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STUDIES ON CROP DAMAGE BY WILD ANIMALS IN KERALA AND EVALUATION OF CONTROL MEASURES

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ABSTRACT

Crop damage by wild animals in Kerala was studied during the years 1993 to 1996. The data were collected from the offices of the Kerala Forest Department, field survey and from the intensive study area at Marayur. Idukki District. Fortyfive species of crops were destroyed by wild animals in Kerala and major among them were paddy *(Oryza sativa).* coconut palm (*Cocos nucifera*). plantains *(Musa* sp.), cassava (*Manihot esculenta*). arecanut (*Areca catechu*), coffee (*Coffea arabica*), oil palm (*Elacis guineensis*), pepper (*Piper nigrum*). jack tree (*Artocarpus heterophyllus*). mulberry *(Morus alba)* and mango (*Mangifera indica*). The main animals involved in crop damage were elephant (*Elephas maximus*). gaur *(Bos* gaurus), sambar (*Cervus unicolor*). wild boar (*Sus scrofa*). bonnet macaque (Macaca radiata). common langur (*Presbytis entellus*). blacknaped hare (Lepus nigricollis) and pea fowl (*Pavo cristatus*). Among these. elephant and wild boar did maximum damage. Of the total compensation claimed by the farmers only 8.2% was sanctioned by the Kerala Forest Department.

Highest crop damage (30%) was recorded from the forest Ranges coming under the Northern Circle: pineapple (47%), sweet potato (47%) tapioca (42%). alocassia (39%). beans (25%) and plantains (23%) recorded highest percentage of damage. In the intensive study area at Marayur 28 species of crops were damaged and highest damage was during the summer months. At Marayur maximum damage was by elephant (72%) followed by gaur (62%). sambar (17%) and wild boar (16%). Tiger (*Panthera tigris*) panther (*Panthera pardus)* and wild dog (*Cuon alpinus*) were the main cattle lifters in the State. A total of 31 deaths and 64 injuries caused by wild animals were recorded from the State during the period 1983 to 1993. Thirteen indigenous methods used for controlling the crop damage had been identified. High voltage electric fencing using energiser was effective for stopping elephants and other herbivores from entering the agriculture fields. Washing soap was found efficient in stopping entry of sambar into orchards far short periods. Crop damage is found to be linked to the cropping pattern and location of the agriculture fields. Short-term and long-term measures needed to prevent the crop damage are discussed.

1. INTRODUCTION

The forests in Kerala is highly fragmented due to settlements and agriculture. Crop damage by wild animals in agricultural fields. adjoining the forest areas is very heavy. This is mainly due to the straying of wild animals such as wild boar *(Sus scrofa),*elephant (*Elephas maximus*). Indian porcupine (*Hystrix indica*) 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 increasing. At present Kerala has 24% of the forests as protected area. Wild animals in these tracts are protected against poaching. Census figures show that, majority of these animals are increasing in number over the years (KFRI. 1993).Especially the population of sambar (*Cervus unicolor*). wild boar, Indian porcupine and elephant are growing. In addition to this past activities like, large scale conversion of forests into monoculture plantations of teak and eucalyptus, shifting cultivation. hydro-electric projects and organised encroachments reduced the available habitat of wild animals in Kerala. This scenario is leading to man - wildlife conflict in many places.

In order to ameliorate the deteriorating situation. Forest Department pay compensation for crop damage and human casualties. This study was initiated to assess the overall pattern of crop damage and human casualties in Kerala. Initial results of this study were published earlier (Veeramani and Jayson, 1995: Veeramani *et al.* 1996).

Objectives of the study were

1. To survey and quantify the crop damage by wild animals on agriculture crops in Kerala.

2. To evaluate the efficiency of electric fences and other methods to stop the wild animals from entering into the crop fields.

REVIEW OF LITERATURE

Crop damage by vertebrate pests. has been studied extensively all over the world. Studies on crop depredation by larger mammals are also well documented in India. Man-wildlife interaction in Karnataka. especially the conflict between elephant and man has been studied by Sukumar (1988. 1989. 1991. 1994)and Appayya (1992).Crop raiding and economic loss due to elephants were reported from Bihar by Mishra (19711 and Datye and Bhagwat

Similar studies were also conducted in the Western Ghats, especially in Nilgiris by Sukumar (1990). Balasubramanian *et al.* (1993) and Ramesh Kumar and Sathyanarayana (1993).According to Santhiapillai and Jackson (1990)elephants kill about 100to 200 people each year in India. No detailed information is available on these aspects from Kerala.

Many reports are available on the problem of cattle lifting and human casualties in India. Cattle lifting by carnivores in North India had been reported by Banerjee (1994)and Thosre and Mahajan (1994).Dwivedi (1982) stated that, on an average 618 heads of cattle were killed by tigers annually within an area of 413 Km^2 in Bandhavagarh National Park. Human deaths due to elephants have been reported from parts of Central India by Datye and Bhagwat (1993).Injury to human beings from wild animals are common as shown by Mohan (1994)and Tiwari (1994)in Garhwal area. No similar data were reported from Kerala so far.

Recent cases of man eating incidence by mugger in Gujarat have been reported by Vyas (1993). Similarly attacks on domestic livestock by the Saltwater crocodile in Orissa was described by Kar and Bustard (1984). Depredation of crops in the fringe areas of North Bengal forests by elephants had been reported by Dey (1991).Schultz (1986)had given, one of the early suggestions on how to manage crop damage in India. Similar studies were reported from other countries also. Conflict between humans and elephants in Northern Kenya was reported by Thouless (1994).In the same way conflict between wildlife and local people living adjacent to protected areas in Tanzania was given by Newmark *et al.*(1994).

Crop damage and protection methods

Damage to various crops by different species of wild animals were recorded in the literature. Tree and shrub mortality caused by sambar after a drought in Gujarat has been described by Khan *et al.*(1994).But many of these studies were conducted outside India. Damage to coppice regrowth by muntjac deer had been described by Cooke and Lakhani (1996). Depredations of winter wheat and field corn by deer (*Odocoileus virginianus*) had been extensively studied in North America (VeCellio*et al.*. 1994). The efficacy and costs involved in using crop protection dogs and deer repellent to protect white pine seedlings from damage by white-tailed deer were evaluated by Beringer *et al.* (1994). Gill (1992) reviewed the causes of browsing, bark stripping and foraging damage by deer in U.K. He concluded that tree species differ in vulnerability and each kind of damage occurs within certain age and size classes. Stem morphology had an important influence on bark stripping. Site related factors such as hiding cover and soil fertility also influence the damage. He recommends that computer models can be prepared as an aid

to damage predictions and decision making in forest protection. The allowable percentage and frequency of damage to scots pine by Elk had been quantified by Dumin (1984). According to him browsing of 20% of the side shoots each year for 4 years, 40% for 3 year or 60% for one year is acceptable. Red deer cause damage to Sitka spruce and Norway spruce by stripping of the bark and highest damage occurs in pole stage trees (Welch *et al.* 1988). Pekov (1988) had reported wild boar damage from many parts of the world.

Apart from deer. wild boar is also involved in crop damage in Australia as in India. They have used hunting dogs for removal of pigs from the crop lands (Peter and Brett, 1995). Damage done by Black bear *(Ursus americanus*) to Redwoods in U.S.A. was described by Givsti (1988). Damage by monkeys to pine trees, by debarking was reported by Bussche *et al.*(1985) . Many authors recommended electric fence as a promising method for crop protection, where costs for equipment and maintenance are much lower than for traditional fences, but close supenision is necessary (Alriksson, 1988).

STUDY AREA

Presently the forest cover of Kerala State is 9400 km^2. This is 1.26% of the total forest area of India and 24% of the land area of the State. The whole State is divided into five territorial forest circles, namely Southern Circle (Kollam),High Range Circle (Kottayam).Central Circle (Thrissur). Olavacode Circle (Olavacode)and Northern Circle (Kozhikode).The circles are divided in to 28 Forest Divisions and divisions are again divided into 94 Forest Ranges (Fig.1).

To quantify the crop damage in the State, the field data was collected from whole of Kerala. From this. areas having highest crop damage was identified. Marayur Range was selected as the intensive study area considering two aspects. From the survey it was obvious that northern and southern Ranges were having heavy crop damage. Wayanad and southern portions of the State were not selected because, in these places similar studies have already been conducted (Jayson. 1998: Easa. 1998). Marayur Range is selected as an intensive study area considering the fact that the crop damage is severe and a variety of crops are damaged by wild animals. One peculiarity noticed at Marayur was that. in addition to other animals, gaur also damaged the crops. which is not reported from any where else in the State. There are 12 Wildlife Sanctuaries and 2 National Parks in the State, The total extent of the Wildlife Reserves is 2312 ^{2} which are 24.6% of the total forest area and 5.9% of the land area of the State.

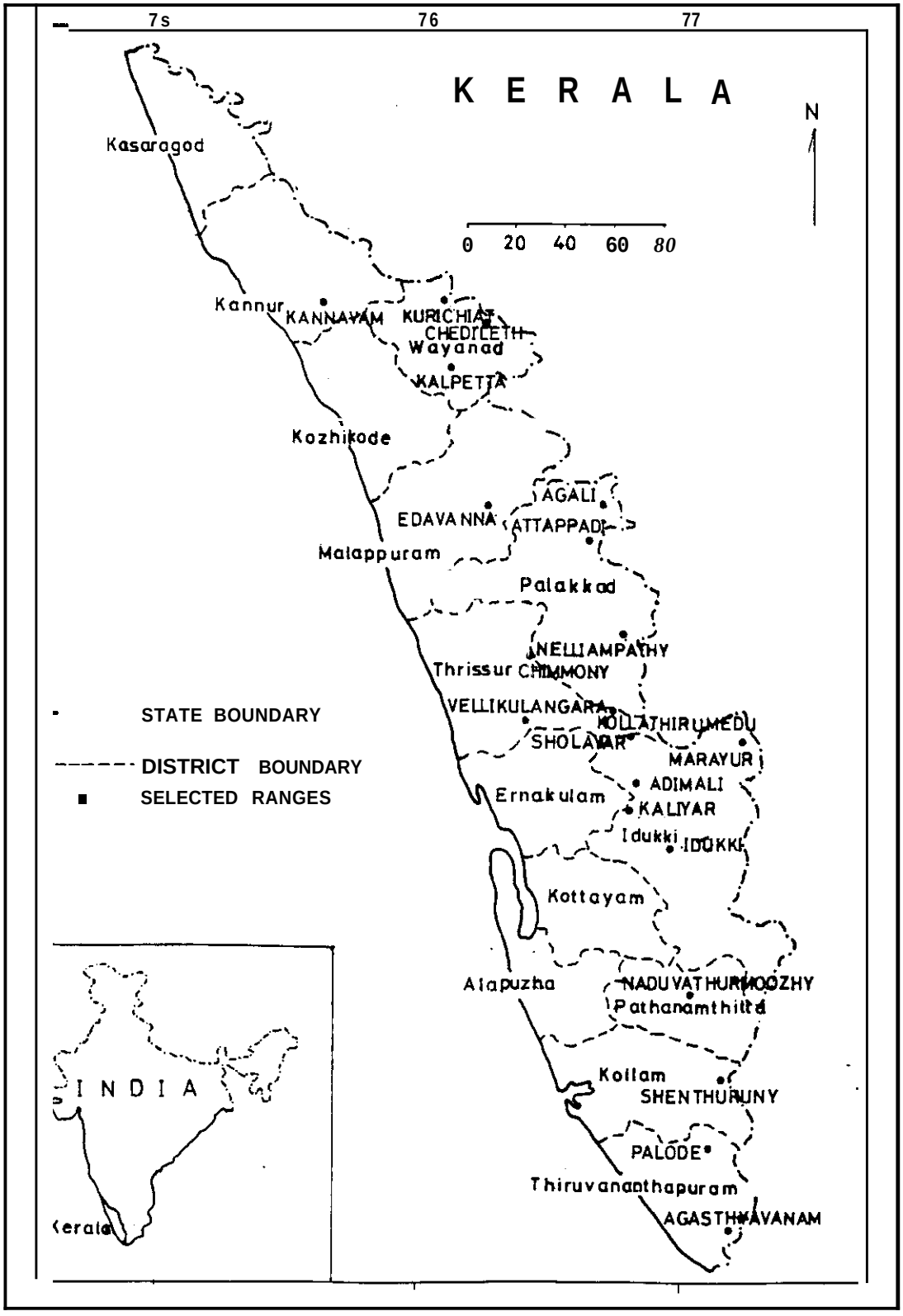

Fig. 1. Location of the study area showing the selected ranges.

Marayur Forest Range

The Marayur Forest Range is situated in the Munnar Forest Division which is located in the higher altitudes of Idukki District. The elevation varies from 850-1050 m above MSL with gently undulating hills and valleys called 'Anjunad Valley'. The tract is situated in the rain shadow region of the Western Ghats and receives precipitation mainly from the northeastern monsoon and getting less rainfall during southwest monsoon. The annual rainfall in the area varies from 1000 to 1500 mm. Winter nights are the coldest (10°C) and summer days, the hottest (36°C) (Venkatesan *et al.*. 19951. The total area of Marayur Range is 204.14 km2 including thevillages and settlements in which the forest cover consists of only 70.88 km^2. The range is divided into two sections. The lower elevated Marayur and higher elevated Kanthaloor. There are a number of villages and settlements located in the range. The southern border merges with the Kannan Devan Tea Estate and west by Eravikulam National Park. North of Chinnar Wildlife sanctuary and East of State border of Tamil Nadu and Kerala (Fig.2).Higher altitudes of this Range experiences extreme cold conditions during winter. creating, highly suitable climate for temperate crops like apple. wheat, white sapota. cabbage and carrot.

The river Pambar is one of the eastward flowing river in Kerala passing through Marayur Range originating from the Nyamakad gap (Thalayar) starting from Kannan Devan Hills and flow towards north to Amaravathy Dam of Tamil Nadu. through Marayur and Chinnar Forest Ranges. Tributaries such as Changalar and Arangadavar flow from the shola forests and join with the Pambar River at Kovilkadavu.

This area form the part of Western Ghats surrounded by Anamalai's. Cardamom Hills, Palani Hills and Kannan Devan Hills. The high elevations, directional orientations and other features increase the drainage pattern. The highest peak of 'Anaimudi' in the Eravikulam National Park about 2697 m MSL is situated near Marayur Forest Range. The area surrounded by various types of vegetation exhibits different floristic and faunistic composition. The topmost level in this slope is mostly rocky followed by area of rich soil cover and profuse vegetation. The interstate highway from Udumalpet to Munnar is passing through this Range and another road from Marayur to Kanthaloor passes through the higher elevated area. A network of roads situated inside the Range enables to reach the villages.

Historical Background

The Marayur area is historically famous for the caves (Muniara)which was built by the Saints (Munis) for shelter and meditation. There is another

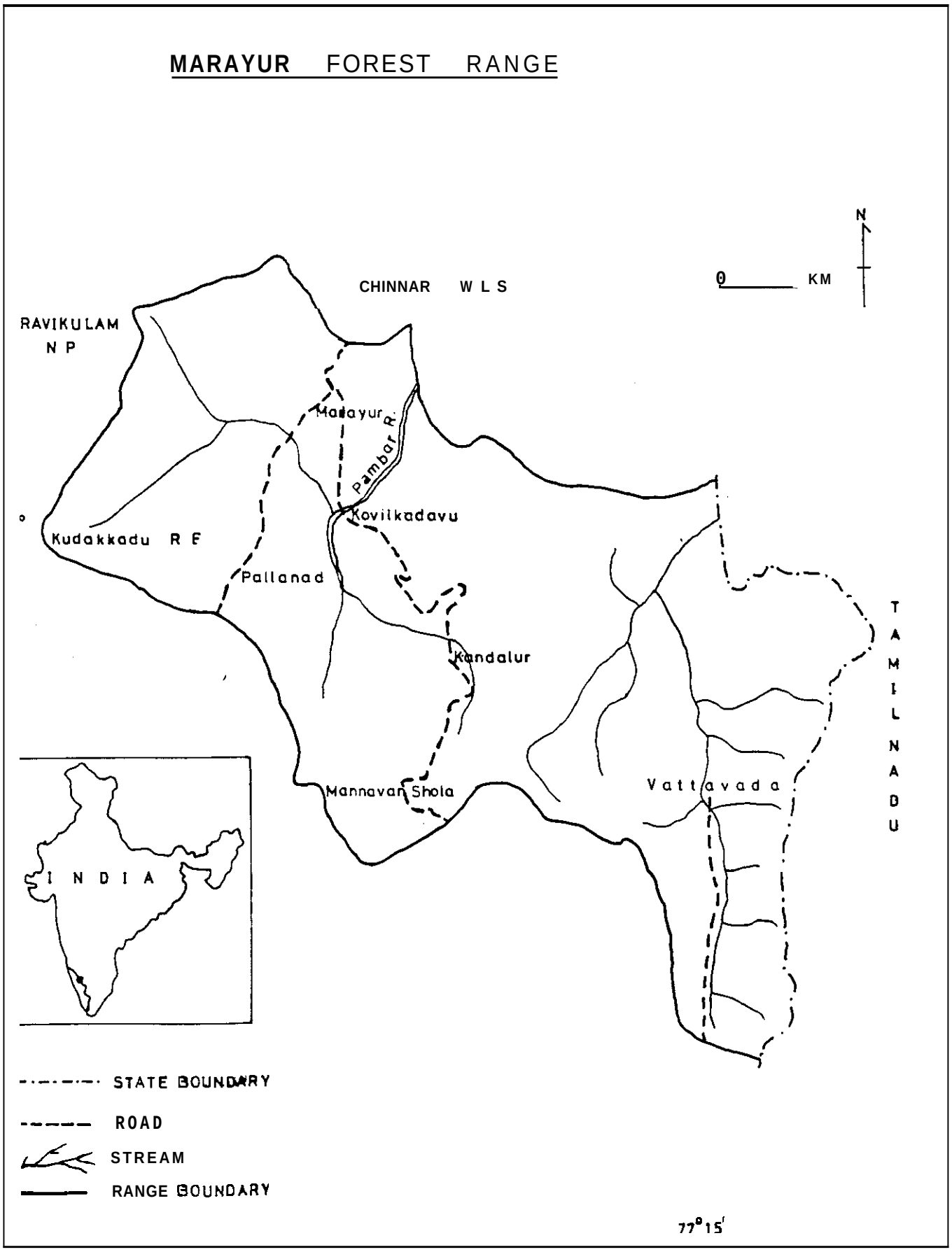

Fig. 2. Intensive studv area-Marayur Forest Range.

hypothesis about these caves, which states that these are burial places of people in the Megalith Age called 'Muniaras'. According to Dr. Padmanaban Thambi, State Superintendent of Archaeology, the Muniaras belongs to the period between AD 200 and BC 1000. The Dolmens excavated from the Anjunad valley were on flat tableland in-groups of three, four or five. Around each was found circular packing of rough sheet of stones on boulders. They were distributed in a circle. The upright stones were rectangular in size and were 3 x 1.5 x 2.1 m. The cover slab was 3.2 x 2.1 x 2.4 m and the floor was paved with a stone slab. Remnants of rubble stone packing were found over some of the cover slabs. There was also a semi-circular opening on one side (Menon. 1975).

Vegetation

Both natural and man made vegetation are found in the area. The natural forests are broadly classified on the basis of Champion and Seth (1968),which are given below -

1. Southern dry mixed deciduous forest
2. Southern moist mixed deciduous forest
3. Southern Montane wet temperate or Shola forest
4. Southern Montane wet grassland
5. Plantations

Southern dry mixed deciduous forests

The northeastern and eastern portion of the Range is surrounded by the dry mixed deciduous forests. Trees such as *Anogeissus* sp.. *Hopea* sp.. *Lagerstroemia* sp.. *Emblica. Tectona* sp.. *Chloroxylon* sp. and *Santalum* sp. were the dominating species in this area. The under cover constituted mainly by *Lantana* and *Eupatorium.*

Southern moist mixed deciduous

These type of forests occur in the north western part of the Range adjacent to Kannan Devan Coffee and Tea Plantations. The major species occurring in these habitats were *Santalum. Albizia. Dalbergia, Ernblica. Terminalia.*

Dillenia. Pterocarpus. Ficus, Careya etc. There were patches of bamboo in this part. The under cover mainly composed of Lantana camara.

Southern Montane wet temperate or Shola forest

The southeastern parts of the Range have a thick shola forest called 'Mannavan Shola'. 'Vatta Shola and Manda Shola'. The shola are generally confined to the sheltered valleys. glens, and hollows. The ground vegetation consists of ferns, mosses and herbs mainly of Urticales and Ranunculus sp. The shrub consists of trees with rounded and compact crowns. The major genera are Syzygium. Celtis. Cinnamomum. Litsea. Prunus, Ilex, Elaeocarpus. Miollusa. Symplocos etc.

Southern Montane wet grassland

The northwestern portion of the Range joins with the Eravikulam National Park. The area is surrounded by hilly mountains that cover dominant families in the order of abundance are graminae mainly composed of, Chrysopogon. Arundinella. Themeda Ischaemum. Heceropogon, followed by Compositae. Anaphalis. Marshes and streams often occur in the grasslands and the grasslands have scrubs like Phyllybophyllus kunthianus. Hypericum. Pteridium. Hedyotis. Gaultharea. Eupatorium. etc.

Plantations

The northern portion of the Range is Pothumoola and Kudakkadu Reserve. The area adjacent to Eravikulam National Park, was planted with Black Wattle by the Forest Department and the eastern portion of Kannan Devan and Thalayar Coffee and Tea Plantations. There are number of cultivated arecanut and coconut farms owned by private people. The southwestern part adjacent to Kulachivayal Muduva Kudi and Perumala has Black Wattle Plantations. Kanthaloor. Kuhanathapuram. Vattavada and Kovilur have Eucalyptus plantations owned by the private parties and Forest Department. There is a natural sandal wood forest, which is untouched and protected having around 55 ha. in area in 9 different blocks. The under growth consist of Lantana camara. and Eupatorium sp.

Human habitations

Two tribal communities are settled in the Range, they are Muduvas and Hill Pulayas. In addition to tribals, people from the plains also settled in the area.

Muduvas

Muduvas stay in the 'Muduva' colonies found in the high altitude areas. They originally lived in Madurai. Owing to troubles of war in which the Pandiyan Raja was engaged. they fled to the hills. They settled on the northern and western portion of Cardamom Hills and the high ranges of Travancore. known as the Kannan Devan Hills. They live in a village on the western slope of the high range at about 2000 to 6000 feet above MSL (Thurston and Rangachari. 1975).They were traditionally dry-cultivators, practicing shifting cultivation. At present they depend on agriculture and minor forest products for their livelihood. Some of them are appointed by the Forest Department in sandal wood depot as temporary watchers. They cultivate paddy, corn. ragi, tapioca. lemon grass and cardamom.

Hill Pulayas

They are the native tribals depending mainly on forests and Forest Department for their sustenance. They were employed by the Forest Department as protection and fire watchers. They also do dry land cultivation, mainly cultivating ragi. tapioca, corn lemon grass and fruiting trees. These people have their own cattle which they leave in the forest for grazing. They also used to collect minor forest products for their income. They are settled mainly inside the forest and in settlements adjacent to the local people.

Others

Other communities include Hindus, Christians and Muslims settled in villages and township. Most of them have their own lands. cultivating mainly paddy, sugarcane, mulberry. arecanut, coconut, plantains, tapioca, lemon grass and vegetables.

The people, migrated from Tamil Nadu mainly depend on agriculture. Earlier they have worked with the Kannan Devan and Thalayar Tea Estates and now they lead a settled life. They cultivate paddy, sugarcane, lemon grass, tapioca and vegetables. They were settled in groups in the fringe areas of the forest, namely Puttur. Kuhanathapuram. Perumala. Kanthallur and Kizhandur. They mainly depend on agriculture and the collection of minor forest products. Some of them were appointed as temporary forest watchers.

Climate

Maximum rainfall is obtained during the north-east monsoon and temperature vaned from 10^{o} to 30^{o}C and highest temperature was recorded during the month of May (Table 1).

Table 1. Rainfall, temperature and humidity at Marayur (1995-1996)'

Months	Rainfall (mm)	Temperature (O°C)		Humidity	
		max.	min.	max.	min.
January	9	24	10	95	45
February	21	23	12	98	40
March	120	27	16	96	38
April	116	27	18	95	38
May	95	30	20	100	60
June	121	26	18	95	70
July	128	26	18	95	72
August	59	27	16	98	72
September	210	28	16	98	80
October	174	24	14	98	80
November	114	24	12	96	83
December	134	24	12	95	85

* Source : Kerala State Board

The study was mainly based on observational methods. Status of larger mammals in the forests of Marayur (intensive study area) was assessed by direct methods. To record the presence of larger mammals, different trek paths in the forests and adjacent areas were surveyed by walking. Observations were made in the morning and evening and whenever an animal was sighted the species. sex. group size, activity, time and vegetation type were recorded.

2. CROP DAMAGE

Kerala is endowed with 30 species of larger mammals. Census figures show an upward trend for most of these larger mammals (KFRI. 1993). Consequent to this the crop damage is also increasing. The results obtained from the analysis of data collected from the Forest Department offices, field surveys and intensive study area at Marayur is given below.

METHODS

Two methods were employed to assess the crop damage and human- wildlife conflict in the State. One method was by analysing the incidences reported to the Forest Department and another by collecting field data from the forest areas.

Cases reported to Forest Department

Data on crop damage incidences and compensation paid by the Forest Department was collected from the Divisional Offices and office of the Chief Conservator of Forests. In addition to this discussions were also carried out with the forest staff. where the crop damage was severe. The details gathered included, animals involved in crop damage, species of crops destroyed. compensation claimed by the farmers and the amount sanctioned by the Forest Department. Enquiries were also made with the cultivators in Wayanad. Neyyar. Peppara and Chinnar wildlife sanctuaries to collect information on patterns of cultivation. animals involved in crop damage and the type of protection methods employed. Munnar and Attappady were visited to collect field data. Along with this. details of animals involved in cattle lifting, human casualties, injury and damage to the property and compensation paid for these damages were collected.

Field survey on crop damage

A field survey was conducted to collect data on crop damage from the affected areas because only the information reported to the offices was available from the office records. But actually many incidences of crop damage were not reported to the forest offices by the cultivators. As no compensation was offered for the damage from wild boar this was also not reported to the offices.

Field survey was carried out from August 1994 to February 1995. As it was not feasible to collect data from all the Ranges in Kerala. stratified random sampling method was adopted. The forests in Kerala was divided into 5 Circles and from each Circle, four Ranges were selected randomly using random number Table. From each selected Range, two villages or settlements were selected, one was inside the forest and another one outside the forest border. Transects of one km each were laid in these settlements and 10m x 10m plots were made after l00m interval. Details such as name of crop, phenology. number of damaged and undamaged plants, animals involved and protection methods employed were recorded.

Crop damage at Marayur

Detailed studies on crop damage was carried out at Marayur between March 1995 and November 1996. Fifteen village/settlements were selected in different part of the Range depending up on the crop pattern and species of animals involved in crop damage. The villages were regularly visited and the crop damage details recorded. Permanent plots of 10 m x 10 m size were laid in different part of the vllages and the number of damaged and undamaged crop plants were counted. The phenological status of the crops were also recorded. The animals involved in crop damage was identified from the indirect evidences and also from enquiries. Protection methods employed were also documented.

Sandal wood damage

Damage of sandal wood trees by herds of gaur were studied in the sandal wood plantations. Plots of 10 m x 10 m size were laid at an interval of 25 m on line transects which were laid 100 m apart from each one. Following details were collected from such plots. namely -

1. Number of damaged and undamaged trees
2. GBH of trees
3. Animals involved in damage
4. Pattern of damage

RESULTS

Pattern of crop damage

The major crops destroyed by wild animals in Kerala were paddy (Oryza sativa), coconut (Cocus nucifera). plantains (Musa sp.), arecanut (Areca

catechu). coffee (Coffea arabica). tea (Thea sinensis), rubber (Havea braziliensis), cashew (Anacardium occidentale) oil palm (Elacis guineensis), pepper (Piper nigrum), mango (Mangifera indica),jack tree (Artocarpus heterophyffus). sugar cane (Saccharum officiniarum), cassava (Manihot utilissirnum). mulberry (Morus alba),lemon (Citrussp.),Colocasia sp..Alocassia sp..ginger (Zingiber officinalis), sweet potato (Ipomaea batatus), lemon grass (Cymbopogan citratus). beans. cardamomum. clove. cocoa. guava, pineapple and red grams.

This survey showed that maximum crop damage was in Wayanad wildlife sanctuary followed by Wayanad North. Wayanad South, Kozhikode and Munnar Forest Divisions. Less destruction of crops was recorded in Kannur. Nilambur South, Nilambur North, Manarkad. Ranni Divisions and in Idukki and Trivandrum Wildlife Divisions. Only little harm was reported from Mankulam, Thenmala, Palakkad. Vazhachal, Chalakudi. Thrissur and Malayattur Forest Divisions. No crop damage was reported from Silent Valley National Park, Periyar Tiger Reserve, Parambikulam Wildlife Sanctuary, Kothamangalam, Kottayam. Konni, Punalur and Trivandrum Divisions.

Animals involved in crop damage

Elephant (Elephas rnaximus), wild boar (Sus scrofa), Indian porcupine (Hystrix indica),gaur (Bos gaurus) sambar (Cervus unicolor), bonnet macaque (Macaca radiata), common langur (Presbytis entellus), barking deer (Muntiacus muntjak). mouse deer (Tragulus rnerninna), blacknaped hare (Lepus nigricoflis).Malabar giant squirrel (Ratufa indica) and pea fowl (Pavocristatus) were causing damage to the agricultural crops in Kerala. Among these. elephant and wild boar did maximum damage to agriculture crops all over Kerala. Elephants were primarily involved in destroying crops like coconut palm, plantains, arecanuts. rubber, coffee, pepper and paddy. Wild boar destroyed mainly tapioca, sweet potato and lemon grass. Gaur was involved in the damage of sugar cane. mulberry, paddy and other cash crops in the Marayur Range of Munnar Division. In Neyyar and Peppara Wildlife Sanctuaries and Agasthyavanam Biological Park of Trivandrum Wildlife Division wild boar, elephant. mouse deer and barking deer were making severe damage. Sambar was damaging crops in Mannarkad Range of Mannarkad Division and elephants were causing problems to crops in Agali and Attappady Ranges in Palghat District. Other animals caused only little harm to the crops in Kerala.

Compensation

The total compensation claimed by cultivators in Kerala for the period starting from 1985 to 1993 is around Rs. 1.06.24.689. Kerala Forest Department had sanctioned an amount of Rs.8.69.227 as compensation (Table 2). In some

places the cultivators have not claimed any compensation, but only reported the damage to the Forest Department based on which the forest officials assessed it and paid compensation. Forest Department on an average pay Rs.96580/- per year as compensation for crop damage in Kerala.

Table 2. Compensation claimed by cultivators and sanctioned by the Kerala Forest Department during 1985-1993

Sl. No.	Divisions	Claimed (Rs.)	Sanctioned (Rs.)
1.	Wavanad Wildlife	48.50.549	2.40.505
2.	South Wayanad	22.30.824	1,23,828
3.	Mannarkad	9,14,500	3,315
4.	Nilambur South	5.42.225	43,040
5.	Munnar	5.16.680	43.600
6.	Kozhikode	5.09.101	21.630
7.	Chalakudi	3,76,090	6.175
8.	Kannur	2.21.320	15,990
9.	Idukki	1.70.750	24,000
10.	Palakkad	1,35,900	800
11.	Malayattur	50,000	0
12.	North Wayanad	47,500	3,30,492
13.	Vazhachal	24,000	0
14.	Mankulam	16,000	3,000
15.	Nilambur North	11,250	1,500
16.	Periyar Tiger Reserve	5,000	500
17.	Thenmala	3,000	802
18.	Kothamangalam	0	1,500
19.	Ranni	0	3.550
20.	Trivandrum Wildlife	0	5.000
	Total	1,06,24,689	8.69.227

Crop damage (Field survey)

One deficiency felt in the crop damage assessment based on the data from office records was that. only the reported cases of crop damage was taken into conslderation. was found from personal discussions that all the crop

damage incidences were not reported to the Forest offices. To overcome this lacunae actual field survey of crop damage was carried out. Following Ranges coming under 5 Circles were selected for the study by random sample method.

1. Northern Circle

1. Kannavam
2. Kurichiat
3. Kalpetta
4. Chedaleth

2. Olavacode Circle

5. Edavanna
6. Attappady
7. Agali
8. Nelliampathy

3. Central circle

9. Kollathirumedu
10. Sholayar
11. Vellikulangara
12. Chimmony

4. High Range Circle

13. Kaliyar
14. Adimali
15. Marayur
16. Idukki

5. Southern Circle

17. Naduvathumuzhy
18. Shendurni
19. Palode
20. Agasthyavanam

In this analysis highest crop damage was found in the Northern Circle (30%) followed by Southern Circle (Table 3).

Table 3. Comparison of crop damage in five Circles of Kerala

Sl. No.	Name of Circle	Crop damage (%)
1.	Northern Circle	30
2.	Southern Circle	28
3.	High range Circle	20
4.	Olavacode Circle	13
5.	Central Circle	9

When the crop damage was assessed among the randomly selected Ranges. Kalpetta Range showed highest crop damage(55%) followed by Agasthyavanam Range (39%) (Table 4).

Table 4. Incidence of crop damage in 20 selected Ranges

No.	Name of Ranges	No. of plants		Percentage damage	Sample size
		damaged	un-damaged		
1.	Kalpetta	254	212	55	20
2.	Agasthyavanam	525	838	39	20
3.	Palode	591	973	38	20
4.	Shendurney	465	928	33	20
5.	Kurichiat	158	343	32	20
6.	Edavanna	255	623	29	20
7.	Chedaleth	92	291	24	20
8.	Marayur	17	385	16	20
9.	Chimmony	243	1359	15	20
10.	Vellikulangara	864	4800	15	20
11.	Nelliampathy	76	575	12	20
12.	Idukki	11	118	9	20
13.	Kannavam	20	238	8	20
14.	Attappady	70	798	8	20
15.	Kollathirumedu	3	53	5	10
16.	Agali	29	699	4	20
17.	Neduvathumuzhi	4	293	1	20
18.	Sholayar	11	1394	1	20
19.	Adimali	0	223	0	20
20.	Kaliyar	0	177	0	20
	Total	3745	15320	20	390

It was found that, on an average 20% of the crop was being damaged in the Ranges surveyed. Seventeen species of crop were damaged in Kerala according to this survey and crops like beta1 leaf, chashew, clove, cotton, curry leaf. mango and turmeric were not damaged (Table 5). Highest damage was recorded for pineapple, sweet potato and tapioca. Among the animals. wild boar, elephant and gaur causes highest damage followed by sambar. chital. bonnet macaque, porcupine and barking deer. In addition to this beans,cocoa and redgram was also damaged in some areas.

Table 5. Percentage of various crops damaged in Kerala

No.	Species of crop	No. of plants		Percentage damage	No. of plants damaged/ ha
		un-daman-aged	damaged		
1.	Pineapple	128	144	47	33
2.	Sweet Potato	26	29	47	7
3.	Tapioca	1456	1976	42	373
4.	Alocassia	118	185	39	30
5.	Plantains	691	2354	23	177
6.	Coffee	131	506	21	34
7.	Colacassia	29	116	20	7
8.	Cardamomum	25	98	20	6
9.	Pepper	87	508	15	22
10.	Cacholum	775	4920	14	199
11.	Arecanut	71	471	13	18
12.	Coconut	37	349	10	9
13.	Ginger	124	1343	8	32
14.	Rubber	38	412	8	10

Crop damage at Marayur

Detailed studies were conducted at Marayur on crop damage. Marayur Range was selected for the intensive studies due to the reasons described earlier. Elephant. gaur. sambar. chital. wild boar. bonnet macaque and Indian porcupine were the crop destroyers at Marayur Range. This was revealed from the data collected on the incidences of crop damage and also reported by the villagers.

Animal sightings

During the course of studv. 20 species of mammals were sighted in the area (Table 6). Sightings of Gaur were maximum (207) followed by chital. Mean herd size of gaur was 18 individuals and male to female ratio was 1:3. Herd structure of gaur is given in the Figure 3.

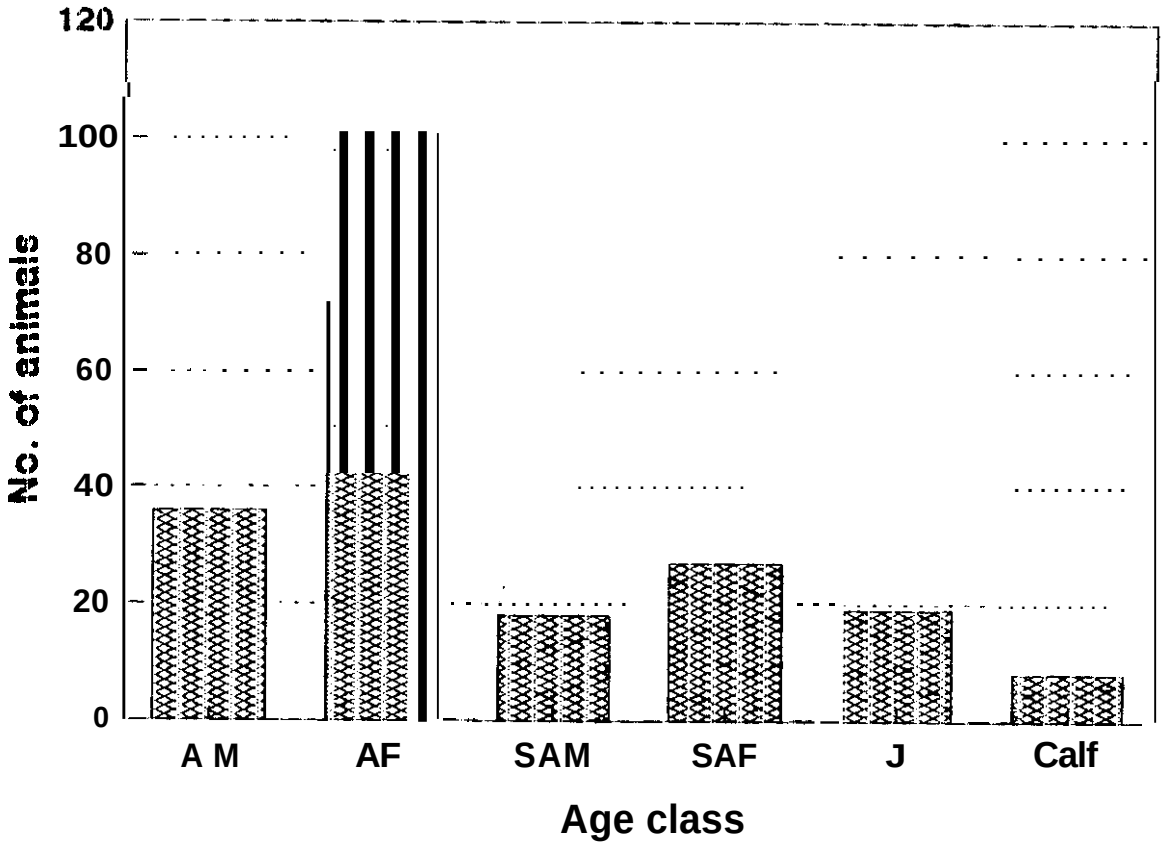

Fig. 3 Herd structure of gaur at Marayur (N = *207)*

AM = Adult male, AF = Adult female, SAM = Sub adult male. SAF = Sub adult female, J = juvenile

Table 6. List of mammal species recorded during the study period in Marayur and adjacent area

Sl. No.	Common name	Scientific name
1.	Bonnet macaque	*Macaca radiata*
2.	Nilgiri langur	Presbytis johni
3.	Tiger	Panthera tigris
4.	Panther (Leopard)	Panthera pardus
5.	Jungle cat	Felis chaus
6.	Small Indian civet	Viverricula indica
7.	Toddv cat (Palm Civet)	Paradoxurus hermaohroditus
8.	Wild dog	Cuon alpinus
9.	Sloth bear	Melursus ursinus
10.	Malabar Giant Squirrel	Ratufa indica
11.	Grizzled Giant Squirrel	Ratufa macrura
12.	Large brown Flying Squirrel	Petaurista petaurista
13.	Indian Porcupine	Hystrix indica
14.	Elephant	Elephas maximus
15.	Gaur	*Bos gaurus*
16.	Nilgiri Tahr	*Hemitragus hylocrius*
17.	Sambar	*Cervus unicolor*
18.	Chital or Spotted Deer	*Axis axis*
19.	Muntjak or Barking Deer	*Muntiacus muntjak*
20.	Wild Boar	*Sus scrofa*

The animals were sighted from Marayur colony, Perumala. Kozhipannai. Puttur, Thirthamalakudi. Korakadavu. Karimutti. Kuhanathapuram. Mannvanshola. Kamalankudi. Palanad. Anakalpetty. Churakulam, gampally. Kulachivayal. Thoovanam, Marayur check post and Menjapatty.

Agriculture crops

Twenty eight species of crops were damaged by wild animals at Marayur. Species of crops damaged and the months of damage is given in the Table 7. Among these crops Mulberry was damaged maximum by gaur followed by plantains, paddy. sugar cane, coffee, tapioca and others (Table 8). Highest number of raids were also recorded in mulberry, followed by plantains. sugar cane and coffee.

Table 7. Crops destroyed at and the months of incidence

No.	C rops	J	F*	M	A	M	J	J	A	S	O	N	D
1.	Alocassia							+					
2.	Arecanut	+		+			+	+			+	+	+
3.	Beans	+		+		+			+	+			
4.	Beet root			+									
5.	Cabbage			+									
6.	Cardamomum			+		+		+					
7.	Carrot			+									
8.	Coconut	+		+		+	+	+			+		+
9.	Coffee	+		+	+	+	+	+			+	+	+
10.	Garlic	+		+	+	+	+		+	+			
11.	Green peas	+											
12.	Guava	+											
13.	Lemon												+
14.	Maize					+	+						
15.	Mango			+				+					
16.	Mulberry	+		+	+	+	+	+	+	+	+	+	
17.	Orange				+								
18.	Paddy									+	+		+
19.	Pepper				+	+	+	+			+	+	
20.	Plantain	+		+	+	+	+	+	+	+			
21.	Plums	+											
22.	Pomegranate	+											
23.	Potato			+		+	+		+	+			
24.	Sugar cane	+			+	+	+	+	+	+	+		
25.	Sunflower			+									
26.	Tapioca			+	+	+	+				+		
27.	Vanilla										+		
28.	White sapota	+		+	+	+	+						

*+ = Damaged; * = no data collected.*

Table 8. Percentage damage of various crops at Marayur

No.	Species	Total No. of plants	No. of plants damaged	Percentage damage	No. of raids	No. of occurrence
1.	Mulberry	15929	9562	60.03	149	795
2.	Plantains	1276	561	43.97	98	566
3.	Paddy	2016	601	29.81	30	165
4.	Sugar cane	14849	4171	28.09	84	455
5.	Coffee	1541	432	28.03	81	484
6.	Tapioca	1918	526	27.42	51	264
7.	Arecanut	885	207	23.39	75	363
8.	Sunflower	2760	643	23.30	20	110
9.	Garlic	5440	1215	22.33	46	235
10.	Pepper	333	69	20.72	32	222
11.	Beans	1782	357	20.03	17	121
12.	Coconut	198	38	19.19	46	239
13.	Potato	5854	830	14.18	69	364

During the months of June. July, August and September, crop damage was moderate and in other months it was severe. Highest crop damage was recorded during November followed by January (Table 9). South-west monsoon was active during the months of June to September and the growth of vegetation and availability of fodder was maximum in the forests. Combined with this, the availability of water was also high. This situation contributes to the low crop damage incidences during the months of monsoon.

Lemon grass was cultivated in 741 ha at Kanthallur whereas 800 ha of sugar cane is available at Marayur. Area of each crop is presented in the Table 10.

Table 9. Percentage of crop damage in different months at Marayur

Months	No. of villages where damage occured	Total No. of plants	No. of plants damaged	Percent-age damage	Sample size N
January	5	3938	1992	50	
February	No data				
March	5	7013	2977	42	70
April	4	6013	2274	38	50
May	7	6827	2791	41	90
Ju ne	5	9916	3673	37	100
July	5	3060	869	29	50
August	5	5072	555	11	70
September	5	5941	1376	23	60
October	5	5840	2047	35	60
November	2	1198	674	20	
December	2	839	202	25	20

Table 10. Area under each crop at Marayur and Kanthallur (ha)*

No.	Crop	Kanthallur	Marayur
1.	Lemongrass	741.5	0
2.	Paddy	302.5	200
3.	Potato	218.0	0
4.	Garlic	151.0	0
5.	Sugar cane	137.5	800
6.	Tapioca	82.0	0
7.	Coffee	80.0	200
8.	Beans	63.5	0
9.	Plantains	32.5	50
10.	Fruit plants	23.0	20
11.	Tomato	16.0	0
12.	Coconut	15.0	100
13.	Chillies	12.5	0
14.	Beet root	8.5	0
15.	Cabbage	8.5	0
16.	Carrot	4.0	0
17.	Cauliflower	3.0	0
18.	Rubber	0	3
19.	Pepper	0	180
20.	Arecanut	0	40
21.	Ginger	0	4
22.	Turmeric	0	3
23.	Ragi	0	100
24.	Vegetables	0	30
	Total	3538	10681

* Source :*Agriculture Office. Gout. of Kerala.*

Among the 15 villages monitored, maximum crop damage was recorded at Palanad followed by Kovilkadavu and others (Table 11).At Palanad. damage was mainly on mulberry by gaur. Extensive damage, going up to 58% of total plants, was recorded from this village. Of the four species of animals. involved in crop damage, elephant caused maximum damage (72%) followed by gaur (62%) (Table 12). Other species were responsible for only less damage. Elephant damage was recorded from Korakadavu. Perumala, Kovilkadavu and Churakulam. In one incidence, sun flower grown in Marayur colony was completely consumed by spotted deer. Damage of wild boar was wide spread and was recorded from 10 villages.

Table 11. Occurrence of crop damage in different villages at Marayur

No. of village	Total no. of plants	No. of plants damaged	Percentage damage	Sample size N
Palanad	19137	11104	58	220
Kovilkadavu	901	452	50	20
Chamakulam	682	312	46	20
Palanad checkpost	2459	1076	44	40
Korakadavu	10383	3063	30	90
Perumala	4243	1194	28	50
Kozhipannai	700	189	27	20
Marayur colony	2760	643	23	20
Karimutti colony	195	41	21	10
Anakkal petty	3571	713	20	70
Puttur	6713	1107	16	70
Kuhanathapuram	2080	312	15	40
Michaelgiri	1237	164	13	10
Theerthamalarkudi	375	30	8	10
Kulathivayal	2680	106	4	20

When the occurrence of crop damage was compared. outside the forest areas and inside the forest area, highest crop damage was recorded outside the forest area (36.55%). In the settlements inside the forest, crop damage was only 28.78%. This was mainly because extensive agriculture areas were outside the forest and only five villages inside the forest were of tribals and they were more vigilant in keeping watch and ward against the crop raiding animals.

Table 12. Crop damage by different animals in the villages of Marayur

Name of animal	Villages where damage occurred	Total no. of plants	No. of plants damaged	Percentage damage
Elephant	Korakadavu Perumala Kovilkadavu Churakulam	5917	4281	72
Gaur	Palanad Anakkal petty Palanad checkpost	18809	11724	62
Sambar	Puttur Perumaia Kuhanathapuram	9300	1605	17
Wild boar	Kozhipannai Theerthamalarkudi Korakadaw Kuhanarhapuram Kulachivayalkudi Karimulti colony Perumala Anakkal petty Micheal giri Churakuiam	8002	1257	16

Sandal wood damage

Sandal wood trees *(Santalum album)* were extensively damaged bv herds of gaur during June 1996. Along with the sandal wood. thirty other species of trees were also destroyed. A total of 200 plots were surveyed for assessing the damage and 2458 trees were enumerated from these plots (1229 trees/ha). Among these 312 trees were found damaged (13%). The damage was by pushing down the trees and breaking the central stem or branches after this leaves were consumed by gaur. Eventhough thirty species of other trees occurred in the study plots, except sandal wood, only *D. brachiata was* affected. with a GBH below 30 cm (Fig.4). A list of species of trees along with their abundance is given in the Table 13.

Trees with higher GBH were only few. All the damaged trees were under the category of 40 cm. the majority falling under 20-40 cm followed by 67 trees in the less than 20 cm category.

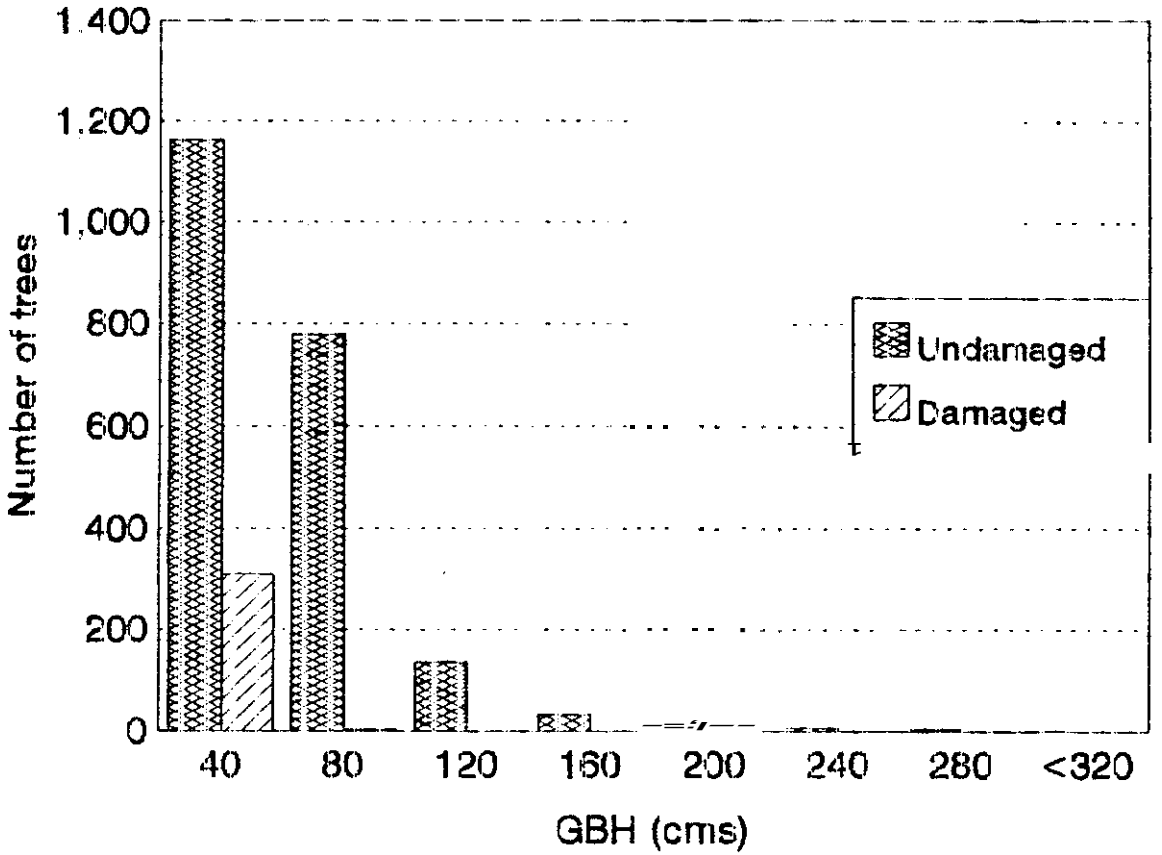

Fig.4. Distribution of the GBH of damaged and undamaged Sandal wood trees in the Marayur sandal wood forests

Table 13. Species of trees found in the Marayur sandalwood forests

Species	Number	Percentage abundance
Santalum album	1943	79.04
Dalbergia latifolia	23	11.00
Anogeissus latifolia	260	10.50
Pterocarpus marsupium	49	1.99
Albizia sp.	17	1.69
Diatoma brachiata	37	1.50
Cassia fistula	32	1.30
Acacia leucoflocia	16	0.65
Grewia tiliifolia	9	0.36
Ixora arborea	7	0.28
Bombax ceiba	6	0.24
Bauhinia racemosa	5	0.20
Ficus benghalensis	5	0.20
Pygeum wightianum	4	0.16
Randia sp.	4	0.16
Emblica officinalis	4	0.16
Tamarindus indica	3	0.12
Mallotus sp.	3	0.12
Vitex altissima	2	0.08
Strychnos potatorum	2	0.08
Unidentified	2	0.08
Bridelia retusa	2	0.08
Ficus sp.	2	0.08
Eugenia montana	2	0.08
Gmelina arborea	1	0.04
Chloroxylon swietenia	1	0.04
Acacia intia	1	0.04
Holigarma arnottiana	1	0.04
Terminalia chebula	1	0.04

DISCUSSION

The combined analysis of data from the three methods showed that. altogether 45 species of crops were damaged by wild animals in Kerala (Table 14). Among the animals. wild boar and elephant inflict highest damage followed by Indian porcupine, gaur and bonnet macaque (Table 15) and altogether about 20% of the cultivated crop is damaged by these animals.

Table 14. Species of crops damaged by wild animals in Kerala

No.	Common name	Scientific name
1.	Arecanut	*Areca catechu*
2.	Beans	*Dolichos lablab* var. *typicus*
3.	Beetroot	*Beta vulgaris*
4.	Cabbage	*Brassica oleracea* var. *capitata*
5.	Cacholum	*Kaempferia galanga*
6.	Cardamomum	*Elettaria cardamomum*
7.	Carrot	*Daucus carota*
8.	Cashew	*Anacardium occidentale*
9.	Clove	*Syzygium aromaticum*
10.	Cocoa	*Theobroma cacao*
11.	Coconut	*Cocos nucifera*
12.	Coffee	*Coffea arabica*
13.	Taro	*Colacassia esculenta*
14.	Elephant foot yam	*Amorphophallus campanulantus*
15.	Garlic	*Allium sativum*
16.	Ginger	*Zingiber officinale*
17.	Green peas	*Pisum sativum*
18.	Guava	*Psidium guajava*
19.	Jack tree	*Artocarpus heterophyllus*
20.	Lemon grass	*Cymbopogon citratus*
21.	Lemon	*Citrus limon*
22.	Maize	*Zea mays*
23.	Mango	*Mangifera indica*
24.	Medicinal plants	Many species
25.	Mulberry	*Morus alba*
26.	Oil Palm	*Elaeis guineensis*
27.	Orange	*Citrus sinensis*
28.	Paddy	*Oryza sativa*
29.	Pepper	*Piper nigrum*
30.	Pineapple	*Ananas comosus*
31.	Plantain	*Musa paradisica*
32.	Plum	*Prunus domestica*
33.	Pomegranate	*Punica granatum*
34.	Potato	*Solanum tuberosum*
35.	Red gram	*Cajanus cajan*
36.	Rubber	*Hevea brasiliensis*
37.	Sugarcane	*Saccharum officiniarum*
38.	Sunflower	*Helianthus annus*
39.	Sweet potato	*Ipomaea batatas*
40.	Cassava	*Manihot esculenta*
41.	Tea	*Camellia sinensis*
42.	Vanilla	*Vanilla planifolia*
43.	White sapota	*Casimiroa edulis*
44.	Arrow root	*Maranta arandinaeae*
45.	Lesser yam	*Dioscorea esculenta*

Table 15. Mode of crop damage by wild animals in Kerala

Species of animal	Crops damaged	Mode of damage
Wild boar	tapioca. tubers, paddy	digging
Elephant	coconut. plantain, paddy	trampling
Porcupine	tapioca, pineapple	feeding
Blacknaped hare	tubers, paddy	cutting & feeding
Bonnet macaque	tapioca. fruit trees	pulling out & feeding
Gaur	mulberry. sandal	browsing
Sambar	white sapota	browsing
Mouse deer	tubers, tapioca	browsing
Barking deer	tapioca. tubers	browsing
Palm civet	pineapple	feeding

Incidence of damage was more during the summer months. Many reasons can be attributed to this. Usually during summer, availability of water and forage was less in the forests. Increased incidences of fire, drive away the animals from forest areas to cultivated crops.

No single reason can be attnbuted to the crop damage in the northern areas of the State. It is only natural that wild animals preferred more sweet and nutritious crops like pineapple. sweet potato to other crops. At Marayur mulberry was heavily damaged. This was principally due to the preference of gaur to feed on mulberry leaves. Highest damage was also recorded during the months of summer. which can be explained from the behaviour of gaur. Because during summer. forage availability was less in forests and gaur heavily depended on the mulberry for green foliage.

Damage by gaur was noticed in the summer season. During summer, the availability of food and water was reduced in the forests. In addition to this, as large tracts of forest have been converted to wattle plantations natural forest was reduced. Kudakkadu RF adjacent to Eravikulam National Park is an example for this. During summer, water was available only in the Pambar River, so inorder to reach the water source, the animals have to cross extensive agriculture areas. During these movements. they damaged the crops. addition to this, fire incidences and extensive cattle grazing, restricted the availability of food during summer.

As a remedial measure, the existing wattle plantations can be reverted to natural forests and to avoid the shortage of water. check dams may be constructed in the suitable areas. Fire lines should be made adhering to strict specifications, so that forest fire can be controlled effectively. Cattle grazing should be discouraged in the forest areas and no weeding operations carried out in the sandal wood plantations. Construction of stone walls may be attempted. where crop damage is extreme and changing the crop pattern. to less vulnerable species like coffee,will go a long way in reducing the problem.

Cattle lifting

Cattle lifting by predators is known to occur in many parts of Kerala. Compensation to the owners of cattle killed by wild animals is provided by the Forest Department. Cattle lifting was mainly by panther *(Panthera pardus).* tiger *(Panthera tigris)* and wild dog *(Cuon alpinus).* Tiger was involved in twenty two attacks on goats and twenty one cases of cattle lifting also reported within a period of ten years. Most of the incidences occurred. when the cattle went for grazing in the forest during the day. Panther preyed up on goat, pig, cow and dog and nearly all the incidents took place around the human habitations and majority of the assaults were at night (Table 16).Wild dog were involved in the attack on goat. both around the human habitations and also in forest. Incidence of a cow being killed by an elephant and wild boar were also reported during the period (1983-1993). According to this estimate at least 5 goats and 3 cattle were killed per year in Kerala. But many incidents were not reported to Forest Department and no data is available on such cases.

Table 16. Livestock killed by wild animals in Kerala during 1983 to 1993

Predator	Goat	(%)	Pig	(%)	Cow	(%)	Dome-stic dog	(%)
Tiger	22	43.1	-	-	21	70.1	-	-
Panther	19	37.3	5	100	7	23.3	3	100
Wild dog	10	19.6	-	-	-	-	-	-
Wild boar	-	-	-	-	1	3.3	-	-
Elephant	-	-	-	-	1	3.3	-	-
Total	51		5		30		3	

(_) no cases reported

Wayanad wildlife sanctuary registered maximum cattle lifting and the owners claimed an amount of Rs. 1.20.150/- as compensation for the loss during the decade (1983-1993). Kerala Forest Department sanctioned an amount of Rs. 18,850 as compensation. Lowest amount was claimed in Mannarkad and Idukki Divisions and no amount was sanctioned in Idukki and Munnar Divisions. A total of Rs. 1,86,350 was claimed as compensation for cattle lifting from all over Kerala. but the Forest Department released only Rs.36,600 (Table 17).

Table 17. Compensation paid for cattle lifting by wild animals in Kerala during the period 1983 to 1993

Sl. No.	Forest Divisions	Amount claimed (Rs.)	Amount sanctioned (Rs.)
1.	Wayanad Wildlife	1.20.150	18,850
2.	Kannur	18,700	6,850
3.	Munnar	17,000	0
4.	Periyar	12,500	3,000
5.	Thrissur	10,000	4,900
6.	Mannarkad	4,000	3,000
7.	Idukki	4,000	0
	Total	1,86,350	36,600

Human - slaughter

A total of 31 deaths. 64 injuries to human beings and two cases of house damage were reported during the years 1983 to 1993. Elephants were involved in 30 human deaths. twenty seven due to herds and three due to solitary tuskers. One death was due to gaur in Parambikulam Wildlife Sanctuary. Highest number of deaths(10) were reported in 1990 followed by 1993. 1992 and 1991. In ail other years, only one case each has been reported (Fig.5). The increased number of deaths reported to the Forest Department after 1990 may be due to an increase in compensation offered by the Department from that year. According to this estimate. on an average at least 3 people get killed per year in Kerala. Injury to people by wild animals was reported from the forest fringes. Carnivores were involved in these type of conflict. There were 64 cases of injuries and 2 attacks on houses by wild animals. Out of these. elephants were responsible for 32, panther 14. sloth bear 8. gaur 2 and tiger 2, the house damages were due to elephants.

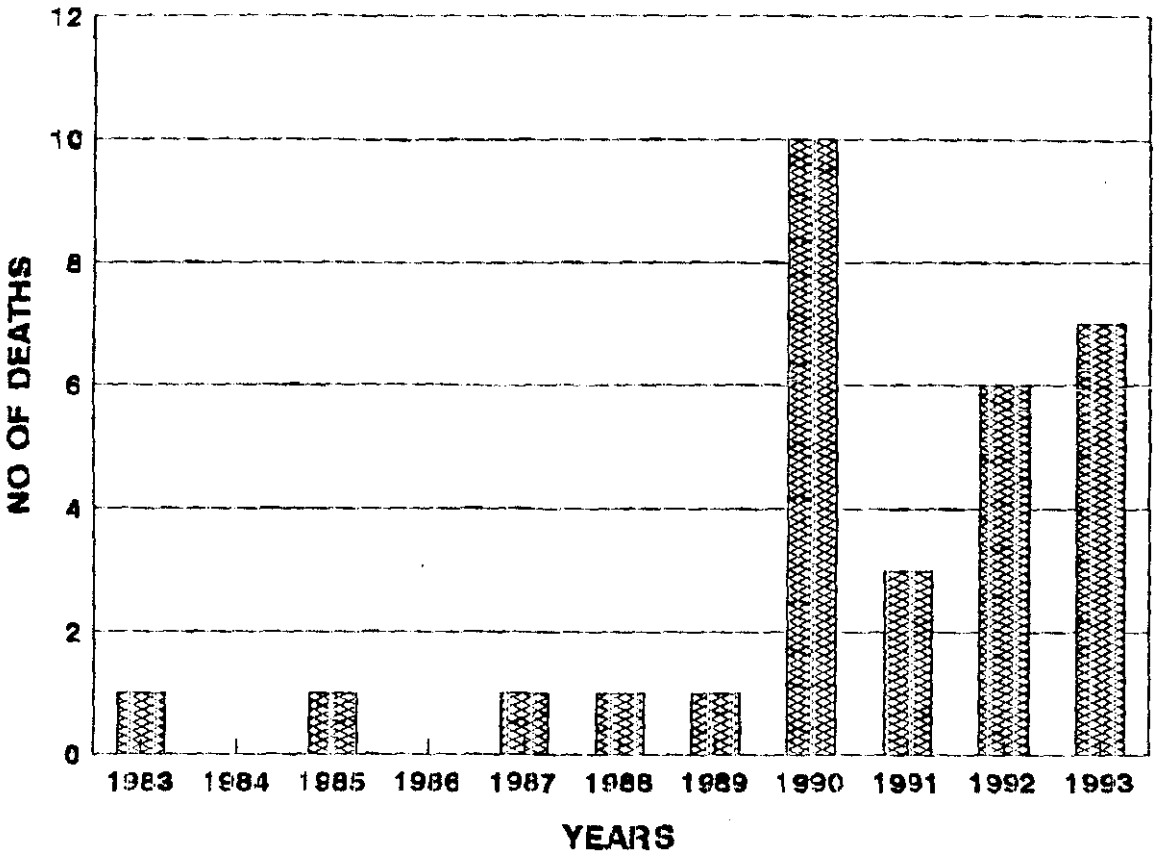

Fig.5. Human deaths due to wild elephants in Kerala

Compensation was claimed for all the wildlife attacks reported. Five thousand rupees was paid as compensation for human death till the year 1989 and then it was increased to Rs. l0,000/-. Wayanad Wildlife Division registered the highest number of injury cases compared to other Divisions. The total amount claimed as compensation was Rs.17,49,500 and the Forest Department sanctioned only Rs.1,25,150. In the North Wayanad and Vazhachal Divisions, there were no claims for compensation, but the Forest Department had paid a small amount to the victims. A total of Rs.20.64.900 was claimed as compensation in the whole of Kerala and an amount 2,95,000 was sanctioned (Table 18).

Table 18. Compensation paid for death and injury to humans and damage to property due to wild animals in Kerala (1983 to 19931

Sl. No.	Forest Divisions	Amount claimed (Rs.)	Amount sanctioned (Rs.)
1.	Wayanad Wildlife	17.49.500	1.25.150
2.	Munnar	96,000	5.000
3.	Thrissur	45.000	6.000
4.	Parambikulam	31,750	25.350
5.	Idukki	30.500	25.500
6.	Chalakudy	28,650	5.000
7.	Kottayam	17.000	0
8.	Nilambur North	16,000	15,800
9.	Palakkad	10.000	10,000
10.	Mannarkad	10,000	20.000
11.	Nilambur South	9,000	1,900
12.	Nemmara	9,000	6.500
13.	Trivandrum Wildlife	5.500	36,000
14.	Kannur	5,000	750
15.	South Wayanad	2,000	750
16.	North Wayanad	0	1,300
17.	Vazhachal	0	10,000
	Total	20,64,900	2,95,000

The incidents reported to the Forest Department is only available for analysis and some cases may be missing from this list. According to this assessment at least 3 cattle and 5 goats were getting killed per year in Kerala. Forest Department sanctioned about Rs.3660/year as compensation for cattle lifting. Similerly on an average at least 3 people get killed in an year due to the wild animal attacks in Kerala. Comparison is not possible with other States as no similar data is available.

3. EVALUATION OF CONTROL MEASURES

Many control measures are employed for preventing crop damage by wild animals in Kerala. These can be classified as traditional and modem methods. Traditional methods are guarding from watch towers, simple fences using iron wire, sound produced from old metallic objects, fire, stray dogs. scaring with cloth, erecting stone walls, bar soap, kerosene, human dummies, reed poles, cloths and plastic bags, arecanut sheaths, traps, fire crackers and trenches. Line wire fences and electric fences are considered as the modem methods. In some countries pigs are controlled with poison baits. (Hone and Kleba. 1984: Mcllroy. 1983).Various design of fences used for controlling the feral pig movements have been described by Hone and Akinson (1983).The effectiveness of hunting dogs for removing feral pigs had been reported by Peter and Brett (1998). In addition to this pigs have been controlled by trapping and shooting. In Australia the best poison identified was compound 1080 (Sodium fluroacetate) (Mcllroy. 1983). Deer damage in white pine plantations was reduced by employing dogs in U.S.A. (Neusinger and Neusinger. 1994). Bomford and O'Brien (1990) reviewed the sonic deterants in animal damage control. Damage to coppice regrowth by muntjak deer and protection with electric fencing had been described by Cooke and Lakhani (1996).

METHODS

Information on crop protection methods were collected from all over the State and also from the intensive study area, through direct observation and the effectiveness of these methods were assessed. An electric fence with energiser was made at Peppara wildlife sanctuary and its efficiency was evaluated. The electric fence had five stripes and a length of 1.7 km and it was erected around Chemmankala settlement, in Peppara wildlife sanctuary, with the technical assistance of ANERT (Agency for Non conventional Energy and Rural Technology), Trivandrum. Weekly observations were carried out. inside and outside the fence to quantify the indirect evidences of wild animals in 10 m x 10 m plots.

Bar soap as a deterrant to Sambar

Effect of bar soap for detering sambar was tested at Perumala. Marayur. Sambar was causing considerable damage to white sapota trees by browsing

the new shoots. Browsed and unbrowsed leaf buds were counted for assessing the deer damage. Before initiating the experiment, 23 trees of white sapota were selected, which were heavily browsed by the sambar. The trial was initiated in the month of January 1996. after the North-East Monsoon. Initially two periods of observations were carried without soap. Bar soap was then tied on the trees and counting of browsed buds were carried on next day morning. after 24 hours. The counting was repeated with the bar soap and after some days, after removing the bar soap.

RESULTS

Traditional methods

Fifteen indigenous methods employed in Kerala for preventing the crop damage were identified which are listed below (Table 19).

Table 19. Indigenous preventive measures used against different animals in Kerala

Preventive measures	Animals
Guarding	all animals
Line fence (different materials)	wild boar, deer
Sound from metalic parts	wild boar, deer
Fire	elephant, wild boar
Dogs	wild boar, deer
Stone wall	wild boar, gaur
Bar soap	wild boar, deer
Bamboo fence	barking deer
Bush fence	barking deer
Reed line	wild boar
Cracker line	wild boar, elephant
Cable	wild boar
Kerosene	wild boar
Plastic bags	wild boar
Cloths	wild boar

At some places, the villagers were using dogs to chase the wild animals, but occasionally elephants chased the dogs back into the human habitations and in the process destroyed the properties. Plastic bags and cloths were used as

Bar soap and kerosene was applied in the field to produce foul smell. which will keep away the browsers.

Trenches

Trenches are employed in many parts of Kerala to keep away the wild animals from settlements and agriculture. In the past trenches were built to keep away the wild elephants from entering the villages. In this study trenches were surveyed at Tholpetty. Chedalayam, Parambikulam and Peppara. At Tholpetty. trench was of 2 km in length, where as at Chedalayam it was 5 km. Trenches completely prevented damage by elephants in these areas. But smaller animals like deer and wild boar occasionally crossed the trenches.

At Parambikulam. trench was built around Kachithodu settlement. for the protection of crops and houses. Hard structure of soil and low rainfall helped the easy maintenance of trench in the northern portions compared to the southern areas of the State, where rainfall was high. In areas like Peppara and Neyyar trenches were not effective as high rainfall was prevalent in all the months and the texture of the soil was loose.

Stone walls

Stone wall was found effective against gaur. chital and wild boar. As the cost of construction was prohibitive, not many people attempted this method. Some private planters constructed stone walls around their fields against gaur and wild boar. At Marayur a planter has constructed 5 km of stone wall using granite, to prevent gaur from entering the mixed crop plantations. It was highly effective in preventing the gaur. wild boar and deer from entering the crop fields. At Kurichiat also 3 km stone wall was constructed to stop elephant and other animals from entering agriculture crops. The only available method against the wild boar is stone wall. Many private planters requested for providing subsidy and loans to construct stone walls around their agriculture fields.

Fences

A variety of fences are employed against wild animals in Kerala. Among them important were line fences (with various materials), bamboo fence, bush fence, reed line, barbed wire cables and cactus fence. All these fences were

effective in preventing wild animals from entering the fields up to certain extend. Live cactus fence at Champakkad colony in Chinnar wildlife sanctuary was highly efficient against elephants.

Electric fences

In order to reduce the animosity towards wild animals and to prevent crop loss, electric fences using energizers were installed by the Forest Department in Peppara. Neyyar and Wayanad Wildlife Sanctuaries.

Electric fences were found in the following places -

1. Periya Range 14 km
2. Begur Range 12 km
3. Tholpetty Range 51.7 km
4. Suthan's Battery Range 21.2 km
5. Kurichiat Range 27.4 km

Two types of electric fence are found in Kerala. Electric fences connected to direct A/c current and fences employing energisers. Previous type is highly lethal and casualties may occur. In one incident an elephant calf was electrocuted near Palakkad due to this type of fence. Electric fences, with energisers were effective and safe in controlling wild animal intrusions. Energiser is an electronic device in which the electric current is boosted to 7000 to 8000 volts. which will give a lethal shock to the animals which comes in contact with the fence. But as the pulse lasts only for $l/10^{th}$ of a second. there will be a break in the circuit and the animal can escape from the fence quickly without getting electrocuted. This type of fence, work basically on the principle of fear pshychosis. because the animal which have experienced a shock earlier, learn to avoid the fence. Due to this fence need not be a physical

In some cases, when animals run amok, they may dash against the fence. and the whole mechanism may break down. In such instances. immediate maintenance of the fence is must. Similarly, the fence should not be left without sufficient power. Because when the animals try to trespass, if sufficient current is not produced, they may push down and destroy the fence. If maintained properly, electric fence with energisers are effective against elephant. sambar and gaur.

It is evident from the Table 20 that the fence was effective against elephant and gaur. But not efficient against other animals at Peppara. In one incident an elephant ran amok and entered the settlement destroying the fence. Except this incidence. the fence completely stopped elephants.

Table 20. Number of indirect evidences recorded inside the fence and outside the fence at Chemmankala. Peppara

Animals	No. of signs inside the fence	No. of signs outside the fence
Elephant	4	12
Wild boar	27	29
Barking deer	3	7
Porcupine	7	5
Sambar and Mouse deer	2	1
Gaur	0	9

Bar soap as a deterrent to sambar

Among the many methods available, efficiency of bar soap as a deterrent to Sambar was tested at Marayur. Out of the various species of animals involved in crop damage at Marayur sambar posed a unique problem by browsing the horticulture crops. An exotic fruit tree, known as white sapota (Casimiroa edulis) was severly browsed by sambar. thus retarding the growth. The owner of the farm employed different methods to stop the browsing of sambar but it was not successful. As the farm was adjacent to forests, feeding occurred during evening and at night. when the human activity was less.

Initial observations showed that, browsing was in the order of 30% to 52% of the available leaf buds (Table 21). After this assessment, bar soap was tied on the branches and observations continued. It was found that. when the soap was introduced, browsing completely stopped. Three more observations confirmed complete prevention of browsing. After this, on 15-3-96 soap was completely removed from the farm. Further observations showed, browsing to the tune of 36 to 41%. The initial experiments thus fully showed the effect of bar soap to stop browsing, for two weeks. On 8-4-96. again soap was introduced and observations continued. At this point mild browsing in the order of 30 to 54% were recorded and soap started missing.

At this period, bar soap had no effect on browsing. Again on 16- 5-96 new soap piece were introduced and observations recorded. Browsing was completely stopped. but the soap pieces were found missing. Again after two observations new soap pieces were placed. It was further observed that not only all the soap pieces were missing but also browsing continued to occur. It was made sure by checking that the soap pieces were not removed by the local people but soon confirmed that the soap was missing due to the feeding

Table 21. Effect of bar soap, to prevent browsing of the white sapota leaf buds by Sambar

Month	Date	%damage of leaf buds	No. of soaps missed	Weather with soap or not	Remarks
January	09.01.98	39	Nil	without soap	
February	12.02.96	52	Nil	without soap	
	19.02.96	0	9	soap	
	22.02.96	0	6	soap	
	05.03.96	0	3	soap	
March	15.03.96	41	Nil	without soap	
	21.03.96	36	Nil	without soap	
April	08.04.96	30	Nil	soap	started missing the soap
	11.04.96	37	Nil	soap	
	17.04.96	35	19	soap	
May	14.05.96	54	14	soap	new soap introduced
	17.05.96	0	All	soap	
	21.05.96	0	Nil	soap	
June	09.06.96	51	All	soap	new soap
	12.06.96	66	All	soap	

of deer. It is concluded from the experiment that bar soap had a deterring effect on sambar at least for 15 days. But with the conditioning, the animals lost fear, and learned to avoid soap. It can be concluded that for short periods (15 days) bar soap can be applied as a deterrent to sambar.

4. DISCUSSION AND CONCLUSIONS

CROP DAMAGE

Crop damage by wild animals is a severe problem in some parts of Kerala. Field surveys showed that on an average 20% of the crop was damaged by wild animals in Kerala. Fortyseven species of crops were vulnerable to animal damage. Highly nutritious crops like paddy, plantains and coconut were more vulnerable. According to Sukumar (1988).Balasubramanian *et al.* (1993)and Ramesh kumar and Sathyanarayana(1993) raggi and paddy were major crop items raided by elephants in the forests of Karnataka and Nilgiris. But in Kerala. coconut palm. sugar cane, cocoa. arecanut and paddy were the main crops raided by elephants. Field surveys and information collected from the Forest offices showed .high incidence of crop damage at Northern regions followed by Southern areas. In most of the Forest Divisions wild boar is causing heaw destruction. This can be compared to the crop depredation created by over abundant population of nilgai and black buck in Haryana and Madhya Pradesh (Chauhan and Sawarkar, 1989).

Only 8.2% of the amount claimed by the farmers were sanctioned by the Forest Department. and in most of the instances. payment was delayed. Cropping pattern and location of the agriculture fields have great influence on crop damage incidence. Crops like betel leaf, cashew, clove, cotton, curry leaf and turmeric were not prone to damage. Damage of mulberry (upto 56%) recorded at Palanad by gaur is unique in Kerala. Gaur is known to damage crop only at Marayur in Kerala. If suitable remedial measures are not taken. the farmers may become hostile and the particular herd of gaur may be wiped out from the area. Sandal wood trees in the forests were also pushed down by gaur. This can be attributed to the practice of weeding adopted in the sandal wood plantations. Unweeded sandal wood plantations never had such problem due to gaur.

Human - slaughter and cattle lifting

Cattle lifting was reported from all the forest areas in Kerala. however. the problem is far less than that reported by Dwivedi (1982) from Central India. Tiger and panther were involved in majority of the cattle lifting cases reported and goats are mostly affected. Along with this man-slaughter by elephant is a serious problem causing at least 31 deaths and 64 injuries during the last 10 years (1983-93). Sawarkar (1986) reported that cattle lifting by leopard was common throughout its range. but there is no hard data as in the case

of tiger or Asiatic lions. As in the case of crop damage, compensation sanctioned by the Forest Department for cattle lifting was much lower than what claimed. It was also reported that the payment of compensation was usually delayed, considerably or even the compensation was not paid in many cases due to paucity of funds. At present Kerala is reported to have a population of about 4300 elephants (KFRI. 1993).During the last decade, human casualties due to wild elephants was on increase in Kerala. Death was more due to herds than solitary tuskers, contradicting the general belief that tuskers are more aggressive. Observation showed that villagers entering the forest to collect NWFPs were also killed. Similar observations were reported from North Bengal.

Control measures

In Kerala. both traditional and modern methods are employed as the control measures against the crop raiding animals. Most of the traditional methods are effective for short periods. Electric fencing using energisers, is an effective method for preventing herbivores like elephant, gaur and deer. Wild boar can be prevented by erecting good fences or stone walls. In this study it was found that bar soap was useful in controlling browsing of sambar for short periods. The method can be employed in critical periods and is economical also. Census of wild boar should be initiated before initiating any reduction in their numbers.

Educating the settlers about the behaviour of wild animals and resettling the enclosures to the outside areas will mitigate the problem of crop raiding to a certain extent. Electric fencing. using energisers. may be installed where the man-wildlife conflict is serious problem, as a short-term measure. Maintenance of electric fence is a must for attaining the envisaged result.

All preventive methods discussed so far can be considered as only short term. which may provide immediate relief. As long term measure, intensive management of wildlife population will be needed. Accurate population assessment of wild animals like elephant, wild boar, Indian porcupine. sambar. spotted deer and gaur is a must to evolve management options. After estimating the optimum population level, the excess individuals may be removed, either by culling or by translocation.

It is found that. most of the available water resources are under the custody of settlers and animals do not have any access to these water sources in summer. To ameliorate the situation, water should be made available to animals during summer by providing artificial methods like tanker lorries or pumps. Availability of fodder is scarce during summer, in many of the places like Wayanad. To solve this shortage, planting of fodder species like bamboo may be carried out in large scale. Cash crops of the settlements inside the

forests are a perpetual attraction for wild animals. These settlements may be relocated to other areas, leaving the forest without disturbance. All the extoic plantations found in the sanctuaries may be removed in a phased manner, giving way to native species. Similarly, monoculture plantations should be reverted to natural forests at least in the wildlife sanctuaries.

MANAGEMENT SUGGESTIONS

Short term measures

1. Construct and maintain electric fences with energisers in problem areas. The fences can be constructed by the Forest Department and maintenance also has to be the responsibility of Forest Department. If the maintenance is handed over to the local communities. collective responsibility is lacking. If the fence is left unattended for a single day. it may get damaged. It is observed that (Jayson, 1998)tribal communities lack enthusiasm and initiative, and technical know how to maintain electric fences with the energisers.
2. Local communities should be adviced to avoid planting cash crops like plantains. coconuts. pineapple and tapioca in the fringe areas of the forests.
3. Maintain the availability of drinking water in the forest areas during summer, either by constructing check dams or by providing artificial water holes.
4. Sanction subsidy and bank loans to the farmers for constructing preventive measures against crop raiding animals.
5. At present the compensation to the farmer is distributed after a long period. Steps may be initiated to release the compensation within a reasonable time limit.

Long term measures

1. Many settlers are having agriculture in the midst of the forests. Some of them are willing to move out of the forest. Suitable measures may be initiated to relocate the isolated villages remaining within the forest areas to outside.
2. Availability of fodder is scarce during summer in many of the forest areas (Eg. Wayanad). To solve this situation ensure the availability of fodder to elephants during summer months by planting species like bamboo and reed.
3. During the summer months, many of the forest area are burnt due to various reasons. This contributes to the local movement of wild animals to safer places. Some of them may come to the agriculture also. To solve this problem, fire may be prevented in the forest areas.

6. REFERENCES

Alriksson, B.A. 1988. Electric fences save plants. Elstangsel raddar plantorna Skogen 3:14-17; from (Forestry Abstracts 49: 91.

Appayya M.K. 1992. Elephant damage problems and measures for mitigation in Karnataka. My Forest 28(3): 257-261.

Balasubramanian, M.. N. Balakrishnan, S. Swaminathan and A.A.Desai 1993. Crop raiding by Asian elephants (Elephas maximus) in the Nilgiri Biosphere Reserve, South India. A Week with Elephants : Proceedings of the International Seminar on Asian Elephants, Bombay Natural History Society, 350-368.

Banerjee, A.K. 1994. Problem of man-eating and cattle lifting by leopards(Panthera pardus) in the Kumaon Hills, with special reference to newly created Binwar Sanctuary. Abstract of paper presented in the workshop on wildlife damage problems and control. Wildlife Institute of India. Dehra Dun.

Beringer, J.. L.P. Hansen. R.A. Heinen and N.F. Giessman 1994. Use of dogs to reduce damage by deer to a white pine plantations. Wildlife Society Bulletin, 22(4): 627-632.

Bornford, M and P.H. O'Brien 1990. Sonic deterrents in animal damage control. A review of device tests and effectiveness, Wildlife Society Bulletin. 18: 41 1-422.

Bussche, G.H.; Von Demi: Z.D. Van Deer 1985. Damage by Samango monkeys (Cercopithecus (mitis) albogulariii) to pine trees in the Northern Trans Vall. South African Forestry Journal 133: 43-48.

Champion, H.G. and S.K. Seth 1968. A revised survey of the forest types of India. Govt. of India publications, New Delhi.

Chauhan, N. P. S. and V.B. Sawarkar 1989. Problems of over abundant populations of Nilgai and Black Buck in Haryana and Madhya Pradesh. Indian Forester 115(7):488-493.

Cooke. A.S. K.H. Lakhani 1996. Damage to coppice regrowth by Muntjak Muntiacus reevsi and protection with electric fencing, Biological Conservation 75(3): 231-238.

Datye, H.S. and A.M. Bhagwat 1993. Estimation of crop damage and the economic losses caused by elephants and its implications in the management of the elephants. A Week with Elephants :Proceedings of the International Seminar on Asian Elephants. Bombay Natural History Society. 375-389.

Dey. S.C.. 1991. Depredation by wildlife in the fringe areas of North Bengal forests with special reference to elephant damage, Indian Forester 117(10):891-899.

Dumin. V.F. 1984. The allowable percentage and frequency of damage to scots pine by Elk. Lernoe khozyaistvo 7: 57-60 (Forestry Abstracts 46:7).

Dwivedi. G.D. 1982. Study of predation on domestic livestock by Tigers. A case study. Wildlife Institute of India. Dehra Dun. 89p.

Easa 1998. Personal Communication

Gill. R.M.A. 1992. A review of damage of mammals in North temperate forests 1. Deer. Forestry 62(2): 145-169.

Givsti. G.A. 1988. Recognizing Black bear damage to second growth redwoods. In Proceedings. Thirteenth Vertebrate Pest Conference, Moterey. California,. University of California pp. 188-189.

Hone, J. and Roland Kleba 1984. The toxicity and acceptability of warfarin and 1080 poison to penned feral pigs. Australian Wildlife Research 11: 103-111.

Hone, and Bill Akinson 1983. Evaluation of fencing to control feral pig movement. Australian Wildlife Research 10:499- 505.

Izac. A.M.N. and P.O. Brieru 1991. Conflict. uncertainty and risk in feral pig management: the Australian approach. Journal of Environment Management 32(l): 1-18.

Jayson. E.A. 1998. Studies on Man-wildlife conflictin Peppara Wildlife Sanctuary and adjacent areas. KFRI Research Report No. 140. Kerala Forest Research Institute. Peechi. 73p.

KFRI. 1993. Wildlife Census - Kerala 1993. A Report, Kerala Forest Research Institute. Peechi. 106p.

Kar. S.K. and H.R. Bustard 1981. Attacks on domestic livestock by the saltwater crocodile (Crocodile porosusl in Orissa. India. British Journal of Herpetology 614): 133-136.

Khan. J.A.W.A Rodgers. A.J.T. Johnsingh and P.K. Mathur 1994. Tree and shrub mortality and debarking by sambar Cervus unicolor (Kerr) in Gir after a drought in Gujarat. India, Biological Conservation 68(2): 149-154.

Mcllroy. J.C. 1983. The sensitivity of Australian animals to 1080 poison V. The sensitivity of feral pigs. *Sus* scrofa to 1080 arid its implications for poisoning campaigns. Australian Wildlife Research, 10: 139-148.

Menon. A.S. 1975. Kerala District gazetteers-Kottayam. State Editor, Kerala Gazetteers. Trivandrum.

Mishra. J. 1971. An assessment of annual damage of crop bv elephants in Palamavu Dist. , Bihar. Journal of Bombay Natural History Society 68(2): 307-310.

Mohan. D. 1994. Leopard depredation problems in Chamoli Garhwal. Abstract of paper presented in the workshop on wildlife damage problems and control Wildlife Institute of lndia. Dehra Dun.

Newmark. W.D.. D.N. Manyanz. D.M. Gamassa and H.I. Sariko 1994. The conflict between wildlife and local people living adjacent to protected areas in Tanzania.: Human density as a predictor. Biological Conservation 8(1): 249-255.

Neusinger. H. and Neusinger. J. 1984. Crop damage by elephants. Loris 16(5)1: 233-234.

Peter. C. and O. Brett 1995. The effectiveness of hunting dogs for removing feral pigs (Susscrofa). Wildlife Research 22(2): 147-154.

Pekov. M. 1988. Game damage in Cork Oak plantations in the Black sea region. Gorslco stoponstvo 44: 17-18 (Forestry Abstracts 53:5).

Ramesh Kumar. S. and M.C. Sathyanarayana 1993. Crop raiding patterns in Hosur and Dharmapuri Forest Divisions. Dharmapuri District, Tamil Nadu. A week with elephants: Proceedings of the International seminar on Asian elephants. Bombay Narural History Society 533-534.

Santhiapillai. C. and P. Jackson. 1990. The Asian elephant. An action plan for its conservation. IUCN/SSO. Asian Elephant specialist group. IUCN. Switzerland.

Sawarkar. V.B. 1986. Animal damage: Predation on domestic livestock by large carnivores. Indian Forester 112110):858-866.

Schulz. B. 1986. The manacement of crop damage by wild animals. Indian Forester 112(10): 891-899.

Sukumar. R. and M. Gadgil 1988. Male - female differences in foraging on crops by Asian elephants. Animal Behauiour 36(4): 1233-1235.

Sukumar. R. 1989. The Asian Elephant: Ecology and Management. Cambridge University Press. 250p.

Sukumar. R. 1990. Ecology of the asian elephant in Southern India. II Feeding habits and crop raiding patterns. Journal of Tropical Ecology 6(1): 33-53.

Sukumar. R. 1991. The management of large mammals in relation to male strategies and conflict with people. Biological Conservation 55: 93-102.

Sukumar. R. 1994. Man-wildlife conflict in India. An ecological and sociological perspective. In Guha (Ed.) Social Ecology. Oxford University Press. 303-317.

Thouless. C.R. 1994. Conflict between humans and elephants on private land in Northern Kenya. Oryx 28(2): 119-127.

Thosre. P.J. andA.G. Mahajan 1994. Cattle depredation. An ecological crisis. Abstract of paper presented in the workshop on wildlife damage problems and control. Wildlife Institute of India. Dehra Dun.

Thurston. E and Rangachari. K. 1975. Castes and Tribes of Southern India. Vol. V.pp. 86-103. Cosmo Publications, Delhi, India.

Tiwari. R.C. 1994. Black bear depredation problems in Chamoli Garhwal. Abstract of paper presented in the workshop on wildlife damage problems and control. Wildlife Institute of India. Dehra Dun.

Veeramani. A and E.A. Javson 1995. A survey of crop damage by wild animals in Kerala. The Indian Forester 121(10): 949-953.

Veeramani. A.. E.A Jayson and P.S.Easa 1996. Man-wildlife conflict: Cattle lifting and human casualties in Kerala. The Indian Forester 122(10):897-902.

Ve Ceillio. G.M.. R.H. Janner and G.L. Storm 1994. Crop damage by deer at Gettysburp Park. Wildlife Society Bulletin 22(1): 89-93.

Venkatesan. K.R.. Srimathi. R.A. and Kulkarni H.D. 1995. Survey of populations. In: Recent advances in research and management of sandal (Santalum album L) in India. For M.S. Swaminathan (Eds.) R.A. Srimathi. H.D. Kulkarni and K.R. Venkatesan. Associated Publishing Company, New Delhi.

Vyas. R. 1993. Recent cases of man-eating by the mugger(Crocodylus palustris) in Gujarat Slate. Hamdryad 18: 48- 49.

Welch. D: Staines. B.N.: Scot D: Catt. D.C. 1988. Bark stripping damage by red deer in a Sitka spruce forest in Western Scotland. II Wound size and position. Forestry) 61(3): 245-254.