). As the Indian crested porcupine belongs to the order Rodentia, cutting of plastic nets and entering the crop fields was recorded from Machad Forest Range.

Table 6. Presence of Indian crested porcupine recorded from different Forest Ranges in Thrissur District

Year	Month	Forest Ranges*							
		Mac	Wad	Pal	Par	Vel	Pat	Pee	Cha
2009	Apr	-	-	-	+	-	-	-	-
	May	-	-	-	-	-	-	-	-
	Jun	-	-	-	-	+	-	-	-
	Jul	-	-	-	+	+	-	-	-
	Aug	-	+	-	+	-	-	-	-

	Sep	+	+	-	-	+	-	-	-
	Oct	+	-	-	-	+	-	-	-
	Nov	-	-	-	-	-	-	-	-
	Dec	+	-	-	-	+	+	-	-
2010	Jan	-	-	-	-	+	-	-	-
	Feb	-	-	-	-	+	-	-	-
	Mar	-	+	-	-	-	-	-	-
	Apr	-	-	-	-	+	-	-	-
	May	-	-	-	-	+	-	-	-
	Jun	-	-	-	+	+	-	-	-
	Jul	+	+	-	-	+	-	-	-
	Aug	-	-	-	-	+	-	-	-
	Sep	-	-	-	-	-	-	-	-
	Oct	+	-	-	-	+	-	-	-
	Nov	+	-	-	-	+	-	-	-
	Dec	+	-	-	-	+	-	-	-
2011	Jan	-	-	+	-	+	+	+	-
	Feb	+	-	-	-	+	-	-	-
	Mar	-	-	-	+	+	-	-	-
	Apr	-	-	-	-	+	-	-	-
	May	-	-	-	+	+	-	-	-
	Jun	-	-	-	-	+	-	-	-
	Jul	+	+	-	-	+	+	-	-
	Aug	-	-	-	-	+	-	-	-
	Sep	-	-	-	-	-	-	-	-
	Oct	+	-	-	-	+	-	-	-
	Nov	+	-	-	-	+	-	+	-
	Dec	+	-	-	-	+	-	-	-
2012	Jan	+	-	-	-	-	-	+	-
	Feb	-	+	-	-	+	-	-	-
	Mar	+	+	-	-	+	-	-	-

+ Presence reported
- Absent

***Forest Ranges**

Mac - Machad
Wad - Wadakkancherry
Pal - Palapilly
Par - Pariyaram
Vel - Vellikulangara
Pat - Pattikkad
Pee - Peechi
Cha - Charpa

Plate 10. Coconuts were damaged by Indian crested porcupine at Vellikulangara Forest Range

Plate 11. Coconut plant was damaged by Indian crested porcupine.at Vellikulangara Forest Range.

Plate 12. Wild pig removed mesocarp with irregular shape (above) and Indian crested porcupine removed mesocarp with sharp edges (below).

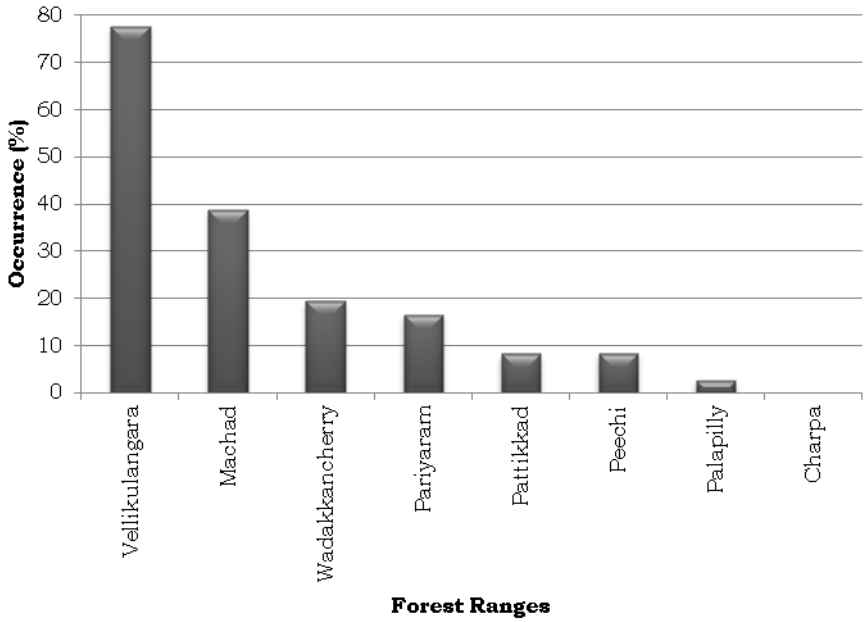


Fig. 18. Percentage occurrence of Indian crested porcupine in the fringe areas of different Forest Ranges in Thrissur District (n=36).

3.1.4. Indian giant squirrel (*Ratufa indica maxima* Schreber)

Indian giant squirrel was recorded from all the Forest Divisions and Wildlife Sanctuaries of the Thrissur District, but the consumption of tender coconuts was observed only from Peechi, Machad and Palappilly Forest Ranges (Fig. 21). Coconuts were consumed by making a hole into the endocarp after removing the mesocarp (Plate 14). It took the endosperm with its fore-limb and consumed the coconut water after inserting head through the hole. The opening had a circumference of 19.1±4.2 cm (n=200). As the endocarp of the pre-ripened coconut is comparatively soft, the animal could easily use its incisors to open the hard nut. Even though the presence of species was recorded throughout the year, highest consumption was recorded during the month of November (3.04±0.61 nuts/tree), followed by December and January and minimum in the month of May (0.79±0.23 nuts/tree).

Indian giant squirrel is doing damage to coconuts in Machad Range (Pangarapilly and Kakkinikkad). The feeding of Indian giant squirrel on coconuts was recorded for the first time in India during this study. During the initial period of study, the damage was approximately 2 coconuts/tree/month in the fringe areas of the forest. But later observations revealed an increase of up to 4 to 5 nuts/tree/month.

Table 7. Number of coconuts consumed by Indian giant squirrel
In different forest ranges.

Months	Machad Forest Range		Palapilly Forest Range		Peechi Forest Range		Mean nuts destroyed per tree
	Number of nuts destroyed (n=20)	Nuts destroyed per tree	Number of nuts destroyed (n=6)	Nuts destroyed per tree	Number of nuts destroyed (n=10)	Nuts destroyed per tree	
Apr-09	29	1.45	2	0.33	-	-	0.89
May-09	21	1.05	0	0.00	-	-	0.53
Jun-09	56	2.8	0	0.00	-	-	1.40
Jul-09	77	3.85	6	1.00	-	-	2.43
Aug-09	55	2.75	7	1.17	-	-	1.96
Sep-09	32	1.6	4	0.67	-	-	1.13
Oct-09	26	1.3	0	0.00	30	3	1.43
Nov-09	74	3.7	7	1.17	27	2.7	2.52
Dec-09	28	1.4	10	1.67	78	7.8	3.62
Jan-10	92	4.6	5	0.83	53	5.3	3.58
Feb-10	44	2.2	3	0.50	77	7.7	3.47
Mar-10	59	2.95	4	0.67	31	3.1	2.24
Apr-10	44	2.2	0	0.00	15	1.5	1.23
May-10	36	1.8	0	0.00	10	1	0.93
Jun-10	41	2.05	1	0.17	41	4.1	2.11
Jul-10	50	2.5	1	0.17	54	5.4	2.69
Aug-10	55	2.75	3	0.50	71	7.1	3.45
Sep-10	49	2.45	1	0.17	88	8.8	3.81
Oct-10	31	1.55	0	0.00	14	1.4	0.98
Nov-10	81	4.05	1	0.17	69	6.9	3.71
Dec-10	34	1.7	8	1.33	43	4.3	2.44
Jan-11	42	2.1	1	0.17	35	3.5	1.92
Feb-11	13	0.65	1	0.17	18	1.8	0.87
Mar-11	2	0.1	3	0.50	27	2.7	1.10
Apr-11	18	0.9	0	0.00	14	1.4	0.77
May-11	12	0.6	0	0.00	21	2.1	0.90
Jun-11	10	0.5	2	0.33	46	4.6	1.81
Jul-11	35	1.75	3	0.50	48	4.8	2.35
Aug-11	22	1.1	3	0.50	65	6.5	2.70
Sep-11	31	1.55	1	0.17	72	7.2	2.97
Oct-11	21	1.05	5	0.83	49	4.9	2.26
Nov-11	32	1.6	1	0.17	69	6.9	2.89
Dec-11	25	1.25	8	1.33	43	4.3	2.29
Jan-12	51	2.55	2	0.33	51	5.1	2.66
Feb-12	41	2.05	1	0.17	68	6.8	3.01
Mar-12	62	3.1	4	0.67	71	7.1	3.62
Overall mean							**2.2**

- Data not recorded

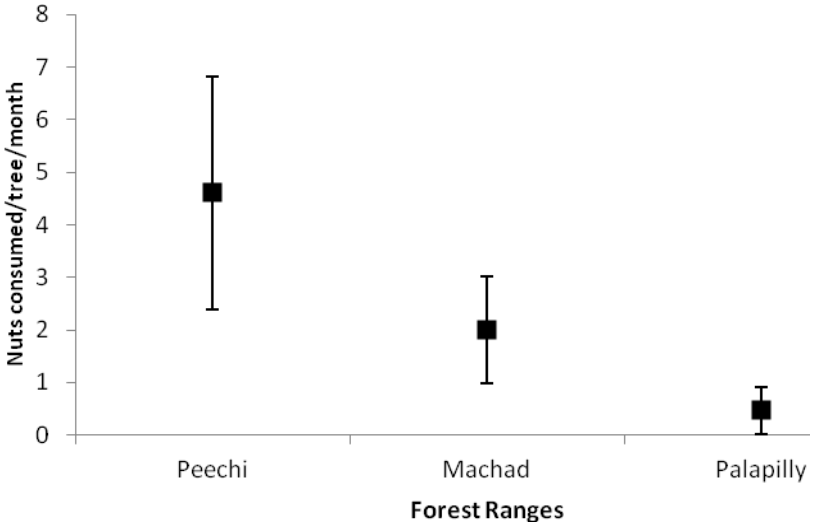


Fig. 19. Intensity of feeding on coconuts by Indian giant squirrel in three Forest Ranges of Thrissur District (n=36)

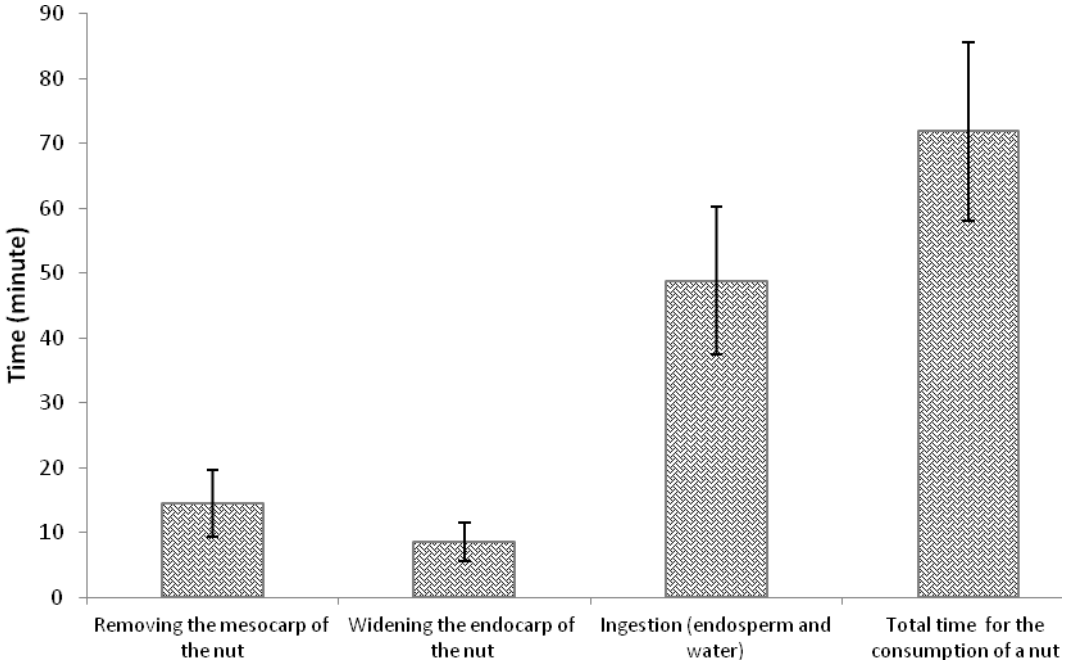


Fig. 20. Requirement of time for consuming a coconut by Indian giant squirrel (n=8).

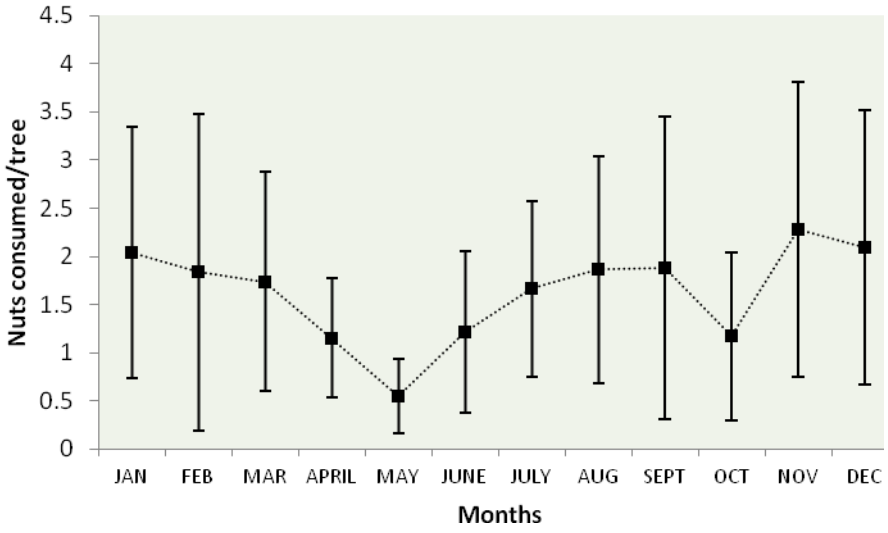


Fig. 22. Seasonal variation in the consumption of coconuts by Indian giant squirrel in Thrissur District (April 2009 to March 2012).

Other rodents namely Giant flying squirrel (*Petaurista philippensis*) (Plate 15) and house rat (*Rattus rattus*) also consumed tender coconuts by making a hole into the endocarp and mesocarp. But the openings had only a circumference of 13±2.4 cm (n=25). Similar mode of attack was recorded in these two species, while consuming coconuts at Palappilly and Pariyaram Forest Ranges.

Vegetation in the periphery of Reserve Forest in Palappilly Forest Range is semi-evergreen, while other areas had moist-deciduous forest. Tree species, relative density and relative dominance are given in the Table 8, 9 and 10. It was observed that, availability of food in the forest limits was sufficient for Indian giant squirrel. Farmers became inactive in the coconut plantations due to the low price of the coconut. As the farming activities reduced the species entered the plantations and consumed coconuts.

Table 8. Density of trees in the periphery of the Reserve Forest in the study area (Peechi Forest Range).

Sl.No.	Species	Relative Density (%)	Relative Dominance (%)
1	*Xylia xylocarpa*	35	25.39
2	*Terminalia paniculata*	11.25	21.18
3	*Terminalia bellirica*	3.75	19.76
4	*Grewia tiliifolia*	11.25	9.13
5	*Calophyllum austroindicum*	10	6.90
6	*Ficus benghalensis*	1.25	4.40
7	*Lagerstroemia microcarpa*	3.75	4.04
8	*Briedelia roxburghiana*	2.5	2.95
9	*Terminalia alata*	1.25	1.20
10	*Cleistanthus collinus*	3.75	1.10

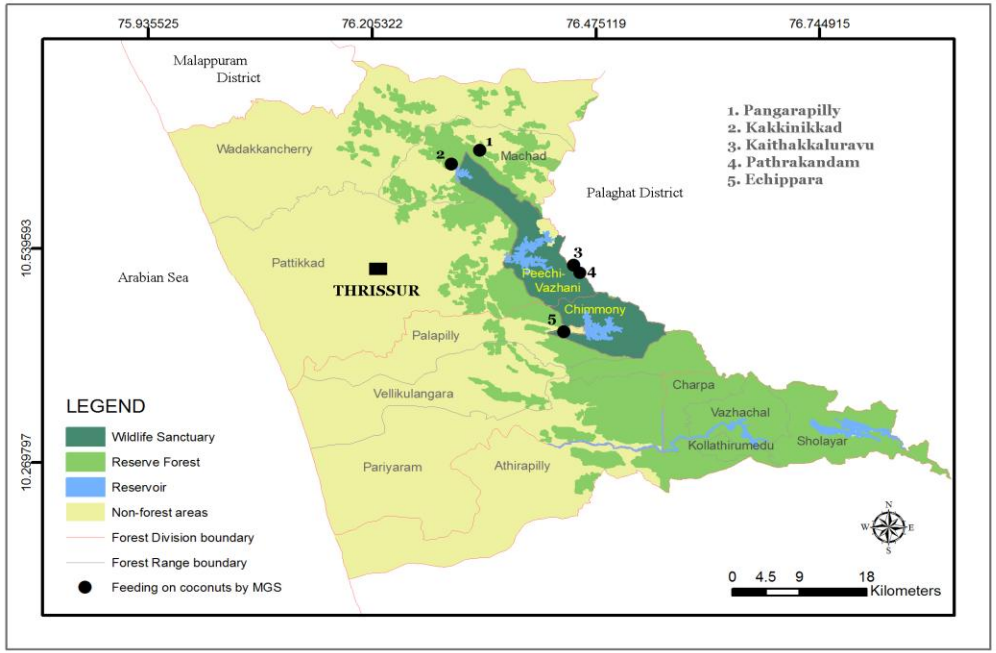


Fig. 21. Feeding of Malabar giant squirrel on coconuts was reported in Thrissur District.

11	*Cassia fistula*	1.25	1.07
12	*Garuga pinnata*	1.25	0.97
13	*Careya arborea*	2.5	0.78
14	*Spendias indica*	1.25	0.34
15	*Sterculia guttata*	1.25	0.31
16	*Bauhinia malabarica*	1.25	0.27
17	*Bombax ceiba*	2.5	0.08
18	*Holarrhena pubescens*	2.5	0.07
19	*Calycopteris floribunda*	1.25	0.03

Table 9. Density of trees in the periphery of the Reserve Forest in the study area (Machad Forest Range).

Sl.No.	Species	Relative Density (%)	Relative Dominance (%)
1	*Albizia odoratissima*	1.47	27.03
2	*Bombax insigne*	10.29	23.23
3	*Xylia xylocarpa*	35.29	18.21
4	*Grewia tiliifolia*	11.76	12.88
5	*Terminalia paniculata*	17.65	5.08
6	*Holoptelea integrifolia*	1.47	5.06
7	*Briedelia retusa*	2.94	2.70
8	*Tectona grandis*	2.94	2.00
9	*Cleistanthus collinus*	8.82	1.86
10	*Stereospermum colais*	5.88	1.51
11	*Dalbergia latifolia*	1.47	0.43

Table 10. Density of trees in the periphery of the Reserve Forest in the study area (Palappilly Forest Range).

Sl.No.	Species	Relative density (%)	Relative Dominance (%)
1	*Hopea parviflora*	7.35	22.49
2	*Tetrameles nudiflora*	2.94	22.45
3	*Aphananthe cuspidata*	7.35	13.08
4	*Polyalthia coffeoides*	7.35	7.38
5	*Knema attenuata*	1.47	5.70
6	*Syzygium cumini*	2.94	4.05
7	*Calophyllum calaba*	1.47	3.60
8	*Lagerstroemia microcarpa*	4.41	3.48
9	*Elaeocarpus serratus*	10.29	3.44
10	*Xanthophyllum arnottianum*	13.24	3.43
11	*Antiaris toxicaria*	1.47	1.62
12	*Aporosa cardiosperma*	1.47	1.62
13	*Croton malabaricus*	1.47	1.39
14	*Baccaurea courtallensis*	14.71	1.30
15	*Schleichera oleosa*	4.41	1.05
16	*Pterospermum reticulatum*	1.47	0.72
17	*Hydnocarpus pentandra*	4.41	0.70
18	*Vitex altissima*	2.94	0.60
19	*Terminalia chebula*	1.47	0.57
20	*Memecylon umbellatum*	1.47	0.44
21	*Diospyros condolleana*	1.47	0.40
22	*Holigarna arnottiana*	1.47	0.40
23	*Diospyros buxifolia*	2.94	0.08

3.1.5. Indian peafowl (*Pavo cristatus* Linnaeus) and other birds

The species is listed under Schedule I of Indian Wildlife Protection Act, 1972. Feeding of paddy by pea fowl and other birds namely rose-ringed parakeet (*Psittacula krameri*) and spotted dove (*Streptopelia chinensis*) was recorded in the District from Wadakkencherry Forest Range. The vegetation and terrain of this Range provided a suitable habitat for them. It mainly consumed paddy near the Chulannur Peafowl Sanctuary, Chulannur, central Kerala (Plate 17). On an average 47 % of paddy was consumed in the immediate fringe areas of the forest and loss of paddy was quantified as 1466.5±247.31 kg per ha. Feeding was recorded only when the paddy was ripened (Plate 16). Dusk (1600 hrs - 1800 hrs) and dawn (0600 hrs - 1100 hrs) were the active hours in the field. Mode of consumption was by peeling off the rice from the plant with its beak and they were highly sensitive to the external sound at the time of feeding. Rose-ringed parakeet and spotted dove were active in the field during the noon hours (11.00 to 14.00 hrs). Awareness of wildlife laws was excellent among the local people. As the farmers (n=15) had only a vague knowledge on the economic loss due to the pea fowls and other birds, compensation was not claimed from the Kerala Forest Department. Damage of paddy estimated in four trials is presented in the Fig. 23.

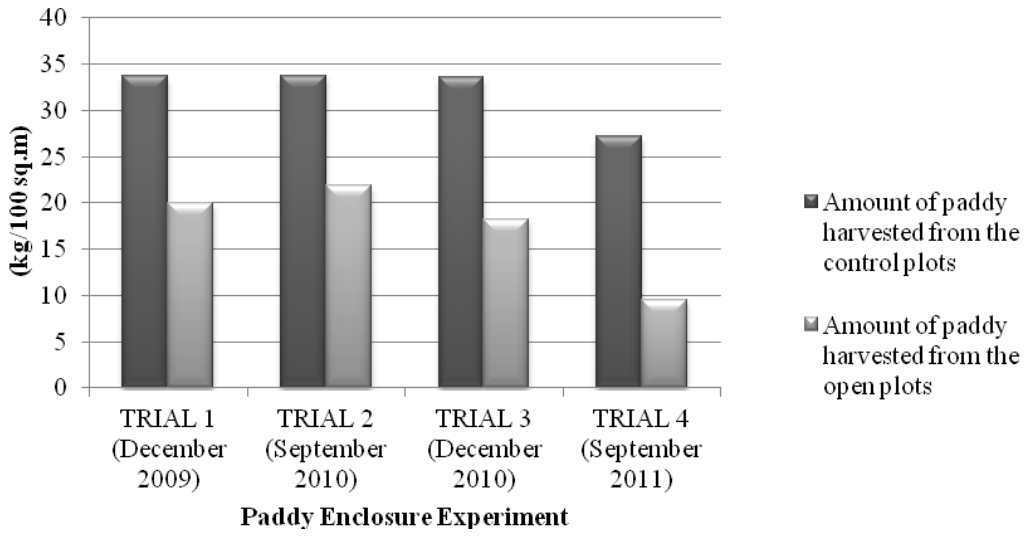


Fig. 23. Consumption of paddy by Indian peafowl and other birds near Chulannur Peafowl Sanctuary, central Kerala.

Plate 13. Malabar giant squirrel feeding on coconuts
at Machad Forest Range.

Plate 14. Mode of attack on coconuts.

Plate 15. Giant flying squirrel damaged coconuts at Palapilly
Forest Range.

3.1.6. Other crop raiders in the District

Bonnet macaque is distributed in all Forest Ranges in the Thrissur District. The menace was reported from the Forest Ranges namely Palapilly, Wadakkancherry and Machad. They mainly consumed banana (Plate 18), followed by jack fruit and mango. Damage to households was the main problem faced by the farmers in these ranges. Three troops each were reported from Wadakkancherry (troop strength, mean = 10.33±2.08) and Palapilly Forest Ranges. Presence of sambar (*Rusa unicolor* Kerr) was reported in the crop field from the Forest Ranges namely Peechi (14%), Pattikkad (3%), Palapilly (3%), Vellikulangara (3%), Pariyaram (8%) and Charpa (3%). It entered the rubber plantation and did partial damage to the newly planted rubber. Browsing, stripping and fraying of barks are the main crop damage reported by deer (Gill, 1992).

3.1.7. Economic loss

Nine species of crops were damaged by wild animals in the District. The economic value of the crops damaged is described in the chapter on methods. The price of the crops varied during the period of the study. Except for rubber, all other crops were having only lower prices. In some years plantain fetched good prices. Price of the commodities collected from the Farm Information Bureau, Kerala during the period of study is given in the Table 11.

Table 11. Price of cash crops collected from the Farm Information Bureau, Kerala.

Sl. No.	Cash crops	Market price (Rs.) (Mean±SD)
1	Coconut	6.31 ± 3.15 per nut
2	Areca nut	88.3 ± 31.5 per kg
3	Rubber	170.72 ± 46.13 per kg
4	Banana (Nendra)	24.38 ± 4.63 per kg
5	Banana (Palayamthodan)	12.5 ± 2.85 per kg
6	Paddy	11.33 ± 3.03 per kg
7	Colocasia	20.5 ± 5.82 per kg
8	Tapioca	11.2 ± 2.74 per kg
9	Elephant yam	18.29 ± 2.71 per kg
10	Plantain (Nendra)	243.8 per plant
11	Plantain (Palayamthodan)	125 per plant

Asian elephant

The species mainly damaged perennial crops (coconut tree, arecanut tree and rubber tree) and plantains. Nutmeg, cocoa and oil palm were also damaged in the District, but these species were not considered for the potential loss estimation, due to the negligible number of trees damaged (<15 trees).

Table 12. Potential value of perennial crops damaged by Asian elephants in the Thrissur 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	23730.08
					Secondary stage	20 – 32	11865.04
2	Coconut tree	60	75 coconuts	Immature phase		0 – 9	15.00
				Productive phase	Primary stage	10 – 34	23662.50
					Secondary stage	35 – 60	11831.25
3	Areca nut tree	20	15 kg of nut	Immature phase		0 – 5	10.00
				Productive phase	Primary stage	6 – 13	19867.50
					Secondary stage	14 – 20	9933.75

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

Sl.No.	Forest Ranges	Loss (Rs. per annum)	Grama panchayaths	Potential loss (%)
1	Pattikkad	517451.4	Athirapilly	51.22
2	Charpa	515045.8	Kodassery	18.38
3	Pariyaram	477749.8	Panacherry	11.86
4	Palapilly	212024.6	Varandharapilly	10.63
5	Athirapilly	7887.5	Puthur	7.91
6	Peechi	5466.1		

Plate 16. Feeding on paddy by Indian peafowl near Chulannur Peafowl Sanctuary.

Plate 17. Paddy was consumed by Indian peafowl in the field.

Plate 18. Bonnet macaque damaged banana at Palapilly Forest Range.

Mean economic loss in the District was estimated as Rs. 17,35,625/- per annum.

Wild pig

The species damaged plantains [Palayamthodan (52.27%) and Nendra (10.2%)], coconuts (26.03%), colocasia (4.6%), tapioca (4.4%) and elephant yam (2.6%). Rubber plants were also cultivated in the quadrats, but partial damage was recorded. Mean economic loss was estimated as Rs. 3,736/- per ha per annum. Maximum damage was reported from Panacherry grama panchayath (41%), followed by Thekkumkara (12%), Chelakkara (11%) and Madakkathara (9%) grama panchayaths. Economic loss was highest in Pattikkad Forest Range, followed by Machad and Palapilly Forest Ranges (Fig. 24).

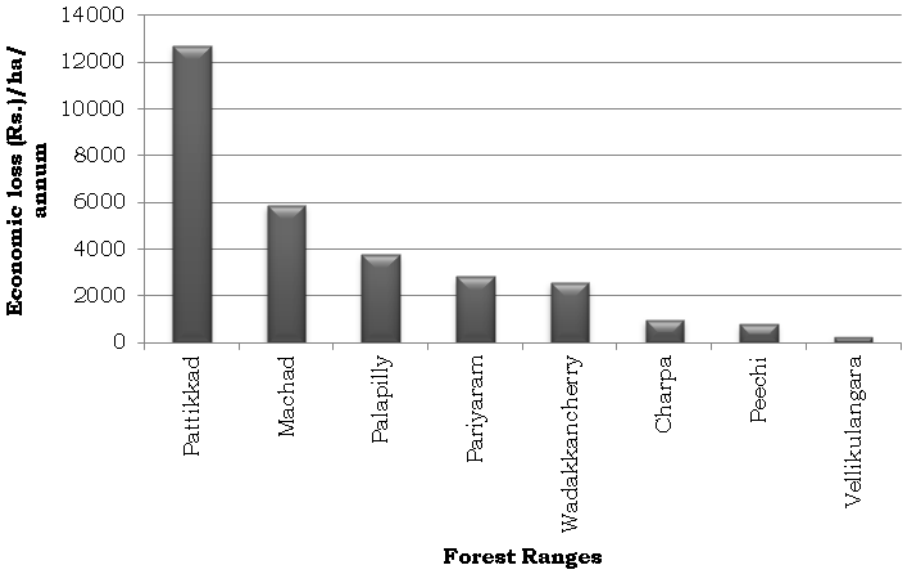


Fig. 24. Economic loss due to wild pig in different Forest Ranges.

Indian crested porcupine

It damaged coconuts (80.1%) and tapioca (19.9%). Mean economic loss was estimated as Rs. 615.47/- per ha per annum. Maximum damage was reported from Mattathur grama panchayath (34%), followed by Kondazhy (23%), Erumapetty (21%) and Kodassery (17%) grama panchayaths. Highest economic loss was in Vellikulangara Forest Range, followed by Wadakkancherry and Pariyaram Forest Ranges (Fig. 25).

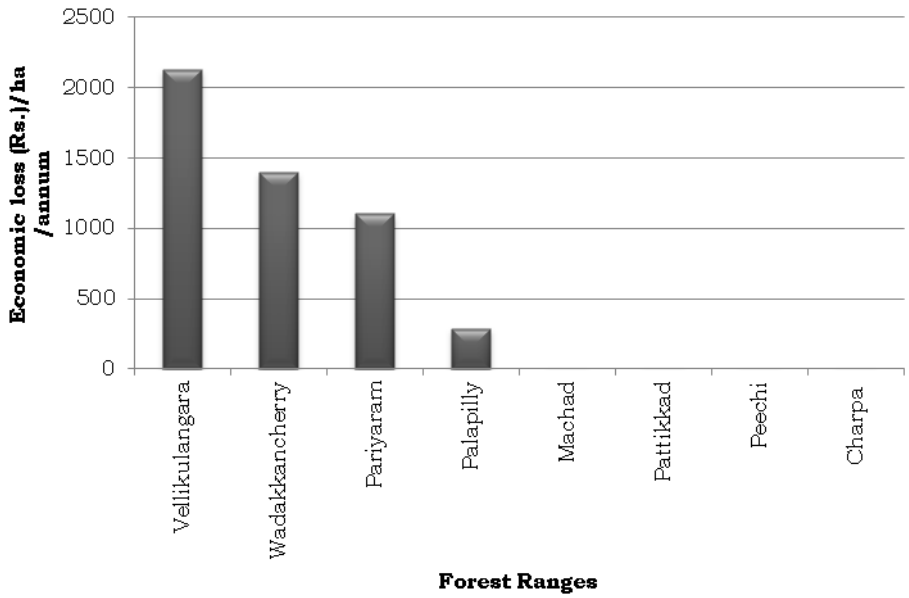


Fig. 25. Economic loss due to Indian crested porcupine in different Forest Ranges.

Indian giant squirrel

Feeding on coconuts was recorded in the Forest Ranges namely Peechi, Machad and Palapilly. Economic loss was calculated by multiplying the number of coconuts damaged in the quadrats, with its economic value @ Rs. 6.31/- per nut. Highest damage was recorded in Peechi Forest Range (Rs. 44,106.96/- per ha per annum), followed by Machad (Rs. 37,623.36/- per ha per annum) and Palapilly (Rs. 2,576.64/- per ha per annum). Mean economic loss per ha per annum was estimated as Rs. 28,102.32/-. Puthur grama panchayath (36%) had the highest damage, followed by Chelakkara (31%), Thekkumkara (31%) and Varandharapilly (2%) grama panchayaths.

Table 14. Economic loss of crops damaged by Indian giant squirrel in Thrissur District, Kerala, India (April 2009 – March 2012).

Forest Ranges	Economic loss per annum (Rs.)
Peechi	3528
Machad	3009
Palapilly	205
Mean economic loss per annum	2247

The market price of coconut in each month and nuts consumed per tree by the species were correlated. No significant correlation (except in Machad Forest Range) was observed between the market price of coconut in each month and nuts consumed per tree by the species. In Machad Forest Range, a slight negative correlation was reported, r = -0.301 (P < 0.1); whereas in Palapilly Forest Range, r = 0.08, (P > 0.1) and Peechi Forest Range, r = 0.184, (P > 0.1). The farmers frequently monitored the coconut plantations of Machad Forest Range and controlled the crop raid by throwing stones and producing sounds with metallic objects, when the price of coconut reached high (observed 3 times during the field visit). In Peechi and Palapilly Forest Ranges, farmers did not adopt any control measures during the field survey, though their mental approach was antagonistic towards this species.

Indian peafowl and other birds

The loss of paddy was quantified as 1466.5±247.31 kg per ha in the immediate fringe areas of Chulannur Peafowl Sanctuary, Kerala. Economic loss was calculated by multiplying the quantity of paddy damaged; with its economic value @ Rs. 11.33±3.03 per kg, which is estimated as Rs. 16,615.45/- per ha.

3.1.8. Factors affecting the crop damage

In central Kerala, Asian elephant did the highest economic loss to the farmers compared to other species of damaging crops. In order to find the variables associated with the occurrence of crop damage in the District, logistic regression analysis was carried out.

The variables selected for the analysis are stated as follows.

1. Altitude (m) - Measured using GPS
2. Slope (angle) - Recorded from Digital Elevation Model (DEM)
3. Aspect value - Recorded from Digital Elevation Model (DEM)
4. Canopy density - Recorded by calculating the Normalized Difference Vegetation Index (NDVI)
5. Distance to river (m) - Measured from toposheets
6. Distance to drainage (m) - Measured from toposheets
7. Types of crop were recorded by the field visit
8. Distance to the human settlements from the area of crops damaged (m) - Measured using GPS

Ten environmental variables were included in the logistic regression analysis and it showed that, only 5 independent variables are significant ($P < 0.05$), including the variable, distance to the river (m) from the crop damaged area ($P < 0.1$). Wald Statistic revealed that, slope and plantain cultivation were the only predictor variables, which influenced the crop raid. The model predicts the odds of the occurrence of crop damage is 11.336 times higher for the slope in the landscapes $>5.895^0$ (62.5%) ($X^2 = 4.571$, $P < 0.1$) and 21.93 times higher for the plantain cultivation. Distance to the river from the area of attack had a crucial role, because most of the sites were the nearby areas of river (58.8%) ($X^2 = 3.348$, $P < 0.1$). Arecanut trees were also attracting the elephants during the encounter (70.6%) ($X^2 = 10.615$, $P < 0.05$). Though the plantains were cultivated in the immediate fringe areas of the forest, elephants preferred this cash crop (76.9%) ($X^2 = 9.791$, $P < 0.05$) and consumed.

Table 15. Variables considered in the logistic regression analysis.

Sl. No.	Variables	X^2	df	Sig.
1	Elevation	0.508	1	.476
2	Slope (angle)	4.571	1	.033
3	Aspect Value	1.054	1	.305
4	Distance to the drainage (m)	0.508	1	.476
5	NDVI Value	1.245	1	.265
6	Distance to the river (m)	3.348	1	.067
7	Distance to the human habitation (m)	6.026	1	.014
8	Plantain cultivation	15.077	1	.000
9	Coconut plantation	1.524	1	.217
10	Arecanut plantation	10.615	1	.001
	Overall Statistics	22.110	10	.015

Table 16. Environmental variables in the logistic regression model.

Sl. No.	Variable	B	S.E.	Wald Statistic (X^2)	df	Sig.	Odds ratio Exp(B)
1	Slope (angle)	2.428	1.457	2.779	1	0.044	11.336
2	Distance to the river (m)	-3.34	2.505	1.779	1	0.182	0.035
3	Distance to the human habitation (m)	-1.817	2.334	0.606	1	0.436	0.163
4	Plantain cultivation	3.088	1.651	3.496	1	0.062	21.925
5	Arecanut plantation	2.397	1.618	2.193	1	0.139	10.989
	Constant	0.764	6.428	0.014	1	0.905	2.147

Low slope = 1 (Reference category); High slope = 2
Distance to the river (low) = 1 (<3035 m) (Reference category); (High) = 2 (>3035)
Distance to the human habitation (low) = 1 (Reference category) (<100 m); High = 2 (>100)
Presence of plantain cultivation = 1; Absence = 0
Presence of arecanut plantation = 1; Absence = 0

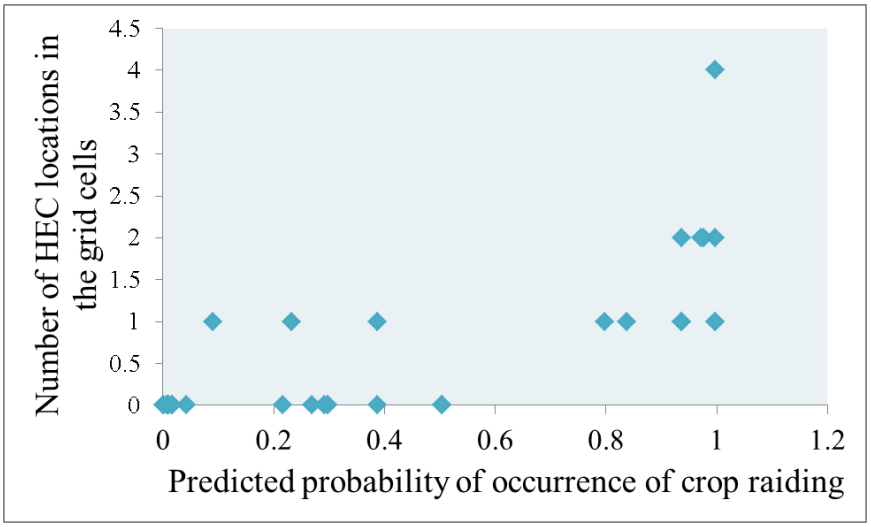


Fig. 26. The relationships between predicted probability of occurrence of crop raiding from the logistic regression model and number of HEC locations in 9 km^2 grid cells (r_s = 0.773, P < 0.01).

Slope of the landscape and plantain cultivation were the main parameter influenced the human-elephant interaction in the District. The result showed that, probability of damaging the crops is directly proportional to increase in the slope of landscape. Besides, elephants preferred plantains in the forest fringes. As the marginal farmers were cultivating these edible crops in the high slope (hilly) areas adjacent to the forest boundary, it attracted the elephants and exacerbated the conflicts. Cultivation of cash crops in the remote hilly areas

also indicated the risks for encroachment and habitat degradation in the periphery of Reserve Forest. It was already ascertained that, increase of human population, developmental activities and encroachment of wildlife habitat for agriculture triggered the habitat fragmentation, which are the ultimate causes for human-elephant conflict (Choudhury, 2004; Leimgruber *et al*., 2008).

3.2. Control measures

People were employing many methods to protect their crop from wild animals. Some of them were traditional methods and others newly introduced. Efficacy of the innovative methods like chilli-rope, chilli-brick, yellow-coloured plastic sheet fence and solar electric fence were evaluated during the study. Local people used crackers for deterring elephants as a usual practice.

3.2.1. Chilli-rope fence

Solar-electric fence and trench are the long-term remedial measures for preventing elephants from entering the human habitations and plantations. Introduction of short term remedial measures are quite relevant, especially in the areas, where crop damage by elephant is only once in a year. In this study, the efficiency of chilli-powder to prevent wild elephants from entering the crop fields in a tropical monsoon climate was evaluated as described in methods.

Chilli is highly sensitive to elephants and the results showed that, it could deter elephants from entering crop fields. Observations of elephant encounter are given in the Table 17. At Ayyampuzha, elephant raids were highest (n=10) followed by Athirapilly (n=4). No crop damage was recorded when this method was employed in these two areas. At Ayyampuzha, a solitary elephant was recorded (n=7) in the crop field and it was observed that the lone male walked along the side of the chilli-rope and entered into the crop field, where the rope ended and through the same route it returned to the forest without touching the chilli-rope. The experiment showed that the noxious smell of chilli-powder could deter elephants from the crop field up to 13 days even in the heavy monsoon season. The local people used crackers for deterring elephants as an alternate measure.

Table 17. Chilli-rope experiment conducted at Athirapilly of Charpa Forest Range and Ayyampuzha of Athirapilly Forest Range

Date and time of elephant presence in the forest	Date of pasting the mixture on coir rope	Distance to the chilli-rope (m)	Remarks
	Athirapilly, Charpa Forest Range		
19-06-11 (10.30 pm)	14-06-11	500	Crackers deterred the elephant
29-06-11 (11.45 pm)	25-06-11	0	Elephants did not enter into the plot, but just stood

			near the chilli rope
	01-07-11 16-07-11		
21-07-11 (03.00 am)		200	Trumpeting of elephants heard from the forest
	28-07-11 04-08-11 15-08-11		
01-09-11 (11.00 pm)		700	Elephants did not enter into the crop field
	09-09-11 02-10-11		
	Ayyampuzha, Athirapilly Forest Range		
	29-06-11		
02-07-11 (10.30 pm)		0	Crackers deterred the elephant
04-07-11 (11.45 pm)		0	Chilli-rope deterred the elephant
05-07-11 (02.00 am)		750	Crackers deterred the elephant
	06-07-11		
11-07-11 (12.45 am)		0	Elephants did not enter into the plot, but just stood near the chilli rope
13-07-11 (01.00 am)		0	-do-
15-07-11 (03.00 am)		0	-do-
19-07-11 (03.00 am)		0	As the mixture was completely wiped off from the rope due to heavy rain, elephant destroyed the chilli-rope and entered into the crop field and consumed jackfruit
	20-07-11 25-07-11		
27-07-11 (11.00 pm)		0	Elephant walked along the side of the chilli-rope and entered into the crop field where the chilli-rope ended and through the same route it returned to the forest after consuming jackfruit.
	29-07-11 04-08-11		
06-08-11 (12.00 am)		500	Crackers deterred the elephant
	17-08-11		
01-09-11 (11.00 pm)		700	-do-
	11-09-11 15-10-11		

During rains, the application of the chilli-engine oil mixture on the rope must be done in every week, in order to keep the smell of chilli powder on the rope. Materials used in this preventive method are easily available and inexpensive. Used diesel engine oil helps to enhance the efficiency, by producing additional smell of smoke and viscosity. Continuous

Plate 19. Preparation of the chilli-engine oil mixture

Plate 20. Smearing the coir rope with the mixture

application of chilli-rope is not advisable, because the elephants will habituate to the short-term control measure.

3.2.2. Chilli-dung brick experiment

Chilli-dung brick was not a good control measure to deter the elephants from the crop field. The elephants entered into the cultivated land, immediately after the chilli-dung bricks were burned (Table 18). On an average 151±26.96 minutes were needed to burn single chilli-dung brick (n=10). As the moisture content was high due to monsoon season, bricks were fired several times for producing the smoke.

Table 18. Chilli-dung brick experiment conducted at Athirapilly, Charpa Forest Range

Date and time of burning chilli-dung brick	Date and time of elephant presence in the forest	Distance to the chilli-dung brick (m)	Remarks
01-05-10 (08.00 pm)	01-05-10 (02.00 am)	0	Crackers deterred the elephants.
06-09-10 (08.30 pm)	06-09-10 (12.00 am)	200	Crackers deterred the elephants.
	06-09-10 (11.00 pm)	0	Crackers deterred the elephants. They entered the field immediately after the chilli-dung brick was burned.
	18-09-10 (12.00 am)	0	Trumpeting of elephants heard from the forest.
18-09-10 (07.00 pm)	21-10-10 (12.00 am)	0	Elephants were damaging crops in the field and crackers deterred them.
21-10-10 (07.00 pm)	03-11-10 (11.00 pm)	0	Elephants were damaging crops in the field and crackers deterred them.
04-11-10 (07.00 pm)	-	-	-

3.2.3. Yellow-coloured plastic sheet fence

Yellow plastic sheet is an effective control measure to deter the wild herbivores namely wild pig, sambar and Indian crested porcupine (Plate 24). This innovative method was commonly seen in Pariyaram Forest Range of Chalakudy Forest Division. Bright coloured sheet was observed in this Range, which could be easily sighted by the herbivores, even in the dark hours. Percentage of encounter was high (73.33%) in the open area, where this control measure was not employed, which was having an economic loss of Rs. 5,908/- per ha. Within the fenced plots, the percentage of encounter was less (10%) without any

economic loss. As the terrain did not support at a certain point of the sheet (<5 feet in height), presence of sambar was recorded (n=3) in the crop field by jumping over the fence. Luckily, no crop damage reported.

Practicing of yellow-coloured plastic sheet fence in Pariyaram Forest Range was recorded in the newly planted rubber plantation, in order to deter the opportunistic crop raiders, especially the wild pig and sambar. White-coloured plastic sheet also revealed positive result to deter wild pig (Gopakumar *et al*., 2012). This innovative remedial measure was known to prevent the entry of wild animals to crop field and the study area was selected in a private land (fringe areas of the forest) having mixed cultivation. Yellow-coloured plastic sheet (6 feet height) was employed in the boundary of a cultivated land, spanning an area of 8,000 m^2 (2 acre). Overall expenditure of the experiment, including the cost of a sheet and its installation charge was Rs. 15,000/- in the year 2009, which was paid by the farmer of the respective cultivate land.

3.2.4. Solar electric fence

In Palapilly Forest Range, presence of wild animals was not recorded within the fence. Fifty per cent of encounter was reported in the Reserve Forest, mainly by sambar and wild pig, where this method was employed. In the Peechi Forest Range, 33.33 % of encounter was reported from Reserve Forest; whereas, 100 % of encounter was recorded within the fence and consumed the edible cash crops.

Solar electric fence is an expensive and effective control measure (Angst, 2001) for all species of wild animals to human habitations. This non-fatal method was introduced to keep different types of mammals (Lokemoen *et al*., 1982) and to deter the elephants from plantations in Malaysia (Blair *et al*., 1979). High voltage current produced by the energizer from the solar panel passing through the iron wire as a pulsating manner, deters them without any harm to their life (Webb *et al.*, 2009). This method will bring ecological side effects, when the wildlife population is isolated in a particular region (Thouless and Sakwa, 1995). The estimated cost for installing a unit was around Rs. 1,75,000/- per km in the year 2012 in Kerala. In both locations of the study area, just prior the installation, farmers were facing huge economic loss due to the crop raiders. As the economic value of rubber was high, large-scale farmers adopted this control method only for protecting the rubber plants in Palapilly Forest Range. In such areas, workers had a keen interest to maintain the fence. No maintenance of the fence was done in the Peechi Forest Range and the system was not

Plate 21. Preparation of chilli-dung brick

Plate 22. Chilli-dung bricks

Plate 23. Burning of chilli-dung brick

functioning properly after 2 weeks of installation. Intrusion of wild pig and sambar to the crop fields was recorded through the damaged fence. Electric fence is an effective barrier against the crop raiders, if it is properly maintained (Kioko *et al*., 2008). In Peechi Forest Range, the Kerala Forest Department gave the duty of maintenance of the fence to the local people, but nobody was interested and the two groups were blaming each other. This problem can be rectified by giving contracts to the agencies who have installed the fence at least for the initial years.

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 metallic objects	Vellikulangara, Pariyaram	Wild pig and sambar
4	Dogs	Peechi, Wadakkencherry	Asian elephant and Indian peafowl
5	Trench	Kollathirumedu, Sholayar	Asian elephant
6	Cable wire	Wadakkencherry, Pattikkad, Peechi, Machad, Vellikulangara, Palappilly, Pariyaram	Wild pig
7	Bright coloured clothes	Wadakkencherry, Vellikulangara	Wild pig and Indian peafowl
8	Spot light	Pattikkad, Pariyaram, Peechi, Palappilly, Charpa	Asian elephant
9	Loud speaker	Pariyaram	Wild pig, sambar and Asian elephant
10	Fences		
	a. Stone fence (small)	Palappilly, Pariyaram, Charpa	Wild pig and sambar
	b. Barbed fence with concrete bar	Wadakkencherry, Pattikkad	Wild pig, Indian crested porcupine and sambar
	c. Yellow coloured plastic sheet	Pariyaram	Wild pig and sambar
	d. Bamboo fence	Wadakkencherry	Wild pig and Indian crested porcupine
	e. Fish net	All Forest Ranges	Wild pig and sambar
	f. Areca nut sheath fence	Peechi	Wild pig, sambar and Indian crested porcupine
	g. Electric fence	Peechi, Palappilly, Pariyaram, Athirappally, Kollathirumedu, Sholayar	Asian elephant

3.3. Conservation attitudes

Conservation attitudes of the affected farmers were collected through a questionnaire survey as described in the method. Human-wildlife conflict being a social issue, attitude of local people is critical to solve or mitigate the problem.

Maximum houses were surveyed from Wadakkencherry Forest Range (28.57%), followed by Pattikkad Forest Range (19.05%). Thirteen Panchayaths were included for the survey and most of the settlements were clustered (78.57%) and the others were spread out (27.43%). Type of the nearby vegetation was moist deciduous (52.86%), riverine (10%) and plantations (37.14%) of teak, rubber, acacia, eucalyptus and cashew. The survey covered 6 Forest Ranges and 13 Panchayaths (Table 20).

Table 20. Panchayaths surveyed from different Forest Ranges

Sl. No.	Forest Ranges	Panchayaths surveyed
1	Wadakkencherry	Kondazhy, Panjal, Mundathikode and Avanoor
2	Machad	Chelakkara, Mullurkkara and Thekkumkara
3	Pattikkad	Madakkathara, Pananchery and Thrissur Corporation
4	Palappilly	Varandarapilly
5	Vellikulangara	Mattathoor
6	Pariyaram	Kodassery

3.3.1. Demography

Both males (76.67%) and females (23.33%) responded to the structured questionnaire survey and all of them had the age limit between 30 - 60 years and most of them were permanent residents of the area (82.86%). Educational status revealed that, 33.33 % of the respondents attended lower primary school and upper primary school (43.33%). Twelve per cent passed the SSLC examination and 9.5 % of the people underwent higher studies. Only 1.9 % of the respondents were illiterates. Well is the main source of drinking water (99%) and they depended the forests only for fuel wood collection (51.43%).

3.3.2. Cultivation

Majority of the cultivators had 1-2 acres of land and they mainly cultivated coconut (95.71%), plantain (85.24%), rubber (62.38%), areca nut (37.14%), tubers (20.48%), vegetables (8.57%) and paddy (11.42%). Other crops cultivated include cocoa, pineapple, turmeric and nutmeg (7.14%). They reported that, areca nut trees were less prone to the attack

Plate 24. Yellow plastic sheet fence at
Pariyaram Forest Range

Plate 25. Solar electric fence at Kollathireumedu Forest Range

of wild animals, except elephants. Rubber cultivation was preferred in the marginal areas, as its market price reached highest during the study period.

3.3.3. Crop damage

Wild pig did the maximum damage in the District, whereas, Asian elephants did only seasonal damage in the crop fields. Other wild animals doing damage were included Indian crested porcupine, Indian giant squirrel, Indian giant flying squirrel, bonnet macaque and Indian peafowl. Pea fowls did extensive damage in the paddy field of Wadakkencherry Forest Range and consumption of coconuts by Indian giant squirrel was reported only from Peechi, Machad and Palappilly Ranges. Toddy cat damaged cocoa in Pariyaram Forest Range (n=2).

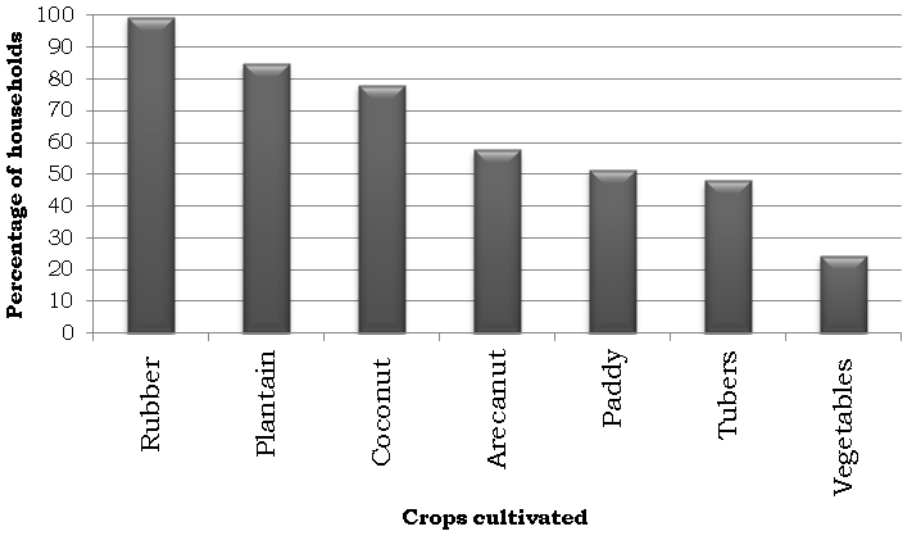


Fig. 27. Crops preferred by the marginal farmers in Thrissur District.

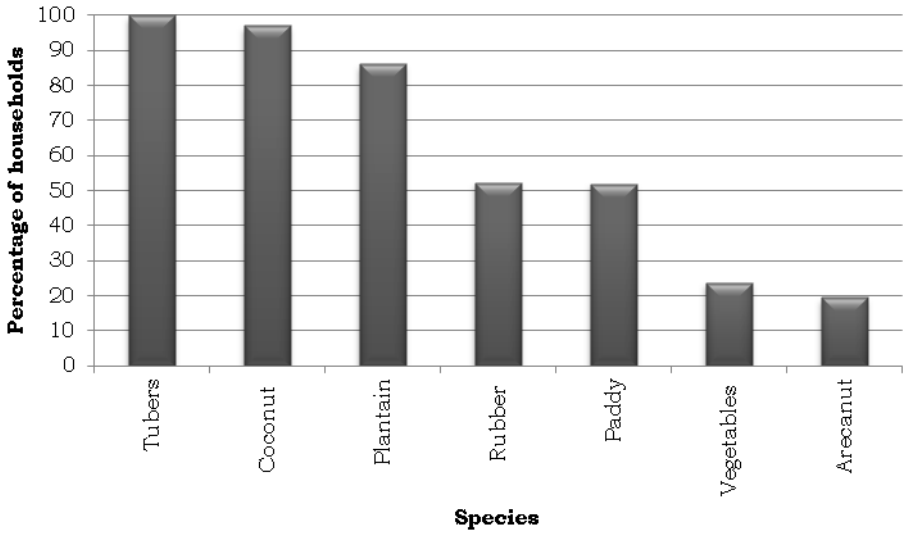


Fig. 28. Crops vulnerable to damage by wild animals in Thrissur District

3.3.4. Cattle-lifting

Twenty per cent of the respondents reported cattle-lifting and the predators involved in the attack were leopard (14.29%), wild dog (1.9%), stray dog (1.43%) and Indian rock python (2.86%). Leopard attack on cattle was recorded from Peechi, Pattikkad, Palappilly, Vellikulangara and Pariyaram Forest Ranges. Presence of wild dog as a predator was recorded from Peechi and Pattikkad Forest Ranges. Indian rock python attacked poultry in Wadakkencherry and Pattikkad Forest Ranges. Their presence was observed in the areas adjacent to the river, originated from Peechi-Vazhani Wildlife Sanctuary. Thirty five per cent of the respondents received compensation from the Kerala Forest Department. No human casualties were reported in the questionnaire survey.

3.3.5. Social dimension

As the main occupation of the respondents was agriculture, both men and women took the responsibility for the control of various resources such as land, crop, etc. Land tenure system showed that, 94.29 % of the marginal farmers had 'Pattayam' (land having legal documents). The survey revealed that, nobody followed the local beliefs and taboo systems regarding wildlife. It is estimated that, 35.6±16.99 per cent of the annual income of the farmers was lost due to the crop damage by wild animals. Awareness on wildlife laws was excellent among all the farmers (n=210) and the local attitude towards crop damage was very severe. They believed that, conservation of wildlife is an inevitable factor for a sustainable environment (n=167), but the government should take the responsibility of the protection of crops from wildlife attacks (n=188). According to many, hunting is an appropriate method

Plate 26. Solar electric fence: If maintained properly an effective method to stop wild animals

suggested for mitigating conflict on the herbivores' having high fecundity (n=151). Delay in sanctioning the compensation from the Kerala Forest Department also made them hostile (n=99).

Due to the stringent Wildlife Protection Act and media coverage, support of local people towards wildlife conservation increased. Knowledge on wildlife laws and conservation issues were good among the farmers. While visiting the houses, they cooperated with us and clearly answered all the questions. As the farmers felt difficulty to answer the economic loss per year in terms of Rupees, the question was limited to the percentage loss per year. It was observed that, when the farmers who acquired the cultivating land without Pattayam was approached, they reacted in a hostile manner because, legally these farmers cannot claim compensation. Many farmers did not claim compensation from the Kerala Forest Department, as they ignored the actual loss occurred due to wild animals. Immediate sanctioning of compensation was also suggested by them. Shooting of problematic wild pig in the crop field was permitted by the Kerala Forest Department in the year 2012. But due to the strict stipulations and procedures prior to the shoot, nobody could use this opportunity. Such approaches adversely affected the interaction between local people and wildlife officials.

3.3.6. Predicting the potential areas of crop loss

Twelve priori models were prepared for predicting the potential areas of crops loss, including a global model with 12 explanatory variables. The variables namely - extent of the agriculture land, distance to Reserve Forest and age of the respondents were influencing the crop damage. Mean estimated probabilities of crop loss for households around the Reserve Forest was 0.36 (S.E. = 0.007, range 0 - 0.54) and the households located near the Vazhani and Peechi reservoirs have higher risks of damaging crops. All the surveyed areas were affected with crop damage, except Varandharapilly and Madakkathara regions. As Varandharapilly of Palapilly Forest Range was occupied with monoculture plantations and Madakkathara of Pattikkad Forest Range located near the township area, farmers reported only a negligible amount of loss from there. Intensity of crop loss also reached highest in Vellikulangara, Randukai and Vettilappara of Pariyaram Forest Range (Fig. 29). The Vazhachal Forest Division was completely omitted from sampling due to monoculture plantations and negligible settlements.

Table 21. Models included in the model sets for crop loss.

Sl. No.	Models
G. distrf+elev+ncrop+land+nwildsps+agripract+settle+age+sex+edu+occup+timraidbeha	
1	distrf + elev
2	distrf + ncrop
3	distrf + land
4	distrf + nwildsps
5	land + ncrop + nwildsps
6	land + agripract
7	elev + ncrop
8	settle + age + sex + edu + occup
9	distrf + nwildsps + timraidbeha + agripract
10	distrf + ncrop + land + agripract
11	elev + nwildsps
12	distrf + land + age

Note: land=Extent of the agriculture land, agripract=Agricultural practice, elev=Elevation, ncrop=Number of crops cultivated, distrf=Distance to Reserve Forest, nwildsps=Number of wildlife species, settle=Nature of settlement, age=Age of the respondent, sex=sex, edu=Educational qualification, occup=Occupation of the respondent, timraidbeha=Time of raiding behaviour, G refers to global model.

Table 22. Best model and coefficients for predicting the crop loss around the Reserve Forest of Thrissur District.

	Model	12 $w_i = 1$
	Intercept	-4.399(2.587)
1	Extent of the agriculture land	0.96(1.38)
2	Agricultural practice	NA
3	Elevation	NA
4	Number of crops cultivated	NA
5	Distance to Reserve Forest	-0.009(0.002)
6	Number of wildlife species	NA
7	Time of raiding behaviour	NA
8	Nature of settlement	NA
9	Age of the respondent	0.78(0.18)
10	Sex	NA
11	Educational qualification	NA
12	Occupation of the respondent	NA
	Model AICc	1319.259

Note: Standard errors in brackets and top-ranked model is shown, w_i is the AICc model weight, NA - Not Applicable

3.3.7. Newspaper media reports

Media is playing an inevitable role among the local people with respect to human-wildlife conflict. Reporting the news regarding the conflicts produce awareness among the local people towards the wildlife. They did not feel any hesitation to inform the highest forest

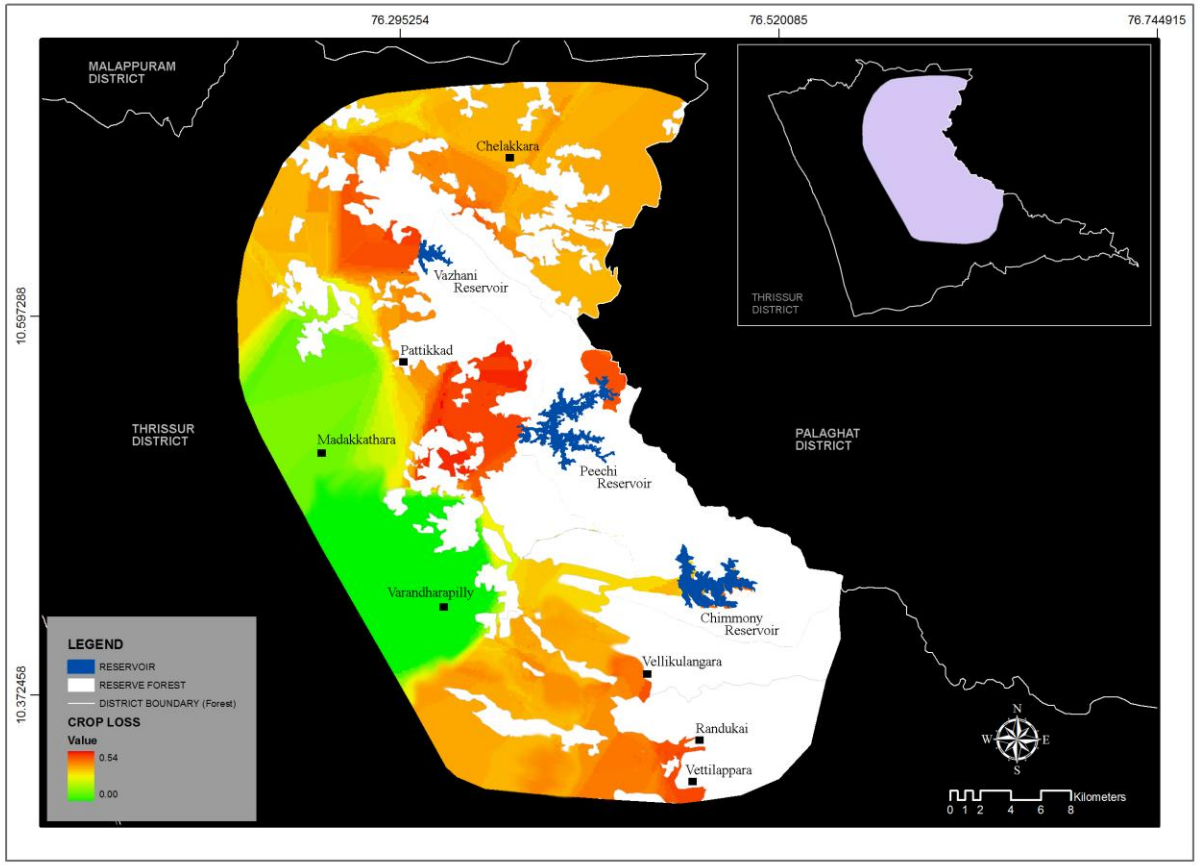


Fig. 29. Potential areas of crop damage around the Reserve Forest of Thrissur District.

officials about the encounter of any wildlife species to human habitations. They demanded the officials to capture and translocate these animals to other forest areas.

Newspaper reports were collected from 1st January 2009 to 31st March 2012. Overall, 44 crop damage issues were reported in the newspaper media during the study period. Asian elephant had the maximum coverage, followed by wild pig. As the elephants encountered in the crop field and did extensive damage on cash crops, the news was occupied even in the urban and rural news pages. Most of the reports focused on poaching and minimal compensation schemes for damaging crops by wild animals.

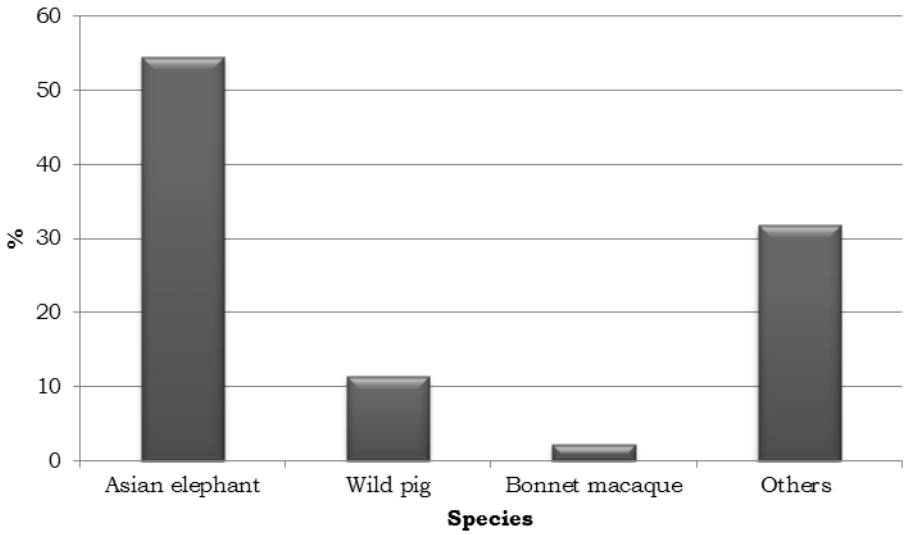


Fig. 30. Media reports on crop damage by wild animals in Thrissur District, Kerala (n=44).

4. DISCUSSION AND RECOMMENDATIONS

Seven species of wild animals are damaging crops in Thrissur District and they are Asian elephant, wild pig, Indian crested porcupine, Indian giant squirrel, Indian peafowl, sambar and bonnet macaque. During the study period, Asian elephant did the highest crop damage (Rs. 17,35,625/- per annum). Wild pig and Indian crested porcupine are distributed in all Forest Ranges. Mean economic loss is estimated as Rs. 3,736/- per ha per annum and Rs. 615.47/- per ha per annum respectively. Activity of Indian crested porcupine was recorded maximum in Vellikulangara Forest Range. Feeding of Indian giant squirrel on tender coconuts is reported for the first time in Kerala and this behaviour was recorded in the Forest Ranges adjacent to Wildlife Sanctuaries in Thrissur District. Highest damage was documented in Peechi Forest Range (Rs. 3,528/- per annum), followed by Machad (Rs. 3,009/- per annum) and Palapilly (Rs. 205/- per annum). Mean economic loss per annum was estimated as Rs. 2,247/-. Indian peafowl and other birds did extensive damage on the paddy near Chulannur Peafowl Sanctuary, Kerala. Loss of paddy was estimated as Rs. 16,615.45/- per ha.

Human-wildlife interactions in Thrissur District are influenced by the price of the commodities. Though the availability of food within the forest limits was sufficient, cultivating coconut trees in the immediate forest fringes lured the Indian giant squirrel to coconut plantations. As the price of coconut decreased, farmers were not concerned its productivity and reduced their activity in farm lands. This approach ultimately encouraged this species to feed on coconuts. For the marginal farmers, 36 % of the annual income was lost due to the crop raiders. Predicted crop loss was reported maximum from the crop fields adjacent to Peechi and Vazhani reservoirs and Pariyaram Forest Range. Immediate sanctioning of ex-gratia is a feasible method to mitigate the human-wildlife conflicts.

Chilli-rope and chilli-brick were already proved successful in African conditions against the crop raiding elephants. Chilli-rope is found to be an effective short term remedial measure to prevent elephants from entering crop fields in the tropical monsoon condition of Thrissur District. But, burning of chilli-brick was not an effective control measure due to the unexpected encounter of elephants in the crop field. In Africa, the farmers were burning chilli-bricks when they find elephants from a long distance in the Savannah plains. The terrain thick of forest areas in Kerala does not allow sighting of elephants far away before to damaging the crops. Yellow-coloured plastic sheet fence is an innovative method and proved

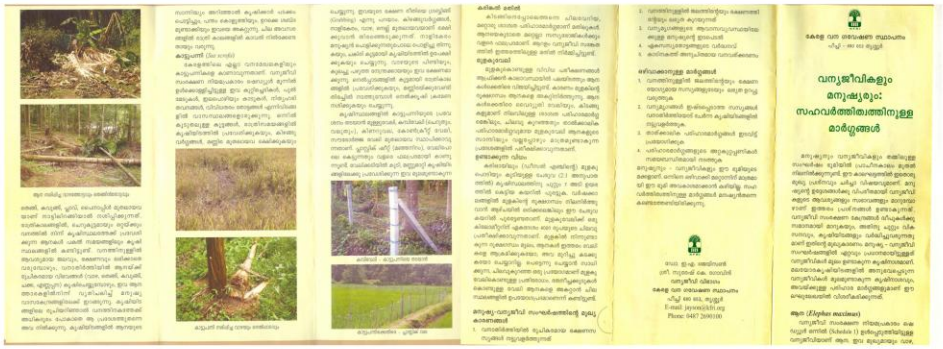


Plate 27. Leaflet produced for the benefit of farmers

CITY/REGION

Translocation seldom settles human-leopard conflicts

The animal might cause problems elsewhere or die in the wild

K.S. Sudhi

KOCHI: Translocating leopards that stray into human habitations cannot permanently solve human-leopard conflicts, pointed out wildlife researchers.

Referring to the recent incidents of sighting of leopards at Vazhachal forest division, researchers said the translocation could turn the animals more problematic and eventually it might cause problems elsewhere or die in the wild.

Wildlife scientists of the Kerala Forest Research Institute who had studied the incidents of human-leopard conflict in the central Kerala region had earlier listed 16 incidents of cattle-lifting between April 2009 and March 2012.

Most incidents were reported in Palapilly, Pariyaram and Pathiloor forest ranges.

Leopard is a nocturnal feeder, which preferred domestic dogs and cattle when they visited villages. Most incidents occurred in the immediate forest fringes of as close as 50 metres to the forest.

During the study, conducted by E.A. Jairam and Suresh K. Govind of the Wildlife Division of the Institute, 15 sightings of leopard were reported from Palapilly, Pariyaram, Pathiloor, Pathirikkad and Vellikkulangara forest ranges. Two female leopards, aged below four years, were caged from at Malakkapara (Sholayar Forest Range) and translocated.

Leopards don't go after human beings and prey on them. However, close encounter with the animal can be dangerous. Animals which feel threatened could turn extremely risky. People should exercise caution during the morning and evening hours when they become very active, they said.

The study indicated that the 'reduction of natural prey within the forest limits, fragmentation of habitat and alteration of countryside' created a suitable habitat for leopards in the fringe areas. Researchers indicated that "all the areas of leopard attack on humans had an ideal habitat for them. In the first incident at Athirapally Forest Range, central Kerala, good habitat near the area of attack, dogs in the human habitation, cattle rearing, free grazing of cattle and the water availability amplified the human-leopard conflict." it said.

Defending their territory

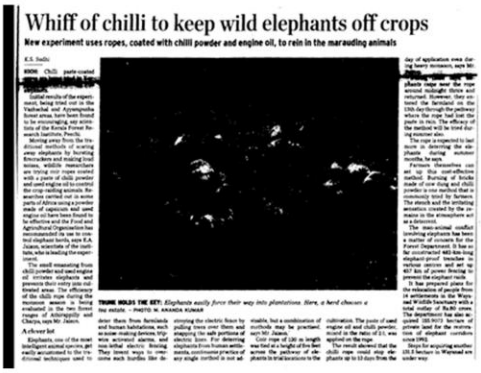
P.S. Easa, Head of the Wildlife Division of the Institute, said leopards, being fierce defenders of their territory, may find it tough to settle down when translocated to other regions. The guidelines issued by the Ministry of Environment and Forest earlier had prohibited the translocation of problematic leopards and it suggested that the animals should be kept in captivity, he said.

The disturbances in the fringe area of the forest may force them to look for new pastures. So, problematic animals should be released in land while translocating them so that their movements could be tracked. Though some proposals were forwarded to the State authorities for preserving them, nothing much has progressed, he said.

Translocating the problematic ones without monitoring its movements would amount to shifting the problem to some other place than managing it, he said.

Dr. Jairam said prominent among young leopards would fight for the weaker ones, forcing them to the fringe areas of forests.

Weaker ones would be forced to look for unoccupied territory or move to fringe areas. Prominent males might even kill the weaker ones. Such situations could occur when the leopards were translocated to new territories, he said.



Whiff of chilli to keep wild elephants off crops

New experiment uses ropes, coated with chilli powder and engine oil, to rein in the marauding animals

K.S. Sudhi

KOCHI: Chilli paste-coated [redacted]

Initial results of the experiment, being tried out in the Vazhachal and Ayyampuzha forest areas, have been found to be encouraging, say scientists of the Kerala Forest Research Institute, Peechi.

Researchers who are using the time-tested methods of scaring away elephants by bursting firecrackers and making loud noises, wildlife researchers are laying out ropes coated with a paste of chilli powder and used engine oil to control the crop-raiding animals. Reports from some countries in parts of Africa using a powder made of capsicum and used engine oil have been found to be effective and the Food and Agricultural Organisation has recommended its use to control elephant herds, says E.A. Jairam, scientists of the institute who is leading the experiment.

The smell emanating from chilli powder and used engine oil irritates elephants and prevents their entry into cultivated areas. The efficiency of the chilli rope during the monsoon season is being studied in the two forest ranges of Athirappilly and Chalyar, says Mr. Jairam.

A clever lot

Elephants, one of the most intelligent animal species, get easily accustomed to the traditional techniques used to deter them from farmlands and human habitations, such as noise making devices, tripwire activated alarms, and non-lethal electric fencing. They invent ways to overcome such hurdles like destroying the electric fence by pulling trees over them and snapping the salt portions of electric fence. For deterring elephants from human settlements, continuous practice of any single method is not advisable, but a combination of methods may be practised, says Mr. Jairam.

Coir rope of 130 m length was tied at a height of five feet across the pathway of elephants in trial locations to the [illegible] day of application even during heavy monsoon, says Mr. Jairam.

[redacted] phanta rope near the rope around midnight thrice and returned. However, they entered the farmland on the 15th day through the pathway where the rope had lost the paste in rain. The efficacy of the method will be tried during summer also.

The team is expected to test-tune in deterring the elephants during summer months, he says.

Various researches can set up this cost-effective method. Burning of bricks made of cow dung and chilli powder is one method that is practised in Sri Lanka now. The stench and the irritating sensation created by the smoke in the atmosphere act as a deterrent.

The man-animal conflict involving elephants has been a matter of concern for the Forest Department. It has already constructed 400 km of elephant-proof trenches in various centres and set up 427 km of power fencing to prevent the elephant raids.

It has prepared plans for the relocation of people from 16 settlements in the Wayanad Wildlife Sanctuary with a view to ease the conflicts. The department has also acquired 100.9972 hectare of private land for the restoration of elephant corridors since 1961.

Steps for acquiring another 155.8 hectare in Wayanad are under way.

Where man, beast confront each other for survival

MIDDLE MIND: *A wild elephant on the periphery of a village.* – FILE PHOTO

പ്രാദേശികം

കരിക്കുവേട്ടയുമായി മലയണ്ണാൻ; ദുരിതകഥയുമായി കർഷകരും

കാട്ടാനകളെ തുരത്താൻ മുളകുവേലി

Plate 28. Newspaper reports on the study

to be a good control measure for the frequent crop raiders like wild pig. Solar electric fence is a good control method for all crop raiders, if it is properly maintained.

As the human-wildlife encounters were highly published by the newspapers and visual media, all such incidents were reported with photographs. 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 elephant, wild boar, Indian porcupine, sambar, spotted deer and gaur 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. Maintaining the availability of drinking water in the forest during summer, either by constructing check dams or by providing artificial water holes is a must. 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. Control of fire is an important measure to prevent the large scale movement of wild animals from the forest to agriculture areas.

Long term measures are (1) relocating the isolated villages within the forest areas to outside, (2) ensuring the availability of fodder to elephants during summer months, (3) planting of species like bamboo and reed. Compensation for damages 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.

The habit of elephants undergoes considerable change due to the interaction with humans. Human intervention in the forest, shortage of food within the forest limits due to agricultural expansion, cultivation of crops like plantains, coconut, areca nut, jack fruit in the fringe areas of the forest and raising of monoculture plantations are the main reasons for human-elephant conflict. It was reported that higher palatability and nutritive value are the reasons for preferring cultivatable crops, compared to the wild plants (Sukumar, 1985).

No settlements or human enclosures are recorded in the Thrissur District with severe crop damage as in Wayanad District. As the market price of rubber is increasing, farmers are trying to cultivate rubber even in the remote and hilly areas. This has put considerable pressure on wild areas lying adjacent to forest and the tendency to encroach the forest land is

severe. This trend will increase the human-elephant conflict. Concentrated efforts are needed to reduce the human-elephant conflict, so that the elephants are conserved.

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7. APPENDICES

Appendix I

I Compensation details

Details of compensation due to wild life attack collected from the TCR division during the study period

Sl. No.	Details of the victims	Category	Compensation applied (Rs.)	Compensation allotted (Rs.)
1	Narayani Kareparambill house Thannipadam PO Chuvannamannu	Crop damage due to wild pig	500	-
2	Mani D/o Narayani Kareparambill house Thannipadam PO Chuvannamannu	Crop damage due to wild pig	500	-
3	Safiya w/o Mohammad Unikattukalathil House Kalapara PO Pangarapilly Village	Snake bite	40000	5000
4	Vijayan Nair Tapioca damage Kormath House Vazhani Manalithara Village Perappadam Thalappilly Taluk	Crop damage by wild pig	13 750	10 000
5	Gopalakrishnan Nair Rubber plant Puthenpurayil House Attoor Village Thalapilly Taluk	Rubber plants damaged by sambar	3250	2438
6	Mohandas Kakkattu House Viruppakka PO Thalappilly Taluk	Tapioca damage by wild pig	2000	1500
7	Hassan .P.K Cheruvayil House Enkakkad PO Wadakkancherry Thalappilly Taluk	Paddy damage by wild pig	16 380	10 000
8	Ramla w/o Usman Vaadakkal House	Human casualty due to the attack of monkey	5000	-

	8th Ward of Mullurkkara Panyt.			
9	Raghavanunni s/o (Late) Parukutty Puthussery Nayaruveedu Varavoor Village Thalappilly Taluk	Coconut damage due to monkey	Exact amount not mentioned	
10	Govindankutty s/o Madhavankutty Nair Kizhakkekalathil House Thrikkanaaya Elanad Village Thalapilly Taluk	Coconut damage by Malabar giant squirrel	Exact amount not mentioned	
11	Jose.K.K Kannelil House Marathukkuzhi PO. Mannamangalam	Cattle-lifting due to wild dog	Exact amount not mentioned	
12	Sheela w/o Babu Puthenpurayil house Vazhakkumpara Panacherry Village	Human casualty due to the attack of monkey	Exact amount not mentioned	
13	Annamma w/o Raju Manithottathil house Vazhakkumpara Panacherry Village	Human casualty due to the attack of monkey	Exact amount not mentioned	
14	Devu m/o Saradha Malayan colony Kakkinikkad	Human casualty due to the attack of sambar	Exact amount not mentioned	

Appendix II

Questionnaire Survey Sheet

QUESTIONNAIRE SURVEY (KFRI/552/08)

GPS:-

DATE :

TIME :

I. DETAILS OF THE AREA :-

1.Name of the colony :

2.Name of Panchayat and ward :

3.Nature of settlement : Clustered / Spread out / Others
4. Type of nearby vegetation : MD / SEG / EG / Riverine / Others

II. RESPONDENT'S DEMOGRAPHY :-

1. Name : .....

2. Age :..... 3. Sex :Male/Female

4. Education : LPS / UPS / HS / > SSLC / Illiterate
5. Occupation : Agriculture / Others / Both

6. Native / Migrated If migrated, reason for the migration
a. Reservoir b.Epidemic c. Land faclility d. Marriage e. Others

7. Are you thinking to migrate from this place again ? Yes / No

8. Source of fuel wood : a. Forest b. Own land c. Others
9. Is there ant fuel wood usage during the monsoon : Yes / No
10. How many times you collect the fuel wood in a week ?
a. Once b. Daily c. Two times d. Three times e. Others
11. How much time do you spend for the collection ?
a. 1-2 hrs b. 2-4 hrs c. 4-6 hrs e. Others

12. Source of drinking water : a. Well b. Stream c. Spring d. Others

III. DETAILS ABOUT CULTIVATION :-

13. Do you have own land ?
a. Yes ..... cent
b. No

14. What are the crops cultivated?
a. Coconut b. Plantain c. Rubber d. Arecanut e. Tubers
f. Vegetables g. Paddy h. Others

15. Location of the land / farm and how long from there?
a. Forest edge
b. Riverine .....meter / Km
c. Estate

16.Quality of the crops damaged: a. Poor b. Moderate c. Good

17. Other crops present but not damaged
a. Coconut b. Plantain c. Rubber d. Arecanut e. Tubers
f. Vegetables g. Others

18. Parts of the plant damaged
a. Root/tuber
b. Stem c. Leaves d. Flowers e.Fruits f. All

19. Whether neighbouring field or garden damaged
a. Yes b. No

20. Brief outline of the agriculture calander

a. Time of planting .....

b. Harvesting .....

21. Farmer's ranking of crops

a. Coconut b. Plantain c. Rubber d. Arecanut e. Tubers
f. Vegetables g. Others

22. Farmer's ranking of crops with respect to their vulnerability to crop damage by wild animals

a. Coconut b. Plantain c. Rubber d. Arecanut e. Tubers
f. Vegetables g. Others

23. Type of agricultural practice
a. Traditional b. Transitional c. Modern

24. If modern, why this type is used ?

25. Do you find any advantage to modern cultivation ?
a. Yes
b. No If yes, Why?.....

26. Do you use the total area for the cultivation ? a. Yes b. No
If No, why ?
a. Wild animals b. No time c. No person to work
d. Not necessary to cultivate e. Others

27. Is there crop raiding by wild animals?
a. Yes b. No

28. Name the wild species causing damage to crops
a. Elephant b. Wild boar c. Deer d. Peafowl e. Monkeys
f. Flying squirrel g. Giant squirrel h. Porcupine i. Others

29. Mode of attack and damage
a. Coconut.....
b. Plantain.....
c. Rubber .....
d. Areacanut.....
e. Tubers.....
f. Vegetables .....
g. Paddy.....
h. Others..... .....

30. Time of raiding behaviour
a. Diurnal b. Nocturnal

31. Frequency of raiding
a. Daily b. Weekly C. Occasionally

32. Where the animal species are coming from, ie. specific areas such as PAs to enter field or they are living in and around field ?
a. Forest b. Reserve land c. Private land

33. How do the farmers ranking of raiding species?
("most" to "least" troublesome species)

a. Elephant b. Wild boar c. Deer d. Peafowl e. Monkeys
f. Flying squirrel g. Giant squirrel h. Porcupine i. Others

34. Approximate loss
in Rupees :...../day/week/month/year
in % :.....%/day/week/month/year

35. Are you aware about the compensation for crop damage ?
a. Yes b. No

36. Any compensation received for crop damage?
a. Yes
b. No Rs.....

37. What are the preventive methods used against the damage and their efficiency?
a. Fence b. Net c. Crackers d. Tin e. Watching

IV. LIVE STOCK LIFTING :-

38. Any incidence of wild animals attacking domestic animals
a. Yes b. No

39. What are the wild animals involved in the attack?
(Victim / Prey)
a. Leopard.....
b. Wild dog.....
c. Alligator .....
d. Elephant.....
e. Others.....

40. Mode of attack
a. Bite on neck b. Bite on other body parts c. Others

41. Any compensation is received ?
a. Yes b. No If yes, how much.....

42. How the livestock is maintained?
a. Put in cage b. Put in room of house c. Others

V. HUMAN CAUSALITY / INJURY :-

43. Is there any human causality/ injury occured?
a. Yes b. No

44. What are the animals involved in the incident?
(Details of victims)

a. Elephant.....
b. Wild boar.....
c. Deer .....
d. Monkey.....
e. Wild dog.....
f. Leopard.....
g. Others.....

45. How the incident happened ?
.....
.....
.....

46. Any compensation received ?
a. Yes b. No If yes, how much ? .....

VI. SOCIAL DIMENSION OF CROP RAIDING :-

47. Land tenure system
a. Pattayam b. Without pattayam c. Others

48. People's degree of dependence to agriculture for subsistence
.....%

49. Whether man / woman take responsibility for control of various resources such as land, crop, etc.
a. Man.....% b. Woman.....%
c. Both

50. Local beliefs and taboo systems regarding wildlife

a.....
.....
.....
b. Nil

51. Traditional methods for controlling crop raiding
a. Watch & Ward b. Line fence with bamboo or bush fence c. Fire
d. Dogs e. Sound from metallic parts f. Stone wall g. Bar soap
h. Reed line i. Cracker line j. Cable k. Kerosene l. Cloths
m. Human dummies n. Arecanut sheaths o. Mouse trap
p. Pit trap q. Deadfall trap r. Pellet bow s. Others

52. Local knowldege of wildlife laws and conservation issues
a. Not satisfactory b. Satisfactory c. Good d. Very good
e. Excellent

53. Number of households affected locally .....

54. Local perceptions of the severity of the damage
a. Very severe b. Severe c. Less severe d. Moderate
e. Nil

55. Do local people use wildlife resource?
a. Yes b. No

Which one .....

Why ?.....

56. Do local communities think that they will get benefits from local wildlife?
a. Yes b. No

57. According to local communities, who should be responsible for protecting crop against the activities of wildlife ?
a. Government b. People itself
c. Others .....

58. Do local communities consider conservation to be an inportant issue locally and if so why ?
a. Yes
b. No
.....
.....

59. Local expectations of benefits from conservation of wildlife

60. What are the local views on how crop raiding by wild animals deal with?