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STUDY ON MAN-WILDLIFE INTERACTION IN WAYANAD WILDLIFE SANCTUARY, KERALA

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(Final Report of Research Project KFRI/214/94)

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ABSTRACT OF PROJECT PROPOSAL

Code	: KFRI/214/94
Title	: Study on man-wildlife interaction in Wayanad wildlife Sanctuary, Kerala
Objectives	: To estimate the population and assess the distribution of animals in relation to season, habitat, water availability and crop pattern
	:To assess the pattern of crop damage by elephants and other wild animals
	: To assess the current status in different land use/vegetation types and
	: To study the socio-economic structure of settlements to assess their dependence on forests
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Funding Agency	: Ministry of Environment and Forests, Government of India
Project Team	:
Principal Investigator	: P. S. Easa
Investigator	: S. Sankar
Research Fellows	: S.A Sabu Jahas (July,1994 to December,1997)
	M. Ananthanarayanan (July,1994 to September,1996)
	A. Veeramani (November,1996 to November,1997)

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SUMMARY

A study was carried out in Wayanad Wildlife Sanctuary and adjacent areas in Kerala during 1994-1997 to collect information on crop raiding in relation to animal abundance and distribution. Wayanad, consisting of the forests under the administrative control of North Wayanad, South Wayanad and Wayanad wildlife forest divisions constitute a major portion of Nilgiri Biosphere Reserve. This also forms part of the Elephant Reserve No.7 comprising elephant habitats in Kerala, Tamil Nadu and Karnataka. The area has southern moist mixed deciduous; west cost semi evergreen and southern dry mixed deciduous forests. A portion of the natural forests is converted to plantations of teak and eucalypts. The area could be divided into three regions based on contiguity. The area is rich in fauna with representation of all Peninsular Indian mammals. The characteristic feature of the study area is the large number of settlements scattered in the form of a mosaic where cultivation is practiced.

A population of more than 25,000 people live in and around the forest. The main occupants of the settlements in the study area are the Wayanadan Chetties and the Gowdas. The principal tribes living in the forest plateau are the Mullakurumas, Paniyas, Kattunaikkans and Uralis.

Dry deciduous forests dominate in Southern region, moist deciduous in Central and teak plantations in Northern region. All these regions have plantations of teak. Twenty seven species of trees were recorded in Southern regions of which *Terminalia tomentosa* was the most dominant. Forty five species were recorded in Central region. *T. tomentosa* was the most dominant tree. *Tectona grandis* was the most dominant among the twenty eight species recorded from Northern Ranges.

The forest cover has been reduced by 1086 km^2 during thirty year period of 1950-82 with a corresponding increase in the area under plantation and cultivation.

The intact and continuous vegetation cover has been fragmented almost throughout having bearing on the movement of the larger mammals.

Household survey was conducted in 2174 houses to collect information on forest dependence, social and cultural activities and peoples' attitudes towards the management of forest and wildlife. Mullakuruman, Kattunaikkan, Adiyan, Urali and Kurichiyans are the main tribal communities in 69 enclosures. About 48 % of the people within the enclosure have title deeds for their lands. Others are in forest lease and revenue lands. Seventy five percent of the inhabitants acquired the land by deforestation. The main source of income for the people living in and around the forests was the daily wage labour followed by agriculture. Nearly 5% of the peoples in enclosures depend on the forest for NWFP collection. Ninety nine percentage of the settlers collect construction materials from the forest. The people of Wayanad are predominantly agriculturist and cultivation is one of the major source of income. Crop damage is a severe problems in most of the settlements. Elephant and wildboar topped among the most damaging ones. Cattle lifting were more in enclosures (68.50%) than periphery and away from the forest. About 73% of the human death reported were inside the forest, 36% near the forest and 9% on roads. House damage in enclosure (91.66%) were higher than periphery and away from the forest. Only 27.27% of the affected were compensated.

Fire wood was collected both for own use (98%) and sale (2%). The dependence of the tribals are higher than the non tribals. NWFP is the main source of income for the tribals. Only a small proportion of the population in Southern and Central regions are involved in NWFP collection compared to Northern region. An estimated 3500 livestock graze in the forest of Wayanad. The dependence of the tribals on forest for cattle grazing was comparatively higher.

About 48.32% of the respondents in Wayanad are willing to be resettled out side. Nearly 75% of the people in the enclosure, 66.56% in periphery and 91.81%

along the transect are of the opinion that forest and wildlife should be protected without affecting the people. About 87% of the people in enclosures, 81% in periphery and 78% along the transect are aware of the need to conserve wildlife.

Information on group size, composition and structure of animals were collected through direct observations. The individuals were classified into different age-sex categories. Transects were laid in the study area in proportion to habitat size. Line transect method was followed to collect information on dung/ pellet density. There was a fluctuation in the annual density of elephants which ranged from 0.85 to 2.04 /km^2 in Southern, 0.59 to 1.36/km^2 in Northern and 0.63 to 1.53 /km^2 in Central region.

Herd size of elephants was found to range from 1-38 in Southern region and 1-33 in Northern region. Adult females formed a major portion of the population in Southern (42.31%) and Northern regions (46.17%). Overall male to female sex ratio in the population was 1: 3.50 in Southern and 1:3.59 in Northern regions. However, an adult male to female sex ratio of 1:40 in Southern and 1:3.59 in Northern regions were observed.

Herd size of gaur ranged from 1 to 26 in Southern region and 1 to 30 in Northern region. Adult females formed a major portion of the population in both the regions. The overall male to female sex ratio in the population was 1:3.31 in Southern region and 1:4.24 in Northern region.

Herds size of sambar deer ranged from 1 to 11 in Southern, Northern regions and 1 to 13 in central region. Adult females formed major portion of the population in all the regions. The overall male - female sex ratio varied in different regions

Herd size of spotted deer ranged from 1 to 26 in Southern region , 1 to 38 in Northern and 1to 12 in the Central region. Adult females formed a major portion of population in all the regions. The male - female sex ratio in the population varied from region to region.

Elephants in the study area were observed to feed on 97 plant species belonging to 34 families. The members of Poaceae and Cypraceae were dominant among the food species. Sambar in the study area were observed to feed on 92 plant species and spotted deer on 93 plant species.

The data from transects were pooled to estimate the animal density in different habitats. Seasonal food availability in different habitat were estimated through clip and weigh method. There were seasonal differences in the density of elephants, gaur, sambar and spotted deer in different habitat.

Twenty nine settlements were selected for crop raiding studies based on surrounding vegetation types, location of the settlements and type of protection methods employed. These settlements were visited twice in a month to collect information on crop damage. The extent of damage due to feeding and trampling was estimated by laying plots. Economic loss due to crop damage was quantified and converted into per unit area. Elephants were responsible for most of the damage in the study area. Paddy was the most affected crop. Trenches was most effective compared to any other protection methods. Total economic loss due to crop damage by animals was Rs.42,43,203.47. There was a positive correlation between the frequency of raiding and size of the settlement.

A number of factors including the food and water availability, higher seasonal density distribution of animals and management of forest areas in the adjacent states contribute to the crop raiding problem in Wayanad.

CHAPTER 1

INTRODUCTION

India has an extensive network of about 500 National Parks and Wildlife Sanctuaries. These are the home of representative natural habitats and wildlife as well as the traditional communities. These are also repositories of natural resources. The industrial economy also looks forward to these areas for exploitation. Protected Areas thus mean different things to different people. Restrictions and denial of access to the resources and the competition by wildlife and human beings for the same resources lead to the conflict between the two. Kothari *et al.*, (1995) have discussed various aspects of conservation problems in India. A survey in the late 1980s by Indian Institute of Public Administration revealed that 69% of the surveyed Protected Areas had human population living inside and 64% had community rights, leases or concessions (Kothari *et al.*, 1989). The authors, through extrapolation estimate about 3 million people inside the Protected Areas. The conflicts arising out of various factors have been evident in some of the Protected Areas in India (Kothari *et al.*, 1995). The conflict could be due to forced displacement of people while declaring the area Protected, the curtailment of access or rights of the people to the resources which they had been enjoying for a long time or could be due to the increase in the animal population resulting in crop damage, livestock lifting and human death. The pressure on the natural resources from the industries competing with the resource demand of the local people along with the fragmentation and degradation of the existing habitat worsen the issue of human animal conflict in most of the Protected Areas.

The once contiguous and diverse forest ecosystem in Western Ghats deteriorated due to deforestation leading to fragmentation of habitat, forming 'islands' affecting the wildlife in general and the larger mammals in particular. These islands are further fragmented/degraded by encroachments, developmental

programmes and the unscientific land use patterns. Recent reports indicate increase in crop damage incidences by wild animals in different parts of Kerala (Easa, 1994; Veeramani *et al.*, 1996).

Crop raiding and manslaughter by elephants have been reported from different parts of its distribution ranges where elephants have been pushed to the fragments. Depredation is a major problem in parts of Malaysia (Blair *et al.*, 1979; Seidensticker, 1984), Sumatra (Santiapillai and Suprahman, 1984; Blouch and Simbolon, 1985), Sri Lanka (McKay, 1973; Santiapillai, 1987), China (Xiang and Santiapillai, 1995), Laos (Venevongphet, 1995) and India (Mishra, 1971; Lahiri Choudhary, 1980; Sukumar, 1985; Appayya, 1992; Murthy, 1994; Naik, 1994; Reddy, 1994; Yadav, 1994; Datye and Bhagavath, 1995a; Balasubramanian *et al.*, 1995; Veeramani *et al.*, 1996).

Information on man-elephant conflict and effectiveness of different kinds of protection methods to deter elephants were well documented in Africa (Thouless 1994 & 1995; Thouless and Sakwa, 1995). Apart from these, numerous reports on crop depredation, livestock death and injuries and damage to properties due to elephants have also been made in African elephant ranges (Kiiru, 1995; Ngure, 1995; Tchamba, 1995; Barnes, *et al.*, 1995). Smith *et al.* (1995) identified the factors influencing the elephant distribution with a focus on human-elephant conflict in Zaire. Hoare (1995) suggested options for control of elephants in conflict with people. Recent research carried out by Osborn and Rasmussen (1995) indicate that *Capsicum oleo-resin* spray could be used as a short term repellent against African elephants. Similar research is being carried out in Sengwa Wildlife Research Area of Zimbabwe (Osborn, 1996).

Crop raiding by elephants has been reported from almost all elephant ranges in Asia where elephants survive in fragmented and disturbed habitats. Quantification of the crop damage in terms of economic losses has been made in

Palamau National Park (Mishra, 1971). McKay (1973) and Olivier (1978a) gave a brief account on the problem of crop raiding by elephant in Sri Lanka and in Malaysia respectively. Blair *et al.* (1979) estimated the economic losses due to the oil palm and rubber plantation damages and manslaughter by elephants in Malaysia. Blair and Noor (1981) reported elephant damage to oil palm and rubber plantations in South East Asia, which run into million dollars in economic loss. Caufield (1984), Santiapillai and Ramono (1993) and Santiapillai and DeSilva (1994) concluded that the elephants are forced to raid crop as their habitat was degraded and lost. Punchihewa (as quoted by Santiapillai, 1994) correlated the attitude of the present-day people with man-elephant conflict and remarked that the settlers who came from towns do not have the tolerance of elephants. Devaraj (1994) reported the socio-economic aspects of elephant damage and problems posed in Andaman Islands.

Allaway (1979), Fernando (1990) and Desai and Krishnamurthy (1992) identified the problem of crop raiding elephants. Studies by Seidensticker (1984), Sukumar (1985 & 1990), Kumar and Desai (1992), Bist (1996), Santiapillai (1996) and Sale (1997) suggested control measures to overcome the problem of crop raiding.

Thousands of families were adversely affected due to crop damage by elephants in Uttar Pradesh (Singh, 1978). Lahiri-Choudhury (1975) and Dey (1991) reported the problem of elephant depredation in North Bengal. Datye and Bhagwat (1995b) studied the crop damage by elephants and its economic implication in Dalma Wildlife Sanctuary in Bihar. Yadav (1994) documented the crop raiding by elephants in North Bengal and suggested mitigation measures. The problem has been highlighted by Reddy (1994) in Pakhui Wildlife Sanctuary in Arunachal Pradesh, Naik (1994) in Mollen Wildlife Sanctuary in Goa and Murthy (1994) in Madhya Pradesh. This has spurred several studies in Tamil Nadu, Karnataka and Kerala

(Kumar 1995, Balasubramanian *et al.*, 1995). The menace due to crop depredation by elephants in Karnataka was identified by Nair and Gadgil (1978) and 900 Km. of elephant trench at a cost of Rs.300 lakhs had been proposed to mitigate the problem (Appayya, 1992). Veeramani and Jayson (1995) and Veeramani *et al.* (1996) documented the wildlife damage and man wildlife conflict in Kerala using the secondary data collected from Forest Department.

Apart from these, there are several reports available on manslaughter by elephants in India. Sukumar (1989) reported the manslaughter in Southern Eastern Ghats. Datye and Bhagwat (1995c) reported a total of 134 human deaths caused by elephants in South Bihar and 74 deaths in Southwest Bengal between 1980 and 1991. About 500 people have been killed by the elephants in Assam in the past decade and one makhna killed about 50 people in Assam during 1993 (Hussain, 1993).

Rhinoceros has been reported to cause crop damage in Royal Chitwan National Park in Nepal (Mishra, 1982) and Jaldapara Sanctuary in India (Ghosh, 1994 & 1996). Crop damages by deer (Dennett, 1965; Moore and Folk, 1978; Onoyama *et al.*, 1990; Ratcliffe 1991; Vecellio *et al.*, 1994), wild boar (Bratton, 1975; Genov, 1984; Kristiansson, 1985; Vassant *et al.*, 1987; Mussa and Debernardi, 1990; Labudzki, 1991; Labudzki and Wiazelko, 1991; Macchi *et al.*, 1992; Brownlow, 1994) and bison (Meagher, 1989) have also been reported from different parts of the world.

Singh and Shrivastava (1994) reported crop damage by nilgai, spotted deer, sambar and wildboar in Madhya Pradesh. Crop depredation by black buck have been reported to be a serious issue in various parts of India (Chauhan and Sawarkar, 1989; Dubey and Rahmani, 1994; Indurkar *et al.*, 1994; Kotwal 1994; Kumar *et al.*, 1994; Manakadan, 1994; Prakash and Bohra, 1994; Rao and Rao, 1994; Sharma, 1994). Crop damage problem in Haryana due to nilgai and black buck (Singh and

Chauhan 1991 a & b) in Rajasthan due to chinkara (Bohra and Goyal, 1991), in Gir due to sambar (Khan *et al.*, 1994) and in Rajasthan due to macaques (Malik, 1994) have also been reported. Singh and Dixit (1994) reported crop-raiding problem in Dudwa National Park and Siktel (1994) in Sikkim.

Ramachandran (1990) and Gopinathan (1990a) have mentioned the migration and crop-raiding problem, due to elephants in Wayanad Wildlife Sanctuary. The Management Plan for Elephant Reserves in Kerala has highlighted the incidences of loss of life and crop depredation due to wild animals in general and elephants in particular (Easa, 1994). A total of Rs. 2,40,505 has been paid as compensation for crop damage and Rs. 1,25,150 for death and injury to human in Wayanad during the period between 1985 and 1993 (Veeramani and Jayson, 1995; Veeramani *et al.*, 1996). This was registered as the highest amount paid compared to the other Forest Divisions in Kerala. The compensation is on the increase since 1986 even after providing live wire fencing in some of the areas in Wayanad (Easa, 1994). These reports indicate the severity of the problem in Kerala especially in Wayanad.

Hence the present study was taken up in Wayanad

- **to estimate the population and assess the distribution of animals in relation to season, habitat, water availability and crop pattern**
- **to assess the pattern of crop damage by elephants and other wild animals**
- **to assess the current status in different land use/vegetation types**

and

- **to study the socio-economic structure of the settlement in study area to assess their dependence on forest products.**

CHAPTER 2

STUDY AREA

Wayanad, consisting of the forests under the administration of North Wayanad, South Wayanad and Wayanad Wildlife Sanctuary Divisions form a major portion of Nilgiri Biosphere Reserve. This also forms a part of the Elephant Reserve No. 7 comprising elephant habitats in Kerala, Tamil Nadu and Karnataka. Wayanad is contiguous with Bandipur Tiger Reserve and Mudumalai Wildlife Sanctuary in the South and Southeast and Rajiv Gandhi National Park in the North and Northeast (between 11^0 20' and 12^0 7' N latitude and between 75^0 28' and 76^0 36' E longitude). The total extent of area is about 520.78 km^2, of which 344.44 km^2 forms the Wayanad Wildlife Sanctuary (Fig 1).

A brief history

'Wayanad' derives its name from the numerous swamps (locally called as *vayals*). Francis (1994) described the political history, forest, agriculture and wildlife in Wayanad in earlier days. The forests of Wayanad were "being almost interminable subtropical jungle in which grow trees and plants unknown to the higher levels and its animal, bird and insect life (not forgetting its leeches) being more in evidence and more varied. It is in short a botanist's paradise and a naturalist's El Dorado".

Paddy was the commonest crop and was cultivated in the swamps. The dry higher grounds were cultivated with crops such as ragi and chama. These were often grown on the shifting system. Wildlife was so numerous that crop raiding was frequent. Fencing or continuous watching was necessary to prevent wild animals from damaging the crop. According to Francis (1994) "One of the characteristics of Wayanad fields is the large number of watchers or raised platforms (*machans*) which are dotted about them".

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FIG.1. STUDY AREA

Coffee was probably the first plantation crop to be introduced into Wayanad in 1828 and by 1839, its cultivation became an enterprise. This triggered a series of monoculture plantations such as tea and then extensive deforestation for raising teak. The plantations actually signalled the start of deterioration of the habitat.

The human populations were so low that labour was a real problem and the Britishers once even thought of encouraging or forcing the Badagas of Nilgiris to migrate to Wayanad to make agriculture extensive and profitable. The tract was feared for its malarial fever that people were reluctant to move to the area. But in the fifties, after the state reorganization, there was a mass invasion of the forests of Wayanad by the settlers.

Commercial plantations increased the requirement of labour. The 'Kurumban' tribals were replaced with coolie labourers brought from elsewhere and the number of settlements increased. The commercial activities and the increased settlements had its effects on the once continuous stretch of thick forests. As the population increased, the settlements began to intrude the neighbouring forests thus fragmenting the wildlife habitat. The developmental programmes that followed contributed further to the deterioration of the remaining forest areas.

During the dawn of the century, the area was protected as Reserved Forests under the jurisdiction of Chedleth Range. Subsequently, Sulthan Battery Range was formed in 1924. After 1958, South Wayanad was managed under Kozhikode Forest Division and North Wayanad under Wayanad Forest Division. The area was declared a Sanctuary in 1973 and brought under the Wildlife Division in 1985. Gopinathan (1990b) has given a detailed description and history of the Sanctuary.

The forest of Wayanad could be considered as three Regions based on the contiguity of forests.

Southern Region- comprises the forests of Muthanga, Sulthan Bathery and Kurichiat forest Ranges. The Region starting from Nulpuzha reserve extends

through Kerala, Karnataka and Tamil Nadu trijunction to the Kabini riverbank. Its contiguity with the Padiri reserve of Chedleth Range is lost due to the encroachment in Pulpally forest areas. However, contiguity is maintained through the forest of Padri reserve and a narrow strip in Karnataka side. A major portion of this region is bordered by Kabini river, both sides of which are under cultivation. A major portion of the segment is boardered by the forests of Mudumalai Wildlife Sanctuary and Bandipur Tiger Reserve of Karnataka. There are about 29 enclosures in the Southern Region.

The forests in this Region represent one of the best examples of dry deciduous forests in the state. Presence of extensive bamboo break is one of the most important characteristics of the area.

Northern Region- The northern region in Wayanad extends from the Shanamangalam, Kartikulam reserve forests boardering North Padri reserves through the highly fragmented patches of Begur and Tholpetty Ranges of North Wayanad and Wayanad Wildlife Sanctuary division respectively. This has contiguity with Periya, Kottiyur and Mananthavady of North Wayanad and Kannur Forest divisions. Rajiv Ghandi National Park of Karnataka is located on the East. The fragile, unique ecosystem of Kuruva islands falls between this region and the Central region. There are about 26 enclosures in the northern region. The vegetation types in the region vary from evergreen to deciduous types.

Central Region- The central Region comprises the forest of Padri reserve under the administrative control of Chedleth Range of South Wayanad Forest Division. A narrow strip of forest along the Kabini river is bordered by Kabini river. Both sides of Kabini are under cultivation. Electric fencing leaving a gap for elephant movement protects the cultivated areas along the Kabini on one side. A large part of the forest falls under the moist deciduous forest with bamboo break. There are 14 enclosures of which two occupy a vast expanse.

Precipitation

The annual rainfall in Southern Region varies from 1200-1700 mm, 1760 mm in Central Region and 1360 mm in Northern Region. Maximum precipitation is from June to September. The South West monsoon brings the greater part of the total rainfall bursts normally by first week of June proceeded by a few showers in April and May. Northeast monsoon brings some rain in October and November. Breaks in the monsoon are not uncommon. Based on the rainfall pattern, three seasons *viz.* dry (January-April), first wet (May-August) and second wet (September-December) could be identified. The moist deciduous forests received more rainfall compared to the dry deciduous forests (Balasubramanian, 1998).

Temperature and humidity

The temperature and humidity data for the Southern Region were collected from the Agricultural Farm at Ambalavayal adjacent to Wayanad Wildlife Sanctuary. Mean atmospheric temperature in Southern Region varied from a monthly maximum of 31°C in March to 24°C in July and monthly minimum of 19°C in May to 14°C in December. The average relative humidity ranged between 60.4% in January and 87.6% in June (Fig 2).

The mean atmospheric temperature varied from a monthly maximum of 34^0 C in March to 24^0 C in August and December and from monthly minimum of 22^0 C in February to 17^0 C in November in Central Region (Fig 3). In Northern Region, the mean atmospheric temperature varied from a monthly maximum of 36^0 C in March to 27^0 C in July and from a monthly minimum of 19.4^0 C in June to 12.9^0 C in December (Fig 4).

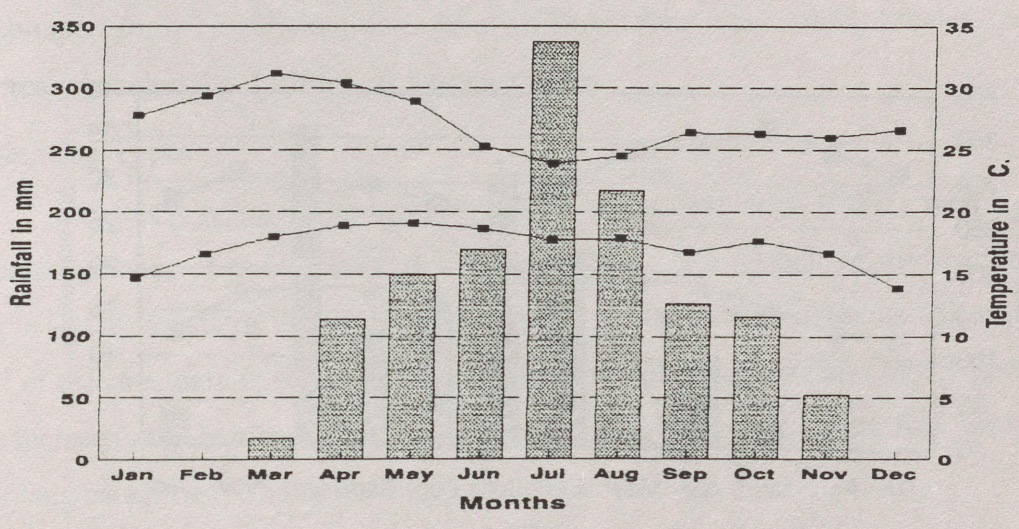


Fig 2. Monthly distribution of rainfall and temperature in Southern Region during 1993 - 1994

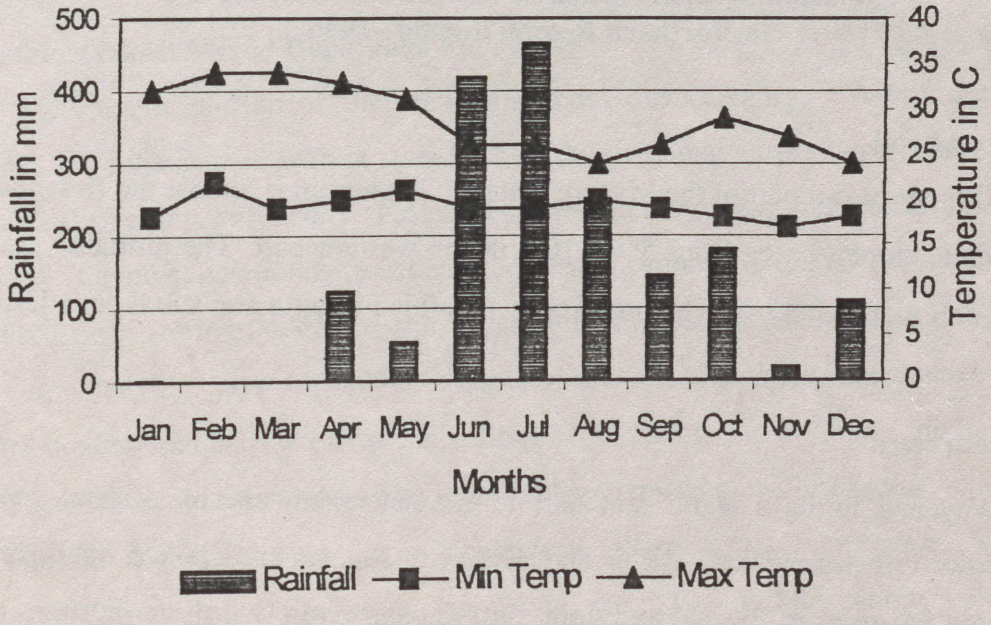


Fig 3. Monthly distribution of rainfall and temperature in Central Region during -1996

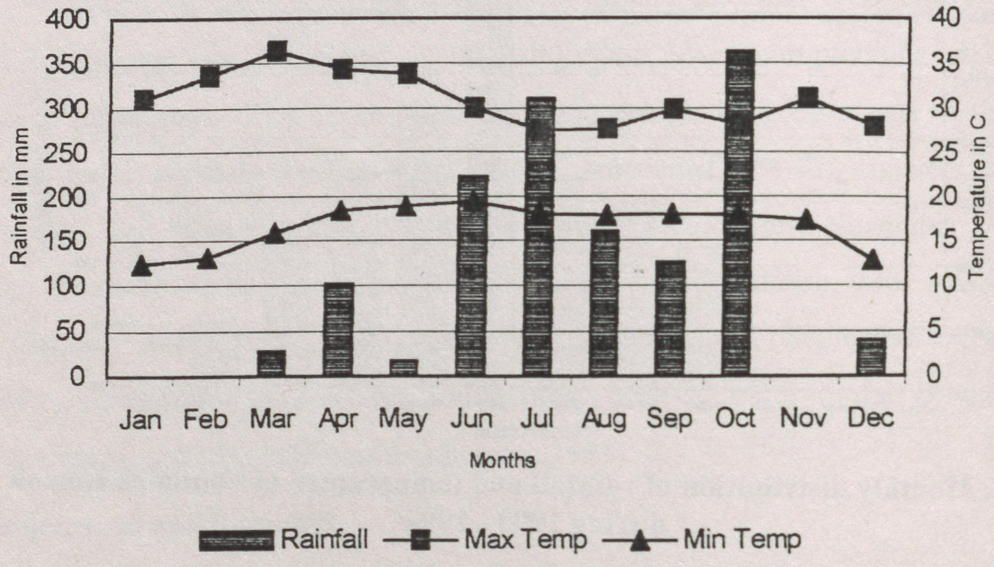


Fig 4.Monthly distribution of rainfall and temperature in Northern Region during –1996

Terrain and soil

This range is a part of the Mysore plateau. The terrain is almost flat (less than 5°) to gentle slope (varies from 5° to 10°) in the western part. The altitude varies between 850 m and 1147 m. The broad type of soil is Ferrolite and sub type is Ustic Altisol.

Water sources

Wayanad forms a significant part of the catchment area of Kabani river which flows into Karnataka. Begur and Tholpetty Ranges are drained by Baveli puzha and Panamaram puzha and join the Kabani river. Northern portion of Kurichiat Range is drained by Kannarampuzha and Kurichiat Thodu flowing northward and joining Kabini river. Towards the southeast, Manjal Thodu and other streamlets join Nuguhole river to flow further north east to Karnataka. Southern portion of the sanctuary is drained by Nulpuzha and Mavinahalla Thodu which

combine to form Nuguhole river. Manjal Thodu and other small streams in the sanctuary become dry during peak summer season.

Vegetation Types

The forest types in the area are mostly moist deciduous (MDF) with a few scattered patches of evergreen and riverine forests. A long belt of dry deciduous forests (DDF) exists in the areas bordering Tamil Nadu and Karnataka. About one third of the sanctuary is covered by plantations of teak, eucalypts and mixed species interspersed with bamboo. The forest types could be broadly classified into the following categories (Champion and Seth, 1968).

1. Southern Moist Mixed Deciduous Forests
2. West Coast Semi-evergreen Forests
3. Southern Dry Mixed Deciduous Forests

Southern Moist Mixed Deciduous Forests

A major portion of the area falls under this category. Moist deciduous forests are interspersed with seasonally waterlogged areas in the depressions known as *vayals* (marshy/wet lands). *Vayals* are dominated by grass and are devoid of tree cover. The moist deciduous forest has a moderate canopy cover (50-70%) during the wet seasons. During the dry season, most of the trees shed leaves and canopy cover is comparatively less (10-20%). Bamboo brakes (*Bambusa arundinacea)* are distributed sporadically all over the habitat. It is also found all along the perennial streams and in the wet areas. The upper canopy consists of *Terminalia tomentosa*, *Terminalia bellirica, Terminalia paniculata, Pterocarpus marsupium, Tectona grandis*, *Grewia tiliaefolia*, *Adina cordifolia*, etc. The middle canopy comprises *Schleichera oleosa*, *Kydia calycina*, *Bridelia retusa*, *Acacia pinnata*, *Butea monosperma*, *Haldina cordifolia*, *Cinnamomum zeylanicum* etc. Main species of ground flora are *Helicteres isora*, *Lantana camera*, *Eupatorium odoratum*, *Hibiscus furcatus*, *Zizyphus xylocarpus*, *Randia dumetorum*, etc. A few climbers like *Butea parviflora*, *Caesalpinia* sp., *Calycopteris floribunda* are also seen. *Xylia xylocarpa*

is conspicuous by its absence. Grasses such as *Cyrtococcum patens*, *Apluda mutica* and *Oplismenus compositus* are thinly distributed with low productivity. Fire occurrence is comparatively less in this type of forests.

West Coast Semi-evergreen forest

This type of forest is found mostly in patches at few places. It is a heterogenous mixture of evergreen and deciduous species. The number of species is high but less than pure evergreen. Climbers are heavy and epiphytes abundant. The main species of top canopy *Terminalia bellirica*, *Olea dioica*, *Schleichera oleosa*, *Hydnocarpus pentandra*, *Aporusa lindleyana*, *Mallotus philippensis* and *Diospyros* sp. Ground flora consists of *Strobilanthus* sp., *Curcuma* sp., etc. Where the canopy is open *Eupatorium odoratum* is seen spreading.

Southern Dry Mixed Deciduous Forests

The dominant tree species are *Shorea roxburghii*, *Anogeissus latifolia*, *Terminalia alata*, *Terminalia chebula*, *Pterocarpus marsupium*, *Gmelina arborea*, *Schrebera sweitenioides*, *Diospyros montana*, *Schleichera oleosa*, *Grewia tiliaefolia*, *Dalbergia latifolia*, *Mitragyna parvifolia*, *Bauhinia racemosa*, *Xeromphis uliginosa* and *Tectona grandis*. The saplings of tree species are abundant along the nullahs where ground water is available. Grass species such as *Themeda cymbaria*, *Themeda triandra*, *Cymbopogon flexuosus* and *Imperata cylindrica* grow more than 200 cm in height and form a dominant ground cover. The canopy layer of the trees is broken due to the spatial distribution as well as comparatively low tree density. Canopy cover is less (10-20%) during dry season. Due to its deciduous nature, leaf fall is common even in the month of December and dry spell extends up to pre-monsoon showers beginning in May. The bamboo (*Bambusa arundinacea*) is less frequented compared to moist deciduous forest. In the dry deciduous forests, the *vayals* are comparatively less and are dominated by tall grass (*Themeda* sp. and *Pennisetum hohenackeri*).

Plantations

Total area of the plantation in the study area is about 163 Km^2, which includes pepper, eucalypts, teak and mixed softwood species. Eucalypts plantations do not have any other tree species except a few saplings of *Cassia fistula* and *Terminalia* sp. The whole plantation is occupied by *Lantana* sp. Tall grasses *viz.*, *Themeda cymbaria*, *Themeda triandra* and *Cymbopogan flexuosus* are found in open areas in the plantations. In Teak plantations, apart from a few deciduous tree species, *Helicteres isora* occupy a large proportion of the area.

Fauna

The area is rich in faunal in diversity and abundance. Almost all the large mammals of peninsular India are observed in the area. The area has a good population of elephant (*Elephas maximus*), gaur (*Bos gaurus*), sambar (*Cervus unicolor*), spotted deer (*Axis axis*), barking deer (*Muntiacus muntjac*), mouse deer (*Tragulus meminna*) and wild boar (*Sus scrofa).* Other animals such as bonnet macaque (*Macaca radiata*), common langur (*Presbytis entellus*), sloth bear (*Melursus ursinus*), tiger (*Panthera tigris*), wild dog (*Cuon alpinus*), panther (*Panthera pardus*), jungle cat (*Felis chaus*), Indian pangolin (*Manis crassicaudata*), porcupine (*Hystrix indica*), Malabar giant squirrel (*Ratufa indica*, and Indian hare (*Lepus nigricollis nigricollis*) are also seen in this area. Sighting of four horned antelope (*Tetracerus quadricornis*) is rare and are restricted to areas bordering Karnataka. A total of 44 species of reptiles (Thomas *et al.*, 1997), 31 species of amphibians (Easa, 1998) and 54 species of fishes (Shaji and Easa, 1997) were identified from Wayanad.

Human habitations and cultivation

An interesting feature of the study area is the large number of settlements where cultivation is practised. A total of 69 enclosures are situated inside the study area. These settlements are confined to the moist deciduous forests and teak plantations. The people occupy almost all the vayals with perennial water sources. A

population of more than 25,000 people live in and around the Protected Area. Their main occupation is agriculture. They cultivate cash crops such as coffee, pepper and coconut followed by primary crops *viz.*, paddy, ginger, tapioca and plantains. Electric fencing, provided by the Forest Department protects a few of the settlements. A total of 166 Km. length of electric fencing has been erected in the study area.

Cattles and goats form the major livestock of the people. The people residing inside the sanctuary own a total population of 3500 cattles. These animals are mostly left to feed inside the Sanctuary. Cattle lifting by panther and tiger are also reported.

The people

The main occupants of the settlements in the study area are Wayanadan Chetties and Gowdas. The principal tribes living in the forest plateau are Mullukurumbas, Paniyans, Kattu Naikans, Uralis and a few Kurichiars (Thurston and Rangachari, 1909). Some of the settlements have also Hindus, Christians and Muslims. The chief occupation of Chetties is cultivation of paddy in the swamps. They also grow pepper, plantains and coffee in their homestead. *Lantana* bushes are found in abandoned shifting cultivation plots.

The Paniyans are an aboriginal race, owning no land, but cultivating paddy for the Chetties. They speak an aboriginal language and also a dialect of Malayalam. Among the Kurumbas, the Mullukurumbas are socially and economically advanced. They cultivate various crops in the adjoining wet lands. They also own cattle. They want little from the forests other than the land to cultivate. The Paniyans used to practice shifting cultivation in the virgin forest. At present, they live by extending labour to neighbouring estates as well as to the Forest Department. The Kattunaikans are considered as the least civilized among the jungle tribes and subsist on the forest by collecting non-wood forest produce such as honey, tubers, fruits, medicinal plants and others.

CHAPTER 3

VEGETATION ANALYSIS

Introduction

The forest areas of Wayanad plateau have witnessed a variety of human activities in the past. Coupled with a rapidly changing rainfall gradient from West to East, different patterns of plant communities exist in the area. Varying degrees of anthropic pressures such as shifting cultivation, extensive grazing, selection felling and various other activities had resulted in formation of mosaic of forest patches. Plots taken along the transects covering the three regions to study the existing vegetation types in the area.

Methods

A reconnaissance survey was conducted in the three region with the objective of identifying different forest types. Transects were laid in the three regions, namely Southern region, Northern region and Central region in the study area. Along the transect, plots of 10 x 10 m were laid in every 100 meter interval. All plants of girth 10 cms and above at breast height (1.3 m above ground level) were marked and identified. Girths at breast height (gbh) of all trees were measured individually for each species. For trees with large buttresses girth was measured at a height of 2-2.75 m to avoid buttressed part and height measurements were also taken.

Basal area was calculated from the gbh measurements and total basal area calculated for each plant species in each region using the formula $(gbh)^2/4\Pi$.

Results

Sampling of Southern region covered two locations, Edavamp and Ponkuzhi dominated by dry deciduous vegetation types. Sampling of Central region covered seven locations; Kottamala, Kuruva, Kuruva 1, Kurichipatta, Perikalloor, Vandikadavu and Chullikadu. All these locations had dominant moist deciduous vegetation except in Kurichipatta where teak plantation with miscellaneous growth of moist deciduous species was found. Sampling of

Northern region covered nine locations; 1995 teak plantations, 2nd Gate, 4th mile, Alathur, Appapara, Bavali, Begur, Camp road and Puthukkal. All these locations have teak plantations except for Begur, which harbours natural forest with dominant moist deciduous vegetation type.

Southern Region

Dry deciduous forest was the dominant vegetation type in this region. Twenty seven species were recorded. *Terminalia tomentosa* was the most dominant tree with the highest total basal area of 20751.55. This was followed by *Pterocarpus marsupium* , *Anogeissus latifolia* , *Tectona grandis*, *Dalbergia latifolia*, *Terminalia paniculata* and *Kydia calycina* . Highest number of individuals were recorded for *Anogeissus latifolia* , *Terminalia tomentosa*, *Olea dioica* and *Kydia calycina* (Table 1).

Table 1. Details of tree species in the Southern Region

Sl. No.	Species name	No. of individuals	Total basal area
1.	*Terminalia tomentosa* .	32	20751.55
2.	*Pterocarpus marsupium*	5	12466.00
3.	*Anogeissus latifolia*	32	9271.78
4.	*Tectona grandis*	6	8593.27
5.	*Dalbergia latifolia*	4	5018.79
6.	*Terminalia paniculata*	7	4392.91
7.	*Kydia calycina*	10	3808.92
8.	*Syzygium cumini*	2	2375.80
9.	*Hopea ponga*	4	1467.32
10.	*Olea dioica*	18	1329.92
11.	*Buchanania recemosa*	2	1029.30
12.	*Lagerstroemia parviflora*	3	935.43
13.	*Grewia tillifolia*	2	872.61
14.	*Buchanania lanzan*	1	828.34
15.	*Wrightia arborea*	1	561.78
16.	*Gmelina arborea*	1	459.87
17.	*Radermachera xylocarpa*	2	360.31
18.	*Emblica officinalis*	9	287.92
19.	*Schleichera oleosa*	2	231.89
20.	*Randia gardneri*	2	158.36

21.	*Terminalia bellirica*	1	140.45
22.	*Casia fistula*	4	120.80
23.	*Diospyros cordifolia*	1	76.51
24.	*Buchanania axillaris*	1	66.96
25.	*Shorea sp.*	2	46.16
26.	*Pavetta indica*	2	38.30
27.	*Butea monosperma*	1	15.61

Central Region

Moist deciduous forest is the dominant vegetation type in this region. Forty five species of trees were recorded. *Terminalia tomentosa* was the most dominant tree with a highest total basal area of 36219.03 followed by *Grewia tiliifolia* , *Stereospermum chelonoides* , *Dalbergia latifolia* , *Terminalia paniculata* , *Pterocarpus marsupium* , *etc.*(Table2) Highest number of individuals were recorded for *Alstonia scholaris*, followed by *Kydia calycina*, *Careya arborea* and *Grewia tiliifolia*. The details are summarised in Table 2. *Alstonia scholaris* and *Careya arborea* were the most regenerating species.

Table 2. Details of tree species in the Central Region

Sl. No.	Species name	No. of individuals	Total basal area
1.	*Terminalia tomentosa*	18	36219.03
2.	*Grewia tillifolia*	45	31953.24
3.	*Stereospermum chelonoides*	17	28692.44
4.	*Dalbergia latifolia*	37	27785.47
5.	*Terminalia paniculata*	30	26184.45
6.	*Pterocarpus marsupium*	16	18967.16
7.	*Careya arborea*	45	17438.85
8.	*Lagerstroemia microcarpa*	13	14707.98
9.	*Ficus racemosa*	1	12738.85
10.	*Alstonia scholaris*	68	12408.44
11.	*Tectona grandis*	24	11321.76
12.	*Terminalia bellirica*	10	10524.60
13.	*Olea dioica*	18	7505.43
14.	*Diospyros malabrica*	3	7377.39
15.	*Haldina cordifolia*	12	7364.33

16.	*Artocarpus hirsutus*	5	5965.68
17.	*Erythrina indica*	5	5956.53
18.	*Kydia calycina*	51	4692.30
19.	*Wrightia tinctoria*	5	4222.37
20.	*Spondias indica*	10	3838.46
21.	*Neolamarckla cadamba*	3	2845.70
22.	*Dalbergia lanceolata*	4	2682.96
23.	*Randia longispina*	9	2524.24
24.	*Casia fistula*	9	2356.05
25.	*Butea monosperma*	4	2275.32
26.	*Bombax ceiba*	3	1920.22
27.	*Syzygium caryophyllaeu*	3	1780.02
28.	*Bridelia crenulata*	11	1774.22
29.	*Albizia lebbeck*	3	1760.27
30.	*Gmelina arborea*	1	1743.95
31.	*Artocarpus heterophyllus*	8	1668.39
32.	*Mangifera indica*	8	1468.09
33.	*Syzygium cumini*	1	1408.38
34.	*Artocarpus ponga*	3	1371.50
35.	*Hopea parviflora*	2	1200.64
36.	*Randia gardneri*	4	1174.60
37.	*Calophyllum inophyllum*	1	1089.89
38.	*Anogeissus latifolia*	1	379.06
39.	*Atalantia recemosa*	3	330.10
40.	*Emblica officinalis*	2	205.20
41.	*Michelia champaka*	1	66.95
42.	*Holigarna arnottiana*	1	31.85
43.	*Chukrasia tabularis*	2	29.06
44.	*Buchanania axillaris*	1	7.96
45.	*Cinnamomum malabatrum*	1	1.27

Northern Region

The sampling locations in this region were dominated by teak plantations. Twenty eight plant species recorded from this region include the moist deciduous ones and the miscellaneous growth of moist deciduous species in the teak plantation. *Tectona grandis* was the most dominant tree species with highest total

basal area of 125196.8 comprising 188 individuals (Table 3). This was followed by *Schliechera oleosa*, *Terminalia bellirica*, *Grewia tiliifolia* and *Randia gardneri*. Tree species with highest number of individuals were *Dalbergia latifolia* (26) and *Cassia fistula* (25).

Table 3. Details of tree species in the Northern Region

Sl. No.	Species name	No. of individuals	Total basal area
1.	*Tectona grandis*	188	125196.80
2.	*Schieichera oleosa*	9	68844.98
3.	*Terminalia bellirica*	4	16987.14
4.	*Grewia tillifolia*	5	13720.00
5.	*Randia gardne*	12	12658.36
6.	*Dalbergia latifolia*	26	11583.44
7.	*Pterocarpus marsupium*	3	10352.07
8.	*Azadirachta indica*	1	4102.63
9.	*Syzygium cumini*	3	3726.35
10.	*Olea dioica*	6	3687.26
11.	*Erythrina indica*	6	3493.47
12.	*Terminalia tomentosa*	1	3184.71
13.	*Adenanthera triphysa*	6	2578.80
14.	*Anogeissus latifolia*	4	2567.91
15.	*Terminalia crenulata*	1	2115.37
16.	*Casia fistula*	25	1912.82
17.	*Sterospermum chelonoid*	3	1454.30
18.	*Lagerstroemia lanceolata*	4	1175.96
19.	*Kydia calycina*	2	1139.65
20.	*Haldina cordifolia*	2	1059.87
21.	*Albizia odoratissima*	2	905.89
22.	*Xylia xylocarpa*	4	669.11
23.	*Butea monosperma*	1	659.32
24.	*Terminalia paniculata*	1	258.68
25.	*Garcinia gummi-gutta*	1	240.84
26.	*Alstonia scholaris*	2	118.79
27.	*Zizyphus xylophyrus*	1	114.97
28.	*Aporusa acuminata*	1	38.54

Discussion

Even though moist deciduous vegetation type was present in all the regions, the regeneration pattern was different in localities within the region. The most regenerating species like *Alstonia scholaris, Careya arborea, Kydia calycina, Cassia fistula, Dalbergia latifolia, Randia* spp. were found to be confined to certain localities within the region. Perikalloor locality of the Central region had vast stands of profusely regenerating *Alstonia scholaris* where as in Kuruva and Kuruva -1 localities, the most regenerating tree species recorded was *Careya arborea.* Chullikad locality of Central region had profusely regenerating *Kydia calycina.* The teak plantations of Northern region had profuse regeneration of *Cassia fistula.*

Higher frequency of *Anogeissus latifolia* and *Terminalia tomentosa* indicate the dry conditions of the southern region. Upper canopy was mostly dominated by moist deciduous species and regenerating species are mostly of dry deciduous type. Certain localities of this region had vast patches of *Olea dioica,* which is a semi-evergreen species. *Kydia calycina* and *Emblica officinalis* were the other regenerating species found in this region. The structure and composition of this forest type indicate that the anthropic pressure coupled with adverse climatic conditions have brought about changes in the recent past.

CHAPTER 4

LANDUSE

The east sloping Wayanad plateau extends north west of the Nilgiris in between the main watershed line along the western edge of the ghats and the dry Deccan plateau. The plateau is more than 1500 km^2 at an elevation of 900-1000 msl., which is drained by Kabini extending partly into Tamil Nadu and Karnataka. The state boundaries do not correspond with any natural topographic sub division of the Wayanad. In the otherwise gently rolling plateau, a few hills rise up to 1400 m.

Wayanad could be divided into two distinct entities, the eastern drier tract along the state border and the western wetter tract along the western escarpments and borderline ridges of Wayanad hills continuing up to the Brahmagiris. In topography, bio-climate and biological diversity and also in conservation potential, the eastern and western forest belts in Wayanad are essentially different.

The Wayanad plateau forests are mostly restricted to the state border in an irregular strip starting from the Kerala-Tamil Nadu-Karnataka trijunction and it extends north east along the border to near Kabini. It is then broken by the Pulpalli encroachments and after a gap, a small strip of forests remain on the eastern bank of Kabini. On the left bank, through a number of unconnected pockets of forests, the eastern borderline forests of Wayanad can be considered to be in connection with the Brahmagiri slope forests. Across the border, the eastern borderline strip of forests in Kerala is continuous with the forests of Tamil Nadu and Karnataka.

The Reserved Forests in the eastern edge of Wayanad are less than 10 km. wide strip of moist and dry deciduous forests which have been heavily exploited and degraded and mostly converted to teak and eucalyptus plantations. The eastern most parts of Mavinhalla Reserve and Rampur Reserve are of very dry and open forests.

Although degraded and broken up as they are today, forests of Wayanad plateau must have been far denser and moist, a few centuries ago. The topography of the region with low hills and flat terrain has resulted in extensive slushy valleys. `Wayanad', the name itself is supposed to mean land of swamps. These forests were also part of a vast forest belt extending from Coorg and the edge of Mysore plateau all along the Western Ghat eastern slopes, skirting the Nilgiris and continuing along the Moyar Valley to the Eastern Ghats. The forests of Kerala Wayanad and the adjoining now destroyed forests of Gudalur as well as the Coorg forests along Kabini left bank form an extensive belt of forests. But almost a century of heavy forest exploitation, conversion of forests into teak plantations and, very large scale settlements of people during the last half a century in Wayanad have resulted in fragmentation and degradation of Kerala Wayanad. Extensive fragmentation and reduction of natural forest areas in the other states have also taken place.

Since Wayanad was a part of Malabar, most of the forests were privately owned and the government forests were only scattered islands. The only Reserved Forests in the wetter part of Wayanad were on the Brahmagiri slopes and on the north west corner.

Unlike in the Travancore and Cochin area, forest reservation in Malabar was slower and most of the existing Reserves were notified in the later part of 1930s and the early 1940s. Before the process could be completed, the Second World War intervened and the process was halted. Due to the prevailing scarcity of food material, the Government opened up many areas for settlement, in particular the entire Wayanad plateau where the terrain was safe and suitable for paddy cultivation. Thus an opportunity to protect the forests of Wayanad was lost forever.

The Reserved Forests existing in Wayanad today are unlike most of the other Reserved Forests in Malabar or Travancore-Cochin. Instead of the extensive composite uninhabited areas constituting the Reserves elsewhere, the Wayanad forests are very irregularly shaped with enclosures and settlements

scattered all over inside with all the valleys and swamps under cultivation. A large tribal population depends on these forests for survival. As the total forest area rapidly shrunk in the Wayanad plateau, the pressure on the remaining forests from the people and their domestic animals increased. The very irregular boundaries of these Reserves made available more perimeter areas for degradative interactions. The availability of good quality teak had initially attracted Tipu Sultan and later the British to this plateau and as the technique for raising teak plantations were perfected in Malabar, more and more natural forests in Wayanad also got converted. The moist deciduous forests of Wayanad in general and in particular, those on the fringes of the swamps, which were open, had luxuriant growth of bamboo and hence the whole area got worked for bamboo for the Gwalior Rayons (Gopinathan, 1990 b).

Beginning in the 1966-'67 period, the first large-scale encroachment of private forests in Wayanad resulted in the organised destruction of Pulpally forests. This disrupted the continuity of the forest belt along the eastern border of Wayanad with the Padiri, Begur and Kudrakod Reserves and the northern side was cut off from the southern Kurichiyat and Kuppady forests. Wayanad being a flat accessible area and the forests moist deciduous, conversion working was highest including extensive conversion to eucalyptus plantations in the 1970s. When private forests were nationalised, considerable areas in the northern and western parts of Wayanad became vested with the government. About 23,113 hectares were set apart for permanent reservation in the northern and western slopes of Wayanad and an additional 4445 ha. further north in the Brahmagiri slopes along Aralam and Kottiyar areas. Most of the vested areas are potentially wet evergreen habitats of considerable value for the conservation of biological diversity. Besides, these forests clothe the extremely steep precipitous slopes of the western edge of Wayanad and the Brahmagiris from which a large number of rivulets originate. But the act of vesting did not guarantee the protection of these forests. Extensive areas were lost and continue to be lost due to loopholes in the law. The fact that most of these forest tracts are unsurveyed helps considerably

the land grab operations. The grave inadequacy in the protection machinery for the vested forests in manpower, money and material resources further aids in its destruction.

The destruction of the Wayanad plateau forests resulted in the elimination of the wetter part of the habitat complex extending from the northern slopes of Nilgiris to Coorg Ghats. The buffer area of Nagarhole National Park, Bandipur National Park and the Mudumalai Wildlife Sanctuary in the adjoining states was lost. Elephant poaching and sandal smuggling from these adjoining areas mostly by operators based in Kerala Wayanad became a serious problem.

In the entire Wayanad Wildlife Sanctuary area, there is no intact or representative forest habitat except along the eastern edges of Rampur and Mavinhalla Reserves which may be considered examples of the dry deciduous forest type which occur elsewhere only in the Chinnar Reserve in Idukki district in Kerala. But as a wildlife habitat, Wayanad still remains a potential area.

The large-scale conversion of forests into plantations has caused depletion of the diversity of forest produce, which the tribal population used to collect and use regularly. Disruption of ecological processes as a consequence of widespread deforestation has also affected the people. All these have a negative feedback influence on the forests accelerating their degradation. Along with better protection, the management of these forests has also to be modified to cater to ecosystem needs as well as basic human needs..

Growth and expansion of plantations

As early as 1797, the East India Company started its own plantation with a view to experimental cultivation in pepper, cotton, coconut, betelnut, cassia, nutmeg, sandalwood, cinnamom and coffee in Anjarakandi of north Malabar and appointed one Murdock Brown as overseer and manager (Logan, 1951). Initially, though pepper was the largest export earner of Malabar, it started declining by the end of the 1830s and reached a low level of 1 per cent of world trade. This decline is attributed to factors such as spread of `wilt' disease, fall in the price

and high tax (Logan, 1930). Coconut and coconut products were also exported from Malabar during this period.

Though coffee emerged as a successor to pepper, the coffee industry, however, was not fairly established till about 1840, when several European planters opened up estates. The two principal species grown were *Coffea arabica* and *Coffea liberica*. In 1866, there were about 200 coffee estates in Wayanad covering 5,918 hectares of which 3,995 hectares belonged to the Europeans and 4,748 to the natives (Clement, 1866). In 1865, the borer, *Xyllotrechus quadrupas* destroyed whole estates. Soon after a remedy had been discovered, another fungoid leaf disease, *Hemelia vastratrix* devastated the entire coffee plantations in the district by 1875. The decline was further accelerated by fall in prices due to increased production in other countries. To this was added, the Brazilian competition at the end of the century, which drove prices further down. In the ten year period from 1893 to 1903, the area under coffee decreased from 8,139 hectares to 2,218 hectares (Logan, 1930).

Coffee was gradually supplanted by tea. The earliest tea plantations introduced in Wayanad by Ms Parry and Company was later on taken over by Harrison and Crossfield Company limited. Since 1892, numerous coffee estates were converted into tea gardens as tea did well in many parts of Wayanad. The tea planter required more capital than the coffee planter, since tea must be manufactured on or close to the estates where it is picked and a considerable outlay is necessary on machinery and buildings. Picking and manufacturing went on all the year round, whereas the coffee planter had only one crop to deal with. In 1904, there were 69 coffee plantations and 27 tea estates. In the same year the total output of coffee was 645 tons (Imperial Gazetteer, 1908).

Rubber began to attract attention in the early years of the 20th century. The principal rubber species were *Hevea braziliensis* (para), *Manihot gloziovii* (ceara) and *Castilloa elastica*. In 1930, in Malabar, there were about 61 estates with 5,004 hectares under tea, 1,124 under coffee, 3,745 under rubber, 779 under pepper and 179 hectares under cardamom. In the ensuing year, the area under

coffee showed an upward trend. In 1956, plantation cultivation in Malabar extended to an area of about 24,300 hectares consisting of about 12,150 hectares of coffee and the rest shared between tea and cardamom (Varghese, 1970). Almost all the plantations were concentrated in the Wayanad taluk of the district.

Change in landuse (1950-1982).

The amount and pace of forest conversion to other types of landuse during 1950-1982 have accelerated the man wildlife conflict in Wayanad Wildlife Sanctuary. The change in landuse was studied by analysing the toposheets of 1950 (SOI) and the vegetation map prepared by the French Institute, Pondicherry in 1982. The relevant maps are provided in Figs. 5 and 6. The area under different vegetation types was estimated using a digital planimeter and the figures are provided in Table 4.

Table 4. Land cover of Wayanad District (area in km^2)

Land cover type	1950	1982	Difference
Forest	1811.35	724.54	-1086.81
Agricultural plantation	63.93	532.75	462.82
Cultivation	255.72	873.71	617.99
Total	**2131.00**	**2131.00**	

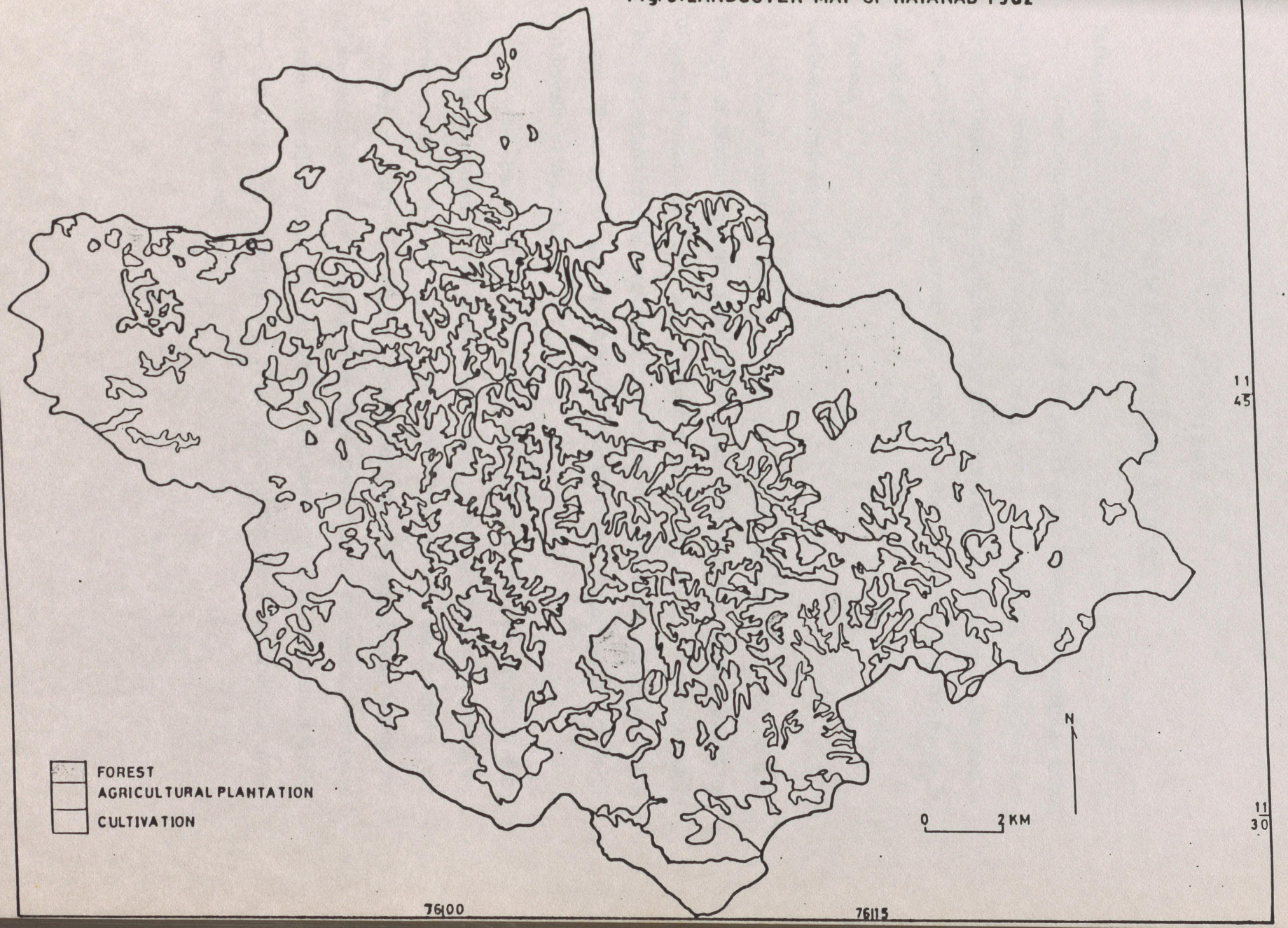
Source: 1950-SOI topographical maps 49M 13 & 14

1982-Vegetation map prepared by French Institute of Pondicherry

The forest cover has been reduced by 1086 km^2 during the thirty year period with the corresponding increase in area under plantations and cultivation. The intact and once continuous vegetation cover has been fragmented almost throughout having a bearing on the movement of large mammals.

Fig. 5. LAND COVER MAP OF WAYANAD 1950

Fig. 6. LANDCOVER MAP OF WAYANAD 1982



CHAPTER 5

SOCIO ECONOMIC SURVEY

Introduction

The socio-economic status of the people in the forests of surrounding areas will have positive or negative impacts on the systems. Considering the importance of such information in assessing the crop raiding and related problems in Wayanad, a survey was conducted among the people in the enclosures and periphery in Wayanad.

Methods

Socio-economic survey

Socio-economic survey was conducted in Mananthavady and Begur Forest Ranges of North Wayanad, Chedleth of South Wayanad and all the Ranges of Wayanad Wildlife division. Large number of people live inside the revenue land, forest leases and reserve forests and these enclosures are scattered in the form of a mosaic. These are located in Nulpuzha, Kidanganadu, Pulpally and Thirunelli Panchayaths of Wayanad.

Twenty percent of the households were selected based on simple random method for household survey in enclosures, settlements in the fringes and along the selected transects (Fig 7). This formed 2174 houses. The questionnaire was formulated in such a way that information on the population, education, employment, agriculture practices, forest dependence, social and cultural activities and their attitude towards the management and conservation of forest and wildlife were collected. The households at 50 m points along the 1 km transects were selected for the survey.

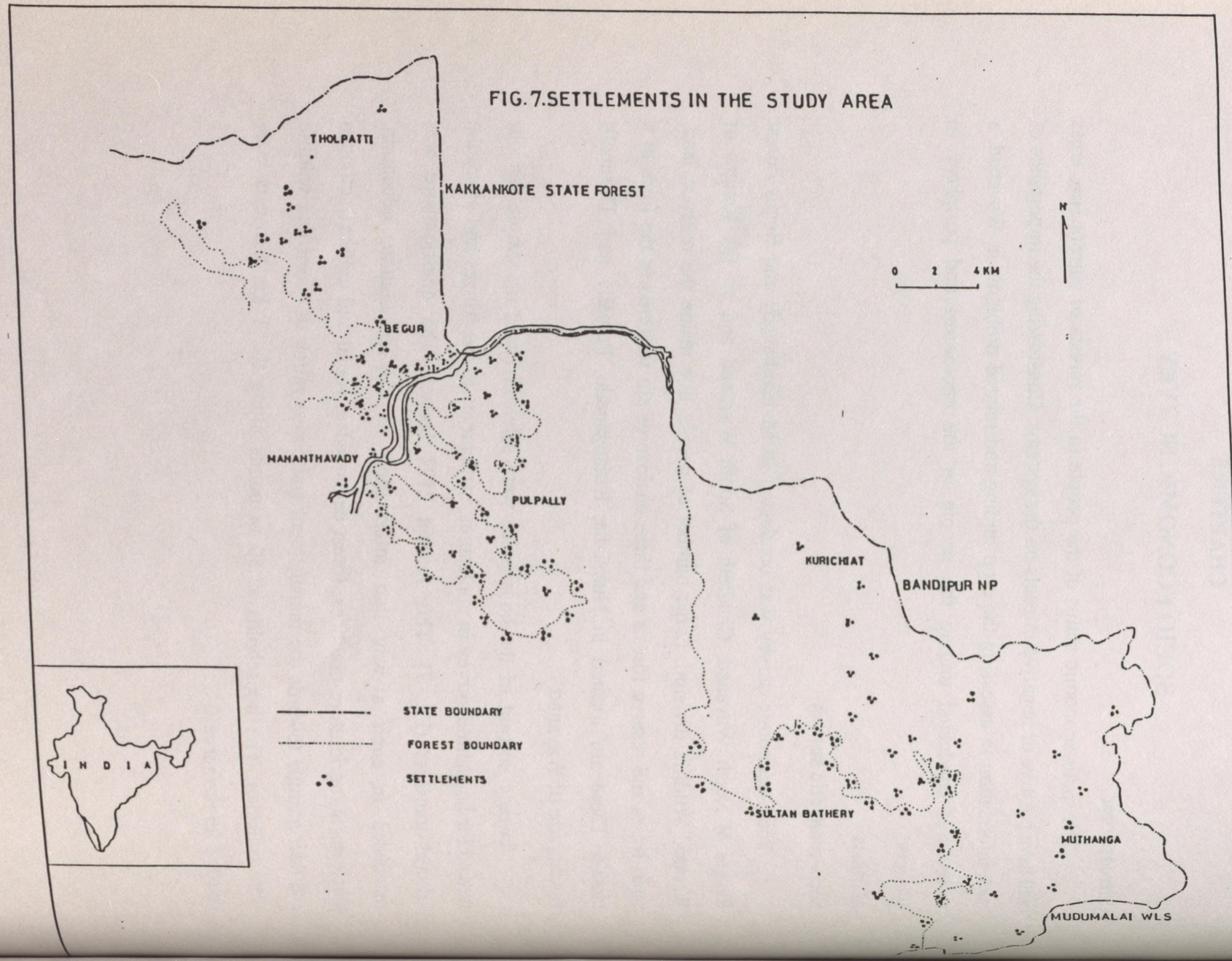


FIG. 7. SETTLEMENTS IN THE STUDY AREA

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Results

Enclosure

There are about 69 enclosures in the study area and are scattered in a mosaic form. Most of the settlements are near to the streams, rivers or vayals (marshy area). The name Wayanad is derived from two colloquial words 'Vayal' (Swamps) and 'Nadu' (place/locality). Recently, most of these vayals were converted into agricultural lands. The enclosures have both the tribals and non-tribals. Most of the non-tribals are immigrants from other parts of Kerala. Golur, Ammavayal and Kurichiat settlements are situated in the most interior of the forest. Large number of tribal settlements is situated along the fringes and away from the forest. Most of them are dependent on the forest for NWFP, grazing, food and firewood.

Most of the enclosures surrounded by teak plantations (43.44%) and moist deciduous forests (39.12%). Percentages of households in different vegetation types are given in Table 5.

Table 5. Percentage of house holds in different vegetation types

SL. No.	Vegetation	% of households
1	Moist deciduous forest	39.12
2	Dry deciduous forest	5.88
3	Semi evergreen	2.90
4	Eucalyptus plantation	8.44
5	Teak plantation	43.44
6	Silveroak plantation	0.22

Demography and habitation

Kuruman (Mullukuruman), Kattunaikan (Then Kuruman), Adiyan, Paniyan, Urali and Kurichiars are the tribals in the enclosures. Non-tribals like Wayanadan chetties, Gowdas, Christians and Muslims constitute about 40% of the population (Table. 6). In the fringes, the tribals form about 61% and non-tribals about 39%. The non-tribal dominate the population away from the forest. Region wise analysis

shows that tribal population is more in Northern region (80%) followed by Central (67%) and Southern region (50%). In the fringes, the tribal population is more in Southern region (80%) than Central (61%) and Northern region (54%). But the non-tribals dominate the population along the transects in all the three regions (Table 7).

Table 6. Percentage of human population

	Enclosure	Periphery	Transect
Tribals	59.79	61.08	10.41
Non-tribals	40.21	38.92	89.59

Table 7. Details of human population in different regions (in %)

Region	Enclosure		Periphery		Transect	
	Tribals	Non-tribals	Tribals	Non-tribals	Tribals	Non-tribals
Southern	50.24	49.76	79.30	20.70	11.04	88.96
Central	66.63	33.37	61.11	38.89	9.86	90.14
Northern	79.83	20.17	54.22	45.79	10.59	89.41

An analysis of the tribal population indicate an almost equal proportion of Kattunaikan and Kuruman in the enclosures (Table 8) Kattunaikans and Paniyans dominate the tribal population in the fringes where as Paniyan formed about 50% of the population along the transect.

Table 8. Percentage of tribal population in Wayanad

Caste	Enclosure	Periphery	Transect
Kattunaikan	33.99	28.42	5.95
Kuruman	30.12	19.63	23.78
Paniyan	20.29	24.78	50.27
Adiyan	5.49	10.95	15.68
Urali	3.83	5.37	0.00
Kurichian	6.27	10.85	4.32

The Hindus, Christians and Muslims constituting the non-tribals, along with others within the enclosures are immigrants from the plains, settled long back.

Hindus form 68.67% of non-tribals followed by 19.39% of Christians and 11.93% Muslims (Table 9). Christians are mostly from Travancore and Cochin where as Muslims immigrated from Malabar. Hindus have come from various places. The Gowadas and Chetties moved from the adjacent Karnataka State. The male-female proportion in the population is almost equal in enclosure, periphery and transect (Table 10).

Table 9. Percentage of non-tribals in Wayanad

Caste	Enclosure	Periphery	Transect
Christian	19.39	22.30	34.61
Muslim	11.93	2.98	19.35
Hindu	68.67	74.72	46.04

Table 10. Percentage of males and females in the population

Sex	Enclosure	Periphery	Transect
Over all			
Male	50.68	51.34	52.25
Female	49.92	48.66	47.75
Tribals			
Male	50.06	51.36	48.11
Female	49.94	48.64	51.89

Land

About 48% of the people within the enclosure have title deeds for their land Others are in lease, revenue or forest land (Table 11). Majority of the non-tribals is in patta or leased lands. Caste wise analysis of the tribals in enclosure shows that most of them are living in patta or leased lands. Nearly 25% of Kattunaikans are settled in reserve forest followed by Uralies (17%) and Paniyans (16%) (Table 12). Paniyans are settled in dry land and Kurumans in fertile wet land for crop

cultivation. Wayanadan chetties and Mullukurumans have forest leases. Leases have to be renewed annually by paying rent. Leases may not be sold or transferred to outsiders. However, there are many cases of leases being sold to outsiders mainly the immigrants.

Table 11. Right of land in enclosure (in %)

Type	Overall	Non-tribals	Tribals
Title deed	48.65	73.82	32.51
Lease	36.57	17.38	48.90
Revenue	5.11	6.65	4.13
Reserve forest	9.64	2.15	14.46

Table 12. Right of land holdings (in %) in enclosures by tribals

Source	Kattu naikan	Kuruman	Paniyan	Adiyan	Urali	Kurichian
Title deed	16.98	37.56	47.41	52.50	3.45	56.82
Lease	55.85	53.05	32.59	30.00	72.41	38.64
Revenue	1.89	5.63	3.70	10.00	6.90	4.55
Reserve forest	25.28	3.76	16.30	7.50	17.24	0.00

In the enclosures, about 72% of the settlers acquired the land by deforestation, 1.47% as dowry, 0.60% as compensation (resettled). About 81% of the tribals and 57% of non-tribals occupied the land by clearing the forest. The details are given in the Table 13. Caste wise analysis of the tribals in enclosure shows that most of them obtained the land by deforestation (Table 14).

Table 13. Source of land in percentage (enclosure)

Source	Overall	Non-tribals	Tribals
Cleared the forest	71.79	57.49	80.76
Dowry	1.47	2.46	0.84
Compensation	0.60	0.67	0.56
Others	26.14	39.37	17.86

Table 14. Source of land in enclosures in percentage (tribals)

Source	Kattu naikan	Kuruman	Paniyan	Adiyan	Urali	Kurichian
Cleared the forest	79.92	84.88	75.56	81.58	96.55	70.73
Dowry	1.14	1.46	0.00	0.00	0.00	0.00
Compensation	1.14	0.00	0.74	0.00	0.00	0.00
Others	17.80	13.66	23.70	18.42	3.45	29.27

Occupation

The people living in the forest and outside areas have a wide range of employment pattern. An overall analysis shows that the main source of income of people living in enclosure, periphery and transect were from daily wage labour (coolies) followed by agriculture related works. Details of the occupation are given in Table 15.

Table 15. Overall source of income (in %)

Sl.No	Source	Enclosure	Periphery	Transect
1	Cultivator	30.94	34.04	58.57
2	Cattle owner	3.91	8.06	7.14
3	Fire watcher –Forest	10.29	4.70	0.24
4	Daily wage labour	46.62	51.40	26.43
5	Fire wood collection	1.12	0.45	0
6	NWFP collection	5.21	0.22	0
7	Government employment	1.61	1.12	5.24
8	Merchant	0.31	0	2.38

The main occupations of non-tribals in enclosure are agriculture related and the tribals depend on daily wages from different sources. The major crops cultivated are paddy, ginger, coffee, pepper, coconut, arecanut, plantain, tapioca, colacacia, alocacia, turmeric, green yam, vegetables, ragi, *etc.* The same pattern was observed in fringes and transects (Table 16).

Table 16. Source of income in different locations

Sl.No.	Source	Tribals	Non-tribals
Enclosure			
1	Cultivation	16.19	58.61
2	Livestock	2.78	6.04
3	Fire watcher –Forest	14.94	1.78
4	Daily wage labour	55.94	29.84
5	Fire wood collection	1.82	0.00
6	NWFP collection	1.82	0.36
7	Government employees	7.18	2.49
8	Merchant	1.15	0.89
Periphery			
1	Cultivator	22.51	51.11
2	Cattle owner	5.44	11.94
3	Fire watcher –Forest	6.75	1.67
4	Daily wage labour	64.16	32.50
5	Fire wood collection	0.75	0.00
6	NWFP collection	0.38	0.00
7	Government employees	0.00	2.78
8	Merchant	0.00	0.00
Transect			
1	Cultivator	25.00	62.83
2	Cattle owner	4.55	7.49
3	Fire watcher –Forest	0.00	0.27
4	Daily wage labour	65.91	21.12
5	Fire wood collection	0.00	0.00
6	NWFP collection	0.00	0.00
7	Government employees	4.55	4.81
8	Merchant	0.00	3.47

Paniyans, Uralis and Naikans were dependant on daily wage labour and the Kurumans and Kurichians on agriculture (Table 17).

Table 17. Overall sources of income of different communities (in %)

Source	Kattu-naikan	Kuruman	Paniyan	Adiyan	Urali	Kuric-hian	Non-tribals
Cultivation	5.47	36.09	11.59	19.38	11.27	34.81	57.84
Livestock	1.70	5.52	1.66	5.43	1.41	10.37	8.11
Fire watcher	13.96	16.55	1.99	6.20	1.41	8.15	1.31
Daily wage	66.60	38.16	77.28	68.99	71.84	45.93	28.34
Fire wood	3.21	0.23	0.99	0.00	2.82	0.00	0.00
NWFP	8.49	1.38	5.96	0.00	11.27	0.00	0.00
Government employees	0.57	2.07	0.33	0.00	0.00	0.74	3.24
Merchant	0.00	0.00	0.00	0.00	0.00	0.00	1.16

Education

Among the tribals, Kuruman (64%) and Kurichians (57.84%) had the highest literacy rate. The non-tribals had a comparatively higher literacy rate. The details are given the Table 18. There are residential schools and tribal hostels in Wayanad. A number of voluntary organizations are currently working among the tribal people to promote education.

Table 18. Literacy among different communities

Caste	Literacy %	Illiteracy %
Kattunaikan	26.99	73.01
Kuruman	64.01	35.99
Paniyan	33.08	66.92
Adiyan	36.95	63.05
Urali	38.46	61.54
Kurichian	57.84	42.16
Christian	87.47	12.53
Muslim	80.63	19.37
Hindu	79.70	20.30

Most of tribals terminate schooling at the primary level. In enclosures, nearly 55.75% of the people are uneducated, compared to 44.55% in periphery and 16.33% along the transect (Table 19).

Table 19. Education status (in %)

Education	Enclosure	Periphery	Transect
Uneducated	55.75	44.55	16.33
1-4	19.55	16.19	13.80
5-7	6.78	16.92	18.53
8-10	11.75	18.61	36.00
Pre-degree	4.67	3.31	1.01
Graduate	1.13	0.49	0.95
Post graduate	0.12	0.00	0.22
Professional	0.21	0.00	0.45

House construction

The design and mode of construction differ from one tribal community to another. The materials used also differ accordingly. Ninety-nine percentage of the people collected the construction materials from the forest and consists mainly of bamboo, grass and soil. Most of the tribal hamlets are thatched with grass (Table 20). Among the non-tribals, only 27.49% of the houses are thatched with grass. The materials used for the construction of wall is mainly bamboo and the floor is mainly of soil. Most of them have only 1 or 2 rooms. The details are given in Table 20. Agencies like bank, government agencies and voluntary organizations help the tribals in the form of money and material's for house construction. However, only 27.37% in enclosure, 17.98% in periphery and 41.17% out side areas received such assistance.

Light and Water

Kerosene is still the main source of light for majority of the people. About 89% of the settlers in enclosure, 91% in periphery and 59% away from the forest are using kerosene for lighting. Few people use traditional method of lighting. The details are given in Table 21.

Table 20. Material used by tribals for house construction (in %)

Material	Kattunaikan	Kuruman	Paniyan	Adiyan	Urali	Kurichian	Non-tribals
Roof							
Grass	45.08	56.65	30.06	65.71	43.75	65.79	27.49
Tiles	39.02	37.93	42.33	28.57	43.75	28.95	42.31
Asbestos	7.95	4.43	2.46	0	3.13	2.63	5.79
Concrete	3.41	0	6.13	0	0	0	4.70
Others	4.55	0.99	19.02	5.71	9.38	2.63	19.71
Wall							
Soil	22.72	40.75	24.70	25.29	23.68	29.07	16.64
Stone	8.88	8.30	10.84	10.34	2.63	4.65	2.84
Bamboo	41.78	23.40	33.13	55.17	42.11	47.67	24.57
Others	26.63	27.55	31.33	9.20	31.58	18.60	55.95
Floor							
Soil	97.16	95.60	98.25	96.30	62.96	94.74	65.41
Cement	2.84	4.40	1.75	3.70	37.04	5.26	34.59
No of rooms							
1	24.24	15.20	25.93	28.95	17.24	5.00	4.45
2	58.33	47.06	48.89	50.00	75.86	30.00	15.59
3	14.02	21.08	22.96	21.05	6.90	45.00	18.71
4	2.65	11.76	0.74	0	0	12.50	24.05
Above 4	0.76	4.90	1.48	0	0	7.50	37.19

Tribals in the enclosures depend on Kerosene. Nearly 51% of Kattunaikans and few Kurichiars and Uralis still follow the traditional method of torches (locally called 'Pantham') (Table 22)

Table 21. Source of light (in %)

Source	Enclosure	Periphery	Transect
Overall			
Kerosene	89.32	91.32	59.46
Electricity	7.63	7.63	40.27
Solar	1.53	0.75	0.27
Others	1.53	0.30	0.00
Tribals			
Kerosene	86.02	90.70	92.11
Electricity	11.35	5.81	7.89
Solar	0.26	3.26	0.00
Others	2.37	0.23	0.00
Non-tribals			
Kerosene	89.14	84.29	54.05
Electricity	10.20	13.79	45.66
Solar	0.67	1.53	0.29
Others	0.00	0.38	0.00

Table 22. Source of lighting for tribals in enclosure (in %)

Source	Kattu naikan	Kuruman	Paniyan	Adiyan	Urali	Kurichian
Kerosene	88.89	87.96	89.63	84.21	100	97.56
Electricity	4.07	6.94	9.63	13.13	0.00	0.00
Solar	1.85	4.63	0.00	0.00	0.00	0.00
Others (Traditional)	5.19	0.46	0.74	2.63	0.00	2.44

Overall analysis show that wells are the major source of drinking water for the people in the enclosures, periphery and transect. A few of them depend on streams and rivers. Small pits (locally called 'Keny') are dug near to streams and rivers for collection of drinking water. The details of analyses are summarized in Table 23.

Table 23. Source of drinking water (in %)

Source	Enclosure	Periphery	Transect
Overall			
Well	74.68	75.63	92.10
Streams	3.92	1.04	1.09
River	5.12	2.08	1.91
Others (pit)	16.28	21.25	4.90
Tribals			
Well	68.85	77.88	86.84
Streams	4.51	1.68	0.00
River	6.28	1.92	7.89
Others (pit)	19.13	18.51	5.26
Non-tribals			
Well	82.67	71.98	92.71
Streams	2.89	0.00	1.22
River	3.11	2.33	1.22
Others (pit)	11.33	25.68	4.86

An overall analysis of the data from enclosures show that wells are the main source of drinking water followed by small pits. The details are given in Table 24.

Table 24. Source of drinking water for tribals in enclosure (in %)

Source	Kattu naikan	Kuruman	Paniyan	Adiyan	Urali	Kurichian
Well	67.42	73.08	73.91	56.41	76.67	60.98
Streams	7.12	2.88	3.62	0.00	6.67	2.44
River	8.24	3.37	7.97	7.69	3.33	4.88
Others (pit)	17.23	20.67	14.49	35.90	13.33	31.71

Health

The health conditions of the tribals are very poor. Mortality is common among the tribal especially the Kattunaikans. The common health problems are diarrhea, anemia due to malnutrition and infections.

Table 25. Details of medical attention (in %)

	Enclosure	Periphery	Transect
Overall			
Allopathy	55.75	75.15	70.45
Ayurvedic	25.18	14.27	18.59
Homeo	9.82	3.80	9.00
Traditional	8.78	6.18	1.17
Others (Pray)	0.47	0.59	0.78
Tribals			
Allopathy	57.58	72.73	86.36
Ayurvedic	20.28	14.02	4.55
Homeo	6.97	3.03	9.09
Traditional	14.11	10.23	-
Others (Pray)	1.06	0.00	-
Non-tribals			
Allopathy	52.27	79.23	69.10
Ayurvedic	31.82	14.70	20.3
Homeo	13.01	5.11	9.44
Traditional	2.65	0.96	1.07
Others (Pray)	0.25	-	-

The basic factors responsible for the health problem are lack of proper sanitation and unhygienic conditions, addiction to smoking, alcohol, tobacco chewing, irregular food habits, etc. Overall analysis show that 55.75% of settlers in enclosure, 75.15% in periphery and 70.45% in transect depend on allopathy for treatment. Only few people depend on traditional methods. The details are given in Tables 25 and 26. Voluntary organizations and Tribal Development Departments are working in the enclosures to make the people aware of the importance of health care.

Primary health centers are functioning in several settlements. Infant mortality rate is high among the tribals and they have no easy access to hospitals because most of the remoteness of the settlement.

Table 26. Medical attention among the tribals in enclosure (%)

	Kattu naikan	Kuruman	Paniyan	Adiyan	Urali	Kurichian
Allopathy	53.21	58.21	56.36	94.87	56.25	61.29
Ayurvedic	18.12	22.39	20.00	2.56	35.42	22.58
Homeo	7.57	11.34	4.55	0.00	0.00	6.45
Traditional	19.27	7.46	19.09	0.00	6.25	9.68
Others (Pray)	1.84	0.60	0.00	2.56	2.08	0.00

Food habits

Majority of the settlers are non-vegetarians (Table 27). They consume meat of buffalo, cow, goat, wild animals and fish. Fresh water fishes are mainly collected from the streams and rivers. Vegetables are mostly purchased from the market.

Thirty three percentage of the people in the enclosures, 20% in the people fringes and 34% along transects cultivate vegetables for their own purpose (Table 28). Dependence on forest for food materials is negligible. The leaves of *Cassia tora*, tender leaves of ferns, fresh shoots of bamboo, etc. are collected from the forests for consumption.

Table 27. Food habits of the respondents

	Enclosure	Periphery	Transect
Overall			
Vegetarian	0.43	0.75	1.37
Non-vegetarian	99.57	99.25	98.63
Tribals			
Vegetarian	0.28	0.24	0
Non-vegetarian	99.72	99.76	100.00
Non-tribals			
Vegetarian	0.67	1.56	1.52
Non-vegetarian	99.33	98.44	98.48

Table 28. Source of vegetables

Source	Enclosure	Periphery	Transect
Cultivation	32.91	19.90	33.76
Market	57.35	66.87	65.88
Collected from forest	9.74	13.23	0.36

Agriculture

The people of Wayanad are predominantly agriculturists. Land use varies with community, size of land-holding and the proportion of dry and wet lands. Agriculture is characterized by a mixture of subsistence farming and mixed cash crops. Cultivation is one of the major source of income and the crops cultivated are paddy, ginger, ragi, pepper, coffee, plantain, coconut, arecanut, vegetables, tapioca, jack tree, etc. The agricultural implements mainly used are spade, pick-axe, iron rod, knife, and shovel. The percentage share of each equipment in agricultural practice in enclosure, periphery and transect are summarized in Table 29.

Most of the people had their own equipments and are purchased from out side (Table 30). Modern agricultural implements like tractor were used together with the traditional methods like buffalo and bullock. The percentage uses of modern implements in agriculture are summarized in Table 31.

Table 29. Details of implements used for agriculture purpose (in %)

Implements	Enclosure	Periphery	Transect
Spade	65.34	76.61	58.35
Pick-axe	9.22	3.71	21.65
Iron rod	11.30	2.72	14.88
Others (Knife, shovel)	14.14	16.96	5.12

Table 30. Source of agricultural implements used (in %)

Source	Enclosure	Periphery	Transect
Own made	3.11	0.80	0.81
Borrowed	4.57	1.76	3.52
Purchased from Outside	92.32	97.44	95.66

Table 31. Percentage of modern implements used for ploughing

Source	Enclosure	Periphery	Transect
Tractor	7.82	6.38	14.84
Buffalo	7.48	3.52	2.47
Bullock	21.12	19.27	15.05
Spade	63.58	70.83	67.63

Table 32. Source of implements for ploughing (in %)

Source	Enclosure	Periphery	Transect
Issued by Government	0.61	0.00	0.00
Borrowed	18.58	14.72	28.30
Purchased from outside	77.34	84.82	71.46
Others (Helped by others)	3.47	0.46	0.24

Most of the agricultural implements are purchased from outside though a few borrow from their neighbors. Very few people go for help from others for ploughing. The various sources of implements in enclosure, periphery and transect are summarized in Table 32. The agricultural practices in Wayanad are dependent mainly on rainfall. However, some them have diesel pump sets for irrigation. Others depend on the near by streams and rivers for irrigation (Table 33). Pesticides and fertilizers are used in the cultivation. Only a small proportion uses the seeds of high yielding varieties. The use of all these are more or less same in enclosure, periphery and away from the forest (Table 34).

Table 33. Percentage of various source of water for irrigation

Source	Enclosure	Periphery	Transect
Pump set	4.89	2.98	2.17
Streams	25.69	16.99	13.59
Weather	69.42	80.03	84.24

Table 34. Percentage use of modern agriculture practices

Method	Enclosure	Periphery	Transect
Pesticides	35.48	33.81	42.98
Fertilizers	50.95	58.99	49.90
Hybrid seeds	13.57	7.19	7.13

Table 35. Percentage use of agriculture loans for various purpose

	Enclosure	Periphery	Transect
Fertilizer	39.88	53.73	31.18
Pesticides	19.65	28.36	23.66
Seeds	16.76	1.49	26.88
Pump set	2.02	1.49	1.08
Wages	6.94	3.48	3.23
Cattles	14.74	11.44	13.98

Agricultural loans are also available for purchase of fertilizer, pesticides, seeds, pump-set and cattles (Table 35). Voluntary agencies, bank, private agency and co-operative societies are the sources for agricultural loans (Table 36).

Table 36. Source of agriculture loans (in %)

Source	Enclosure	Periphery	Transect
Voluntary agency	3.16	0.00	1.32
Bank	86.84	74.59	89.47
Private agency	6.84	14.75	9.21
Co-operative society	3.16	10.66	0.00

Crop damage is a severe problem in most of the settlements. Animals

responsible for crop damage problems were wild boar, elephant, porcupine, sambar, spotted deer, common langur and bonnet macaque (Table 37). Marginal increases in crop raiding incidences have been reported by majority of the respondents in the enclosures as well as periphery. About 73.53% of respondents opined that crop damage was more in rainy season. Even though most of them are aware of the compensation provisions, only a smaller proportion of the affected parties avail the facility mainly because of the procedural complexity. No compensation is paid for damages due to wild boar and people having the licensed gun are not eligible for compensation.

Table 37. Animals responsible for crop damage (% of respondents)

Animals	Enclosure	Periphery	Transect
Wild boar	42.54	32.82	68.32
Elephant	49.83	64.08	29.81
Porcupine	0.11	0.00	0.00
Sambar deer	0.44	0.26	0.62
Spotted deer	1.77	0.52	0.00
Common langur	0.11	0.00	0.00
Bonnet macaque	5.19	2.33	1.24

A questionnaire survey among the farmers in the enclosures indicate that about 52% of them had paddy cultivation about 10 years back. About 18% of them have abandoned paddy cultivation. However, about 6% of the farmers initiated paddy cultivation recently (Table 38). Though a number of farmers shifted from ginger to some other crops during the last 10 years (11% reduction), an additional 35.43% started cultivating ginger. About 10 to 14% of the farmers cultivating pepper, coffee, plantain and coconut abandoned these. While a considerable increase in these plantation was recorded because a number of people started these afresh.

Table 38. Changes in crops cultivated during the last ten years in Wayanad

	Enclosure		Periphery		Transect	
Crops	% of the farmers with cultivation 10 years back	Newly started (% of the farmers)	% of the farmers with cultivation 10 years back	Newly started (% of the farmers)	% of the farmers with cultivation 10 years back	Newly started (% of the farmers)
Paddy	52.06 (82.62)	5.94	39.67 (81.50)	17.73	33.78 (78.22)	13.62
Ginger	30.60 (83.10)	35.43	13.62 (81.31)	39.97	28.97 (88.18)	40.05
Pepper	26.81 (86.50)	28.18	14.82 (90.90)	42.81	46.59 (93.56)	37.60
Coffee	25.08 (91.07)	22.06	13.77 (89.13)	34.73	45.77 (92.26)	36.23
Plantain	21.99 (90.98)	30.17	9.88 (86.36)	57.18	40.59 (91.27)	31.33
Coconut	10.60 (86.99)	31.46	6.58 (90.90)	36.82	25.88 (94.73)	52.86

Figures in parantheses denoted the percentage of the farmers who had paddy 10 years back and still continuing the same crops

In periphery also, the tendency of shifting from one crop to some other due to various reasons was observed (Table 38). But the percentage of farmers who have initiated cultivation of crops other than paddy during the last 10 years was remarkable. Only 7% increase was recorded in the case of paddy. This pattern was true for the area away from the forest also but for increased number of person engaged in paddy cultivation.

Majority of respondents attributed the crop damage 10 years back to a number of animal including elephant, wild boar, deer and monkeys. However, elephant and wild boar topped among the most damaging ones. Interestingly, the number of respondent finding elephant as responsible in the past was high among those residing away from the forest. This was true in the case of wild boar also. The

number of respondents holding wild boar responsible for crop damage increased from enclosures to periphery and then far away places (Table 39). The deer and monkeys were less problematic.

Table 39. Crop damage by animals – a comparison of the past with present (% of respondents)

Animals	Enclosure	Periphery	Transect
Elephant	40.55 (38.08)*	41.66 (12.92)	48.21 (28.13)
Gaur	1.56 (0.05)	1.30 (0.30)	2.86 (0.00)
Wild boar	30.46 (35.91)	40.76 (40.21)	41.79 (63.84)
Deer	13.94 (12.57)	6.09 (7.23)	2.50 (2.24)
Monkeys	13.50 (12.84)	10.19 (9.33)	4.64 (5.80)
Birds	0.00 (0.16)	0.00 (0.00)	0.00 (0.00)
Porcupine	0.00 (0.38)	0.00 (0.00)	0.00 (0.00)

* Figures in parantheses denote the present

Fishing

The people in the enclosures (61%), periphery (78%) and away (93%) from the forest had a preference for marine fishes.

The entire forest is the catchment area of Kabini, a tributary of the Cauvary river. A number of tributaries like Noolpuzha, Mavinahalla, Kurichiat puzha, Golur, Baveli, Ammavayal and Begur drain to Kabini. All these streams are diverse in terms of both fishes and turtles. Most of the people are living near the streams/ rivers.

Nearly 42% of people in enclosure, 71% in periphery and 88% away from the forest obtain fishes from market. The remaining collect the fishes from streams, rivers and lakes in and around the forest. The details are summarized in Table 40.

Table 40. Source of fresh water fishes (in %)

Source	Enclosure	Periphery	Transect
Streams	20.45	7.53	5.73
River	37.03	31.07	6.17
Lake	0.08	0.00	0.44
Market	42.44	71.40	87.67

Both the tribals and non-tribals (Table 41) employ different types of fishing methods. Conventional methods like bund making and sieving are mostly adopted by tribals.

Gears: - Different types of gears are used. An overall analysis showed that 22% of the people in enclosure, 87% in periphery and 16% in transect employed this method.

Trap: - Both tribals and non-tribals used this traditional method. An overall analysis showed that traps are used in enclosure (16%), periphery (21%) and transect (9%).

Rod and line: - People in the periphery (44%) use rod and line to a great extent compared to those along the transect and in enclosures. Earth worms, frogs, fruits and flowers are the baits commonly used.

Bund: - Temporary bunds were constructed for trapping the fishes. Stone and leaves are used for constructing the bund. This method was mainly employed in summer season. Both tribals and non-tribals employed this method. Twenty two percentage of people in the enclosure, 7% in periphery and 15% along the transect employed this method.

Sieving: - Both the tribal and non-tribals used cloth for the collection of small fishes. About 14% of the people in the enclosure used this method.

Dynamite (Locally called **Thotta**): This is a destructive method of fishing used both by the tribals and non-tribals. This method is mainly employed in summer season. However, only very few go for this method.

Poisoning: - This is another destructive method. The fruits of *Randia brandis*, *Sapinelus* sp. *Hydnocarpus pentandra*, bark of *Syzigium carophyllaeum*, *Acatia ruguta* are mainly used for poisoning the fishes during summer season.

Table 41. Percentage of respondent using different fishing methods

Method	Enclosure	Periphery	Transect
Overall			
Gears	22.48	7.38	15.56
Trap	15.84	20.92	8.89
Rod and line	21.87	43.69	37.78
Poisoning	4.02	0.92	0.00
Dynamiting	2.19	5.54	6.67
Sieving	14.26	9.85	8.89
Bund	19.34	11.69	22.22
Tribals			
Gears	15.69	6.69	26.32
Traps	11.26	22.18	21.05
Rod and line	33.31	42.61	26.32
Poisoning	3.38	0.00	0.00
Dynamiting	7.40	4.93	0.00
Cloth	12.95	10.56	5.26
Bund	16.01	13.03	21.05
Non-tribals			
Gears	24.39	12.20	7.41
Trap	17.48	12.20	3.70
Rod and line	43.09	51.22	40.74
Poisoning	0.81	7.32	0.00
Dynamiting	2.03	9.76	14.81
Sieving	3.25	4.88	11.11
Bund	8.94	2.44	22.22

The survey reveals that most of the methods adopted by both the tribals and non-tribals are not eco-friendly. About 99% of the respondents go for fishing for their own consumption (Table 42).

Table 42. Purpose of fishing (% of respondents)

Purpose	Enclosure	Periphery	Transect
Sale	0.86	0.30	0.82
Own use	99.14	99.70	99.18

Hunting

Even though hunting is banned totally, some of the settlers practice it occasionally. Many settlers controlled the crop damage by hunting problematic animals like deer, wild boar and monkeys. Many of them have guns and hunting is done in groups. They hunt and consume wild boar, spotted deer, sambar deer, flying squirrel, Malabar giant squirrel, barking deer, mouse deer, blacknaped hare, mangoose and mouse deer (Table 43). Traps were used for capturing smaller mammals like blacknaped hare, mouse deer, mongoose, *etc.* Birds were captured by using small sticks containing adhesive substance, kept on the trees.

Table 43. Percentage of respondents involved in hunting

Animal	Enclosure	Periphery
Wild boar	23.41	32.38
Sambar deer	6.49	7.62
Spotted deer	31.05	30.48
Bonnet macaque	0.00	0.95
Gaur	4.64	1.90
Jungle fowl	4.52	1.90
Hare	20.05	14.29
Civet	0.46	0.00
Barking deer	5.33	7.62
Birds	1.39	0.00
Rat	0.35	0.00
Porcupine	0.35	2.86
Monitor lizard	0.24	0.00
Flying squirrel	1.62	0.00
Giant squirrel	0.12	0.00

People staying in enclosures and the fringes of the forest hunt more. About

25% of the people in the enclosures are engaged in hunting of whom 35% belong to tribal communities. In periphery, 3.89% go for hunting out of which 5.34% were tribals (Table 43). Hunting is reported to be for own consumption

Bow and arrow are used extensively both in the enclosures (67.16%) and periphery (84.21%). The people in the enclosures (20.15%) and periphery (5.26%) also used crackers as explosives (Table 44). The tribals consume the deer and wild boar, which were predated upon by tiger and leopard.

Among the tribals, there are festivals related to hunting namely 'Thulampath' and 'Uchal'. This is mainly celebrated by Mullukurumans. During the particular day, they went to the forest as groups for hunting and share the flesh of hunted animals. Other tribal communities also accompany them. Bow and arrow are used for hunting in these days. About 3% of the tribals in enclosures and 3.5% in periphery used to go for hunting on this particular day.

Table 44. Methods used for hunting (% of respondents)

Method	Enclosure	Periphery
Overall		
Gun	12.69	10.53
Bow and arrow	67.16	84.21
Crackers	20.15	5.26
Tribals		
Gun	8.77	9.68
Bow and arrow	74.56	87.10
Crackers	16.67	3.23
Non-tribals		
Gun	31.82	14.29
Bow and arrow	45.45	71.43
Crackers	22.73	14.29

Religious and cultural activities

The people belonging to tribal and other Hindu communities have cultural and religious association with the forest area. There are a number of small temples and sacred places through out. Each community has its own festivals, ''Uchal' and 'Thulampath' are famous among them. These two festivals are celebrated mainly by Mullukurumans. Information collected from other sources reported fishing and hunting using trained dogs. The dogs are also used for detecting wild boar, deer and other small mammals. The festivals at Valliyurkavu in Mananthavady and Seetha Devi temple festival in Pulpally are yet other famous celebrations.

Cattle lifting, human death and house damage.

Cattle lifting incidences in Wayanad were comparatively few and were by panther (*Panthera pardus*), Tiger (*Panthera tigris*) and wild dog (*Cuon alpinus*). Most of the incidences occurred at night or rarely when the cattle went for grazing in the forest areas during daytime. Panther and tiger preyed upon goat, cow and dog. Wild dogs preferred goats and cow calves. Incidences of two cows being killed by a solitary tusker was also reported near Erulam of Chedleth Range. Cattle lifting were more in the enclosures (68.50) than periphery (25.96%) and away from the forest (5.52%).

Human casualties' by elephant is common in Wayanad. About 73% of human deaths reported were inside the forest, 36% near to forest and 9% on roads while passing through the Sanctuary. Solitary tuskers were responsible for most of the deaths. Only seventy percentage of the cases were compensated.

House damage by elephant was also reported by respondents. Damages in enclosure (91.66%) were higher than periphery (5.55%) and away from forest (2.77%). Only 27.27% of the affected were compensated.

Forest dependence

Firewood was collected for both domestic use and sale in hotels and teashops in and around. Ninety eight percentage of the people collected firewood for self use and only 2% for sale. Thirty different species were exploited for firewood. People living near to the plantations are mainly depending on teak and eucalypts.

About 70% of the people in the enclosures, 80% in periphery and 25.36% along in Southern region transect depend on forest for firewood. Dependence by tribals were higher than the non-tribals irrespective of location of the houses. The people even from half a kilometer away depend a lot on the forest for firewood (Table 45, 46 and 47).

The people in the enclosures and surroundings in Central region depend almost exclusively on forest for their firewood requirement (Tables 49, 50 and 51). Almost the entire population in the enclosures and in fringes meet their firewood demand from the forests in Northern region. The number of people residing away and depending on firewood supply from the forest was comparatively high in this area (Table 45, 46, 47).

NWFP (Non Wood Forest Products) is the main source of income for the tribals. The major items of NWFP collected from the forest were honey, wax, soapnut, pepper, cheevakai, wild ginger, turmeric and medicinal plants like *Rauvolfia Serpantina, Sida rhombifolia, Desmodium gangeticum, Desmodium velutinum, Solanum torvum, Pseudarthria viscida, Emblica officinalis,* etc. Honey is mainly collected by Kattunaikans and the area of operation extend even to the forests of Tamil Nadu and Karnataka. Mostly the women engage themselves in collection of medicinal plants.

Only a small proportion of the population is engaged in NWFP collection in Southern region and majority of them are tribals.

Only 17% of people in the enclosures and 5.39% in periphery go for NWFP

collection in Central region. People along the transect are not involved in NWFP collection. A higher proportion of the people in the Northern region are involved in NWFP collection. This was 74% in the enclosures, 12.42% in periphery and 1.82% along transect.

The design and mode of construction of house differ from one community to another. Most of the tribal houses were thatched and consists of only 1 or 2 rooms. The materials for construction such as bamboo and grass are mostly collected from the forest. About 55% of the people in the enclosures, 53% periphery and 23% along transect in Southern region depend on forest for the construction materials. Tribals in the enclosures, periphery and transect depend exclusively on the forests (Tables 45, 46, 47 & 48).

In Central region, the dependence on forest for house construction materials were comparatively higher in enclosures 61%, periphery 61%. However, only a few from faraway places depended the forest for construction materials. The dependence by tribals were comparatively higher (Tables 49-52).

Dependence on forest for house constriction material was higher in the enclosures in the Northern region. This was 87% in enclosures, 75% in periphery and 31% along the transect (Tables 53-56). Materials from the forest do not contribute much to the food of the people in Wayanad. However, the traditional method is still followed to a certain expects. The main food materials collected from the forest include mushrooms, tubers, fruits, leaves and tender bamboo shoots. Tender bamboo shoots are collected during the monsoon season.

About 47% of the people in the enclosures, 90% in periphery and 12% along transect collect food materials in Southern region. This was about 93%. in enclosure, 72% in periphery and 6% along the transect in Central region. Food gathering was prevalent more in the Northern region. Ninety six percentage of

people in the enclosures, 76.47% in periphery and 35% along the transect depending forest for food gathering in Northern region.

Forty three percentage of people in the enclosures, 13.73% in periphery and 2.90% along the transect in Southern region depend on the streams and rivers in the forest. In Central region, 77% of the people in the enclosures, 26.08% in periphery and 8.05% along the transect go for fishing (Table 110, 111 and 112). Fishing was not a major activity of the people in the Northern region (Table 49, 50 and 51).

Table 45. Forest dependence in the enclosures in Southern region

Caste	N	Fire wood %	Grazing %	NWFP %	House %	Food %	Fishing %
Tribals	333	91.89	62.88	39.34	66.67	94.59	70.87
Non-tribals	326	47.55	22.08	4.91	42.94	53.37	15.03
Combined	659	69.95	36.56	22.31	54.93	47.20	43.25

Table 46. Forest dependence in the periphery in Southern region

Caste	N	Fire wood %	Grazing %	NWFP %	House %	Food %	Fishing %
Tribals	40	97.50	75.00	20.00	60.00	100	17.50
Non-tribals	11	18.18	44.44	0.00	27.27	54.55	0.00
Combined	51	80.39	64.00	15.69	52.94	90.20	13.73

Table 47. Forest dependence along the transect in Southern region

Caste	N	Fire wood %	Grazing %	NWFP %	House %	Food %	Fishing %
Tribals	14	71.43	33.33	0.72	35.71	42.86	14.29
Non-tribals	124	20.16	26.09	0.00	21.77	8.06	1.61
Combined	138	25.36	26.53	0.72	23.19	11.59	2.90

Table 48. Forest dependence along the transect point in Southern region

Transect point	N	Fire wood %	Grazing %	NWFP %	House %	Food %	Fishing %
0-250	43	37.21	37.93	0.00	18.60	20.93	2.33
250-500	29	17.24	18.18	3.45	31.03	6.90	0.00
500-750	32	31.25	33.33	0.00	21.88	6.25	6.25
750-1000	34	11.76	15.38	0.00	23.53	8.82	2.94

Table 49. Forest dependence in the enclosures in Central region

Caste	N	Fire wood %	Grazing %	NWFP %	House %	Food %	Fishing %
Tribals	152	97.37	19.18	23.68	66.45	98.68	81.48
Non-tribals	74	64.86	7.81	4.05	50.00	83.78	58.11
Combined	226	86.73	13.87	17.26	61.06	93.81	77.43

Table 50. Forest dependence in periphery in Central region

Caste	N	Fire wood %	Grazing %	NWFP %	House %	Food %	Fishing %
Tribals	289	91.70	39.56	7.96	64.36	91.35	38.41
Non-tribals	175	52.57	28.70	1.14	54.29	38.86	5.71
Combined	464	76.94	33.50	5.39	60.56	71.55	26.08

Table 51. Forest dependence along the transect in Central region

Caste	N	Fire wood %	Grazing %	NWFP %	House %	Food %	Fishing %
Tribals	16	75.00	60.00	0.00	12.50	62.50	50.00
Non-tribals	158	15.82	6.25	0.00	17.09	0.63	3.80
Combined	174	21.26	10.66	0.00	16.67	6.32	8.05

Table 52. Forest dependence along the transect point in Central region

Transect point	N	Fire wood %	Grazing %	NWFP %	House %	Food %	Fishing %
0-250	61	29.51	20.00	0.00	26.23	9.84	9.84
250-500	43	16.28	10.71	0.00	11.63	6.98	6.98
500-750	31	25.81	8.70	0.00	16.13	3.23	6.45
750-1000	39	10.26	0.00	0.00	7.69	2.56	7.69

Table 53. Forest dependence in the enclosures in Northern region

Caste	N	Fire wood %	Grazing %	NWFP %	House %	Food %	Fishing %
Tribals	227	96.48	89.74	74.89	89.43	97.80	70.93
Non-tribals	48	87.50	52.38	70.83	77.08	89.58	64.58
Combined	275	94.91	79.87	74.18	87.27	96.36	69.82

Table 54. Forest dependence in periphery in Northern region

Caste	N	Fire wood %	Grazing %	NWFP %	House %	Food %	Fishing %
Tribals	83	97.59	82.61	18.07	75.90	97.59	30.12
Non-tribals	70	72.86	33.33	5.71	74.29	51.43	25.71
Combined	153	86.27	50.00	12.42	75.16	76.47	28.10

Table 55. Forest dependence along the transect in Northern region

Caste	N	Fire wood %	Grazing %	NWFP %	House %	Food %	Fishing %
Tribals	8	100.00	0.00	12.50	37.50	75.00	75.00
Non-tribals	47	48.94	11.11	0.00	29.79	27.66	12.77
Combined	55	56.36	10.81	1.82	30.91	34.55	21.82

An estimated 3500 cattles and goats graze in the forest in Wayanad. Most of the cattles are of poor breed as per the existing standards.

Table 56. Forest dependence along the transect point in Northern region

Transect point	N	Fire wood %	Grazing %	NWFP %	House %	Food %	Fishing %
0-250	15	33.33	15.38	0.00	20.00	26.67	6.67
250-500	13	69.23	14.29	0.00	38.46	46.15	23.08
500-750	16	62.50	9.09	6.25	31.25	25.00	18.75
750-1000	11	63.64	0.00	0.00	36.36	45.45	45.45

About 57% of the respondent in the enclosures in Southern region own cattle. Out of the 74% of the non-tribal having cattle, about 22% leave the cattle in the forest for grazing. However, only 45% of the non-tribals in the periphery leave the cattle in the forest for grazing (Table 57 & 58).

The dependence of tribals on forest for cattle grazing was comparatively higher. This was about 63% in the enclosures and 75% in periphery. Others either stall feed or depend on homestead or other source for cattle feed. About 27% of the cattle owners along the transect in Southern region depend on the forest for feeding (Table 59)

The number of tribals as well as non-tribal with cattles depending on the forest for grazing is higher both in the enclosures and in periphery in Northern region (Table 60 & 61). Interestingly, even the people in the outskirts sent their cattle to the forest in this region (Table 62).

In Central region, the number of persons having cattles were comparatively higher. About 87% of the non-tribals and 48% of the tribals in the enclosures have cattle (Table 63). However, only very few depend on forest for cattle grazing. The dependence on forest by cattle owners in the periphery are considerable higher (Table 64). Those in the outskirts do not depend much on the forest for cattle grazing (Table 65).

Table 57. Details of live-stock and the mode of feeding in Southern region (enclosure)

Caste	N	% of households with cattle	Forest	Stall feeding	Other sources
Tribals	333	36.63	62.88	2.27	34.85
Non-tribals	326	73.61	22.08	20.42	57.50
Combined	659	56.44	36.56	13.98	49.46

Table 58. Details of live-stock and the mode of feeding in Southern region (periphery)

Caste	N	% of having cattle	Forest	Stall feeding	Other sources
Tribals	40	40.00	75.00	6.25	18.75
Non-tribals	11	81.81	44.44	11.11	44.44
Combined	51	49.01	64.00	8.00	28.00

Table 59. Details of live-stock and the mode of feeding in Southern region (Transect)

Caste	N	% of having cattle	Forest	Stall feeding	Other sources
Tribals	14	42.85	33.33	0.00	66.67
Non-tribals	124	74.19	26.09	1.09	73.91
Combined	138	71.01	26.53	1.02	73.47

Table 60. Details of live-stock and the mode of feeding in Northern region (enclosures)

Caste	N	% of having cattle	Forest	Stall feeding	Other sources
Tribals	227	57.54	89.74	0.85	9.40
Non-tribals	48	87.50	52.38	0.00	47.62
Combined	275	57.81	79.87	0.63	19.50

Table 61. Details of live-stock and the mode of feeding in Northern region (periphery)

Caste	N	% of having cattle	Forest	Stall feeding	Other sources
Tribals	83	27.70	82.61	0.00	17.39
Non-tribals	70	64.28	33.3	2.22	64.44
Combined	153	44.44	50.00	1.47	48.53

Table 62. Details of live-stock and the mode of feeding in Northern region (transect)

Caste	N	% of having cattle	Forest	Stall feeding	Other sources
Tribals	8	6.25	0.00	0.00	100.00
Non-tribals	47	22.78	11.11	11.11	77.78
Combined	55	21.26	10.81	10.81	78.38

Table 63. Details of live-stock and the mode of feeding in Central region (enclosure)

Caste	N	% of having cattle	Forest	Stall feeding	Other sources
Tribals	152	48.00	19.18	13.70	67.12
Non-tribals	74	86.48	7.81	15.63	76.56
Combined	226	60.61	13.87	14.60	71.53

Table 64. Details of live-stock and the mode of feeding in Central region (periphery)

Caste	N	% of having cattle	Forest	Stall feeding	Other sources
Tribals	289	31.48	39.56	1.10	59.34
Non-tribals	175	65.71	28.70	4.35	66.96
Combined	646	44.39	33.60	2.91	63.59

Table 65. Details of live-stock and the mode of feeding in Central region (transect)

Caste	N	% of having cattle	Forest	Stall feeding	Other sources
Tribals	16	62.5	60.00	0.00	40.00
Non-tribals	158	70.88	6.25	1.79	91.96
Combined	174	70.11	10.66	1.64	87.70

Among the tribals in the enclosures, nearly 100% of Adiyans and Uralies collect firewood from forests. Dependence of Kurichian (44.39%), Kurumans (44.34%) and Kattunaikans (23.86%) were for firewood. Kattunaikans (56.06%) are depending the forest more for NWFP followed by Kurichian (48.78%) and Adiyans (47.38%). Most of the construction materials of majority of Adiyan (84.21%), Kurumans (80%) and Kattunaikans (75%) came from the forest. Though food from the forest do not contribute much to the diet, Kurichians and Adiyans do collect food materials. Hunting was mainly done by Kurichian (51.22%), Kurumans (43.41%) and Kattunaikans (35.23%). Fishing was mainly by Kurichian (97.56%), Adiyans (81.58%) and Kattunaikans (72.73%). The details are summarised in Table 66.

Table 66. Forest dependence in enclosure (caste wise tribals)

	Kattu naikan	Kuruman	Paniyan	Adiyan	Urali	Kurichian
Fire wood	96.59	87.80	99.25	100	100	92.68
Grazing	70.00	59.86	73.17	83.30	42.85	38.46
NWFP	56.06	42.93	39.26	47.38	34.48	48.78
House	75.38	80.00	62.96	84.21	62.07	68.29
Food	17.42	94.15	97.18	100	93.10	100
Hunting	35.23	43.41	25.19	31.58	13.79	51.22
Fishing	72.73	72.68	71.85	81.58	68.97	97.56

Table 67. Type of area for resettling

Location	enclosure
Periphery	23.56
Town	16.08
Village	60.42

Table 68. Importance of forest and wildlife conservation

Response	Enclosures	Periphery	Transect
Should be protected	18.64	18.89	3.54
No need of protection	6.04	13.94	5.18
Should be protected without affecting settlers	74.89	66.57	91.28
No response	0.43	0.60	0.00

Table 69. Awareness about wildlife protection

Response	Enclosures	Periphery	Transect
Aware	87.40	80.99	77.93
Not aware	12.60	19.01	22.07

About 48.32% of the respondent in Wayanad are willing to be resettled outside the forest. Of this, about 60% of the people preferred villages and 16.08% town and 23.56% in periphery (Table 67). Nearly 75% of the people in the enclosures, 66.57% in periphery and 91.81% along transect have the opinion that forest and wild life should be protected without affecting the people (Table 68). About 87% of the people in the enclosures, 80.99% in periphery and 77.93% along the transect aware of the need to conserve the wildlife (Table 69).

Discussion

Kothari *et.al.* (1995) have summarised the major reasons leading to human-wildlife conflict in the Protected Areas in India. Irrationality in planning, curtailment of local community land and forest rights, access to natural resources inside

Protected Areas, increase in the animal population as a result of increased protection offered by PAs and the urban industrial pressure for the resources are the major factors contributing to the human wildlife conflict.

The survey has brought out the details of dependence on forest by the people of Wayanad. The dependence by the tribal communities for firewood, house construction materials and NWFP clearly indicate their interrelationship with the forest ecosystem. However, the removal of the resources, especially bamboo from Wayanad for the industrial purpose could have more impacts to the system by way of continued human disturbance and also by way of denying the fringe benefits to the local community. The negative impacts on the system due to dependence by the local community would be rather minimal compared to the exploitation for industrial purpose.

Majority of the respondents consider only a marginal increase in the crop raiding by animals and only a few of them attribute this to the increase in animal numbers. Confronted with the crop damage and other related problems, at least about half of the respondents feel resettlement as a viable solution. The high awareness of the people in the area is evident from their statements that the wildlife should be protected but without causing damage to the life and properties of human beings.

The need to protect the interests of both the wildlife and the people has been stressed by a number of workers who have dealt with the problem. However, decisions based on site specific studies and opinions collected from the local people have been lacking. The present survey indicates the necessity of mitigation measures to protect the interests of the people in Wayanad as a long term solution to the conflict. Resettlement of willing people would help in consolidation of the areas, providing problem free contiguous areas for the animals and relief to the people spending sleepless nights to protect their crops.

CHAPTER 6

ANIMAL POPULATION, DENSITY, GROUP SIZE AND COMPOSITION

Introduction

Information on the population of animals in an area is an important pre requisite for the ecological studies. This is especially true in the case of gregarious animals contributing to the biomass to a greater extent. Various authors have reported that the population size, structure and herd size affect the overall utilization of the habitat and also its behaviour (Laws, 1974; Eltringham, 1977; Downing, 1980).

Methods

Population density estimate

The study area was divided into blocks based on the vegetation types and 29 transects of 2 km length were laid in proportion to habitat size. Care was taken to have some of these transects in areas bordering the adjacent Rajiv Gandhi National Park, Bandipur Tiger Reserve and Mudumalai Wildlife Sanctuary and a few radiating from the settlements for correlating the density distribution with cropping pattern.

These transects were followed seasonally (once in four months) taking the rainy season of the study area into consideration (Chapter 2). Information on the number of animals and the details of herd size and composition were collected along with the sighting angle (using a compass) and the sighting distance (using a range finder) (Burnham *et al.*, 1980). The analyses of line transect (direct) data indicated very low sample size resulting in highly unreliable density estimates. Hence, only the indirect evidences were collected subsequently. A fixed width of one meter on both sides were used for sambar deer and spotted deer. The pellet groups within this were counted while covering the transects. Indefinite width was used for gaur and elephants and the perpendicular distance from the transect to the sighted dung was

measured (Barnes and Jensen 1987). In the case of elephants, the decay stage of the dung was also noted. The time spent for sampling and the effort taken was kept uniform.

Herd size, structure and composition

The entire study area was covered every month on foot from January 1994 to December 1996. Size, composition and structure of the animal herds sighted were recorded by direct observation, spending time in all habitat types proportionately. Elephants were classified into different age/sex categories following the criteria as shown below (Sukumar, 1985).

Category		Age class
Infant or calf		0 - 1
Juvenile	I	1 - 2
	II	2 - 3
	III	3 - 5
Sub-adult	I	5 - 7
	II	7 - 10
	III	10 - 15
Adult	I	15 - 20
	II	20 - 30
	III	30 - 40
	IV	40 - 50
	V	> 50

The other animals were classified into young ones, juveniles and adults based on visual estimation of size.

Analyses

Density estimates

The data on indirect evidences of elephant from different transects were pooled for analysis of density estimates in the area using the computer program DISTANCE (Laake *et al.*, 1994). Density of indirect evidences of other animals were also similarly pooled and analysed using the same program.

Estimation of elephant density from dung density

The elephant density, based on the dung density was calculated using the following formula:

$$E = (Y \times r)/D$$

Where E = elephant density/km^2

Y = density of dung piles/km^2

r = dung decay rate per day

and

D = Defecation rate per day

The defecation rate of 16.33/day, obtained from the study at Mudumalai by Watve (1992) was used in the present analysis since this could not be collected from the study area. Experiments were conducted for dung decay rate (Barnes and Jensen, 1987) in different vegetation types in different seasons in the Southern region (Balasubramanian, 1998). The results obtained are summarized in Table 70 and were used in the present analyses.

Table 70. Summary of dung decay rate in Wayanad Wildlife Sanctuary

Season	Habitat	Sample Size	Mean decay rate/day	Standard Error	Confidence Level (95%)
Dry	DDF	122	0.0192	0.0004	0.0184 - 0.0200
	MDF	42	0.0187	0.0006	0.0175 - 0.0200
	Combined	164	0.0191	0.0003	0.0184 - 0.0198
Wet-1	DDF	27	0.0754	0.0074	0.0610 - 0.0899
	MDF	87	0.2037	0.0054	0.1931 - 0.2144
	Combined	114	0.1406	0.0097	0.1215 - 0.1596
Wet-2	DDF	64	0.0360	0.0022	0.0317 - 0.0402
	MDF	47	0.0615	0.0040	0.0538 - 0.0693
	Combined	111	0.0436	0.0023	0.0391 - 0.0482
Overall	DDF	213	0.0251	0.0008	0.0235 - 0.0267
	MDF	176	0.0512	0.0041	0.0432 - 0.0592
	Combined	389	0.0335	0.0012	0.0311 - 0.0359

Dry = Dry Season; Wet1 = First Wet Season; Wet2 = Second Wet Season;
DDF = Dry Deciduous Forests; MDF = Moist Deciduous Forests

Herd size, composition and structure

Only the completely classified herds of elephants were taken for the analyses of herd size and structure. Herd size, composition and proportion of different age and sex classes in the population were derived on the basis of all sightings during the study period. The solitaries were not considered for calculating mean herd size.

Results

Density estimate of animals

Density estimates for elephants in Southern region was 1.33/km^2 and 1.35/km^2 in 1995 and 1996 respectively. Dung and elephant density estimates in different seasons in Southern region are given in Table 71 and Figure 8.

Seasonal differences in the density of elephants in Southern region were evident and the differences in 1995 (χ^2 = 1862.44, df =2, P< 0.000) and 1996 ((χ^2 =1015.6829, df =2, P< 0.000) were significant.

Table 71. Density of elephants in Southern Region in different seasons

Season	Dung density /km^2	% CV	95 % CI Lower	Upper	Elephant density /km^2
1995					
Dry	1746.10	7.88	1496.60	2037.00	2.04
Wet-1	125.12	8.91	105.11	148.90	1.08
Wet-2	473.91	7.74	286.15	387.30	0.89
1996					
Dry	1183.20	9.11	990.07	1414.00	1.38
Wet-1	154.13	11.71	118.75	189.51	1.33
Wet-2	385.01	19.95	259.80	570.58	0.85

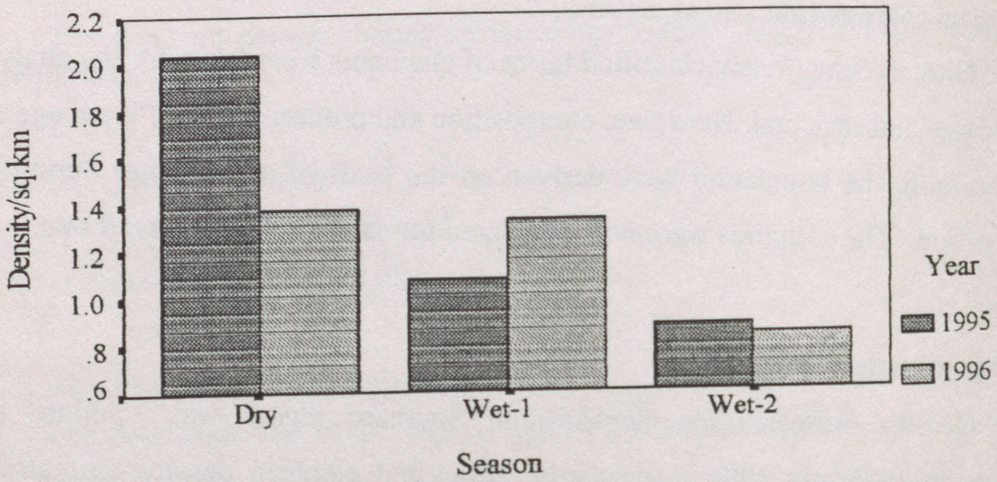


Fig 8. Density of elephants in Southern region in different seasons

There were considerable seasonal variations in elephant density in Northern region (Table 72). The difference was highly significant between seasons in 1995 (χ^2 = 1687.3879, df=2, P< 0.000) and 1996 (χ^2 = 809.0164, df=2, P< 0.000) (Fig 9). The density was not following any pattern. The seasonal difference in density was high in dry season of 1995 where as it was high in second wet season of 1996.

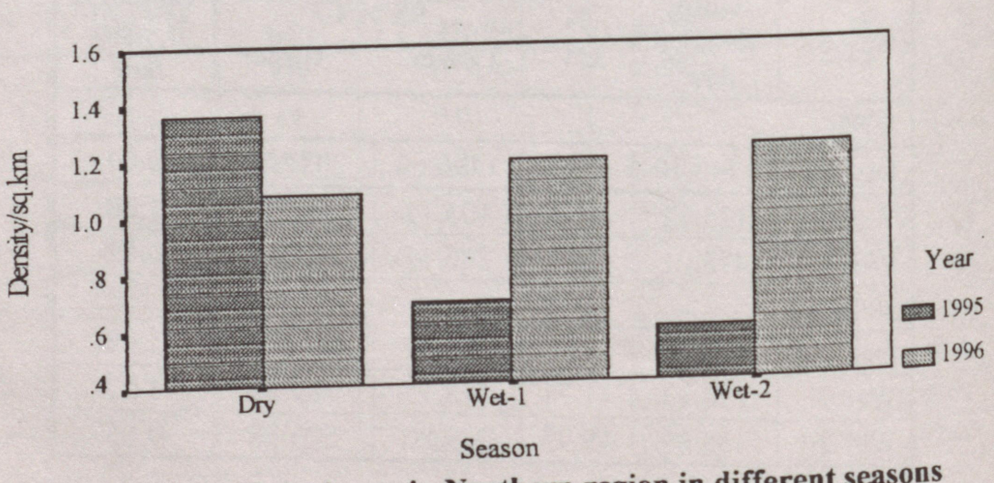


Fig 9. Density of elephants in Northern region in different seasons

Table 72. Density of elephants in Northern region in different seasons

Season	Dung density /km^2	%CV	95 % CI Lower	Upper	Elephant density /km^2
1995					
Dry	1190.00	41.42	526.36	2694.40	1.36
Wet-1	54.94	40.44	23.70	127.35	0.69
Wet-2	156.94	33.92	80.32	306.67	0.59
Overall	128.30	17.73	90.402	182.09	0.26
1996					
Dry	921.58	12.70	719.17	1181.00	1.08
Wet-1	95.83	20.85	62.53	146.85	1.19
Wet-2	327.88	19.09	224.07	479.77	1.23
Overall		449.76	9.83	371.13	545.05

Analysis indicate a higher density of elephant in Central Range in first wet season in both 1995 and 1996. However, there was a difference in the first and second wet seasons in these years. The density was highest in the first wet season of 1996 (Table73 and Fig 10). The differences in density between seasons in 1995 (χ^2 =819.9946, df = 2, P< 0.000) and 1996 (χ^2 =453.9091, df = 2, P< 0.000) were significant.

Table 73. Density of elephants in Central Range in different seasons

Year	Season	Dung density/km^2	% of CV	95% CV Lower	Upper	Elephant density/km^2
1995	Dry	809.72	11.98	638.94	1026.20	0.93
	Wet-1	81.00	24.25	49.35	135.35	1.01
	Wet-2	213.61	16.66	153.48	297.28	0.80
	Overall	418.93	10.45	341.53	513.86	0.85
1996	Dry	552.34	20.63	366.82	861.68	0.63
	Wet-1	123.00	25.00	73.03	207.43	1.53
	Wet-2	181.25	28.96	100.27	327.64	0.69
	Overall	260.25	13.38	199.77	339.05	0.53

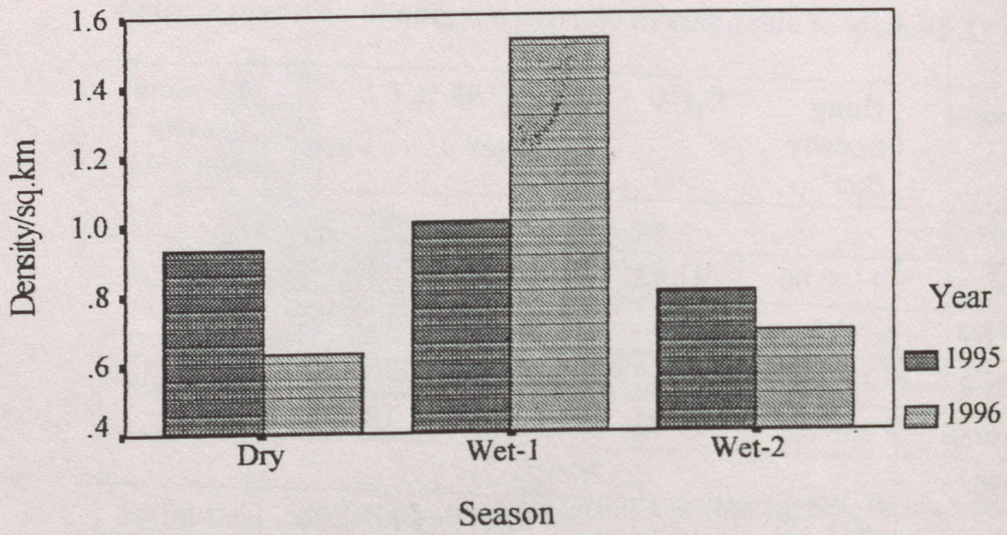


Fig 10. Density of elephants in Central region in different seasons

Density estimate of gaur

Density of gaur is expressed in dung density/km^2. Seasonal variations in dung density of gaur were observed in Southern region (Table 74 and Fig 11). This was highly significant between seasons in 1995 ($\chi^2 = 60.6867$, df = 2, P< 0.000) and 1996 ($\chi^2 = 35.0832$, df = 2, P< 0.000). Further, there was a marked difference especially in the dry seasons.

Table 74. Dung density of gaur in Southern region in different seasons

Season	Dung density /km^2	% CV	95 % CI Lower	Upper
1995				
Dry	690.41	7.62	587.30	793.53
Wet-1	428.50	18.12	276.32	580.68
Wet-2	582.48	19.46	360.31	804.65
1996				
Dry	486.35	9.82	392.74	579.96
Wet-1	371.21	12.12	283.03	459.39
Wet-2	549.68	18.48	379.48	796.21

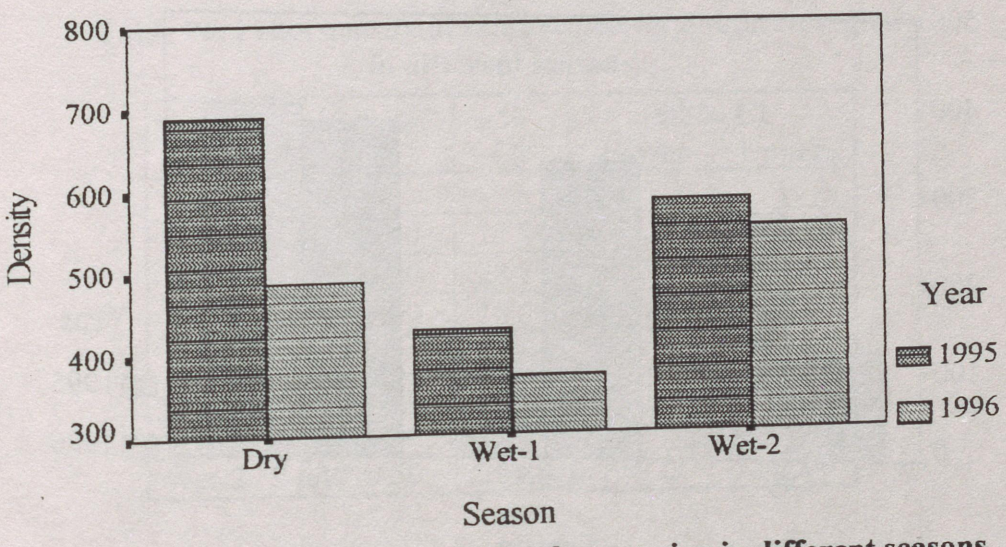


Fig 11. Dung density of gaur in Southern region in different seasons

Seasonal variation in gaur dung density was observed also in Northern region (Table 75 and Fig 12). The difference between seasons were significant in 1995 (χ^2 = 133.0463, df = 2, P< 0.000) and 1996 (χ^2 = 116.0942, df = 2, P< 0.000). However, the pattern was different in both years.

Table 75. Dung density of gaur in Northern region in different seasons

Season	Dung density /km^2	% CV	95 % CI Lower	95 % CI Upper
1995				
Dry	125.00	37.80	52.61	296.64
Wet-1	338.00	42.20	141.85	805.39
Wet-2	380.00	44.43	150.85	959.22
1996				
Dry	281.44	34.07	140.97	561.88
Wet-1	147.82	60.60	40.70	536.85
Wet-2	399.39	24.99	242.61	657.48

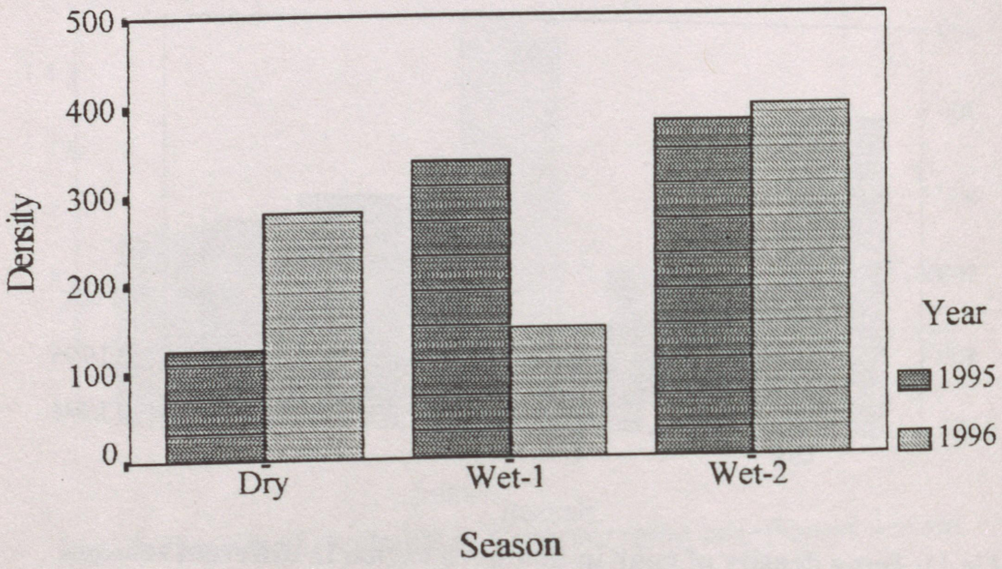


Fig 12. Dung density of gaur in Northern region in different seasons

Density estimates of sambar

Density of sambar deer is expressed in pellet density/km^2. Seasonal variation was observed in pellet density in Southern region and the difference was highly significant in 1995 (χ^2 = 504.5695, df = 2, P< 0.000) and 1996 (χ^2 = 112.5284, df = 2, P< 0.000). The pellet density was higher in first wet season (2767/km^2) followed by second wet season (2627/km^2) and dry season (1394.30/km^2) in 1995. In 1996, pellet density was high in first wet (1559/km^2) followed by second wet season (1210.50/km^2) and dry seasons (1033.60/km^2). The details are summarized in Table 76 and Fig 13.

Seasonal variation in pellet density was also observed in Northern region and the difference was highly significant between seasons in 1995 (χ^2 = 1243.7949, df = 2, P< 0.000) and significant in 1996 (χ^2 = 277.2531, df = 2, P< 0.000). Pellet density was high in second wet season (997.36/km^2) followed by dry season (143.98/km^2) and first wet season (96.16/km^2) in 1995. The pellet density in 1996 followed almost a similar pattern (Table 77 and Fig 14).

Table 76. Pellet density of sambar deer in Southern region in different seasons

Season	Density /km^2	% CV	95 % CI Lower	Upper
1995				
Dry	1394.30	22.84	770.12	2018.48
Wet-1	2767.00	28.85	1202.37	4331.63
Wet-2	2627.00	16.55	1774.85	3479.15
1996				
Dry	1033.60	9.34	844.39	1222.81
Wet-1	1559.00	23.34	845.81	2272.19
Wet-2	1210.50	20.88	794.23	1845.00

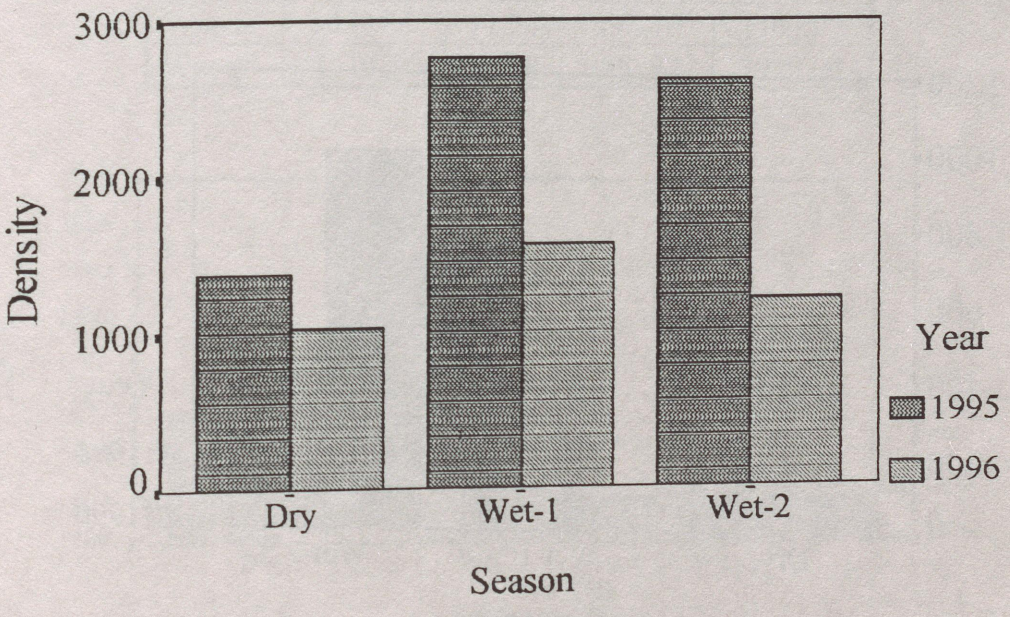


Fig 13. Pellet density of sambar deer in Southern region in different seasons

Observations of sambar deer evidences were so low in Central region that no analysis was attempted.

Table 77. Pellet density of sambar deer in Northern region in different seasons

Season	Density /km^2	% CV	95 % CI Lower	Upper
1995				
Dry	143.98	64.55	27.98	741.00
Wet-1	96.16	76.38	5.26	1777.50
Wet-2	997.36	141.42	127.83	7781.30
1996				
Dry	168.19	58.55	41.63	679.06
Wet-1	106.85	76.38	5.78	1975.10
Wet-2	449.18	25.63	264.94	761.53

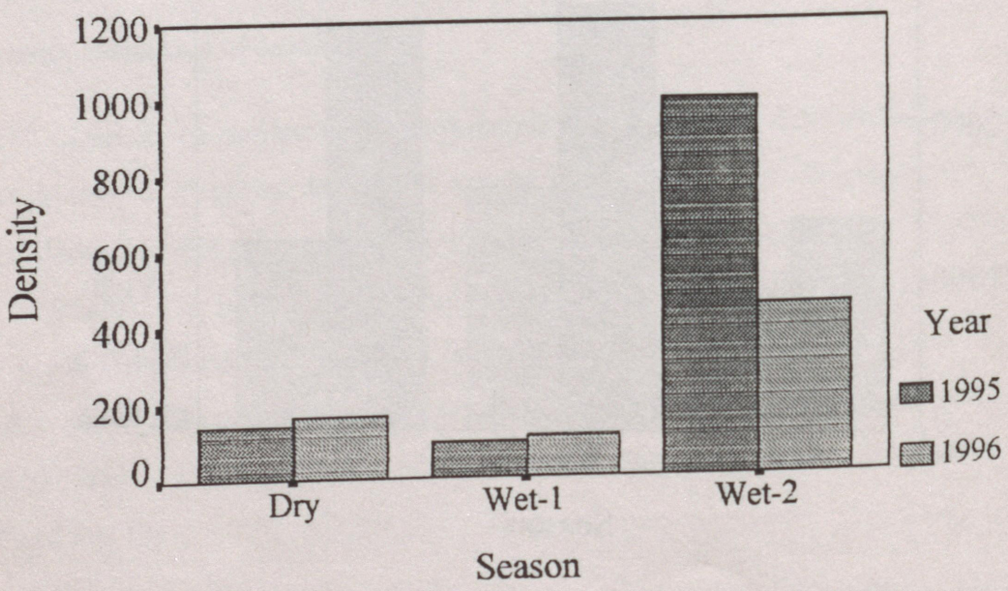


Fig 14. Pellet density of sambar deer in Northern region in different seasons

Density estimates of spotted deer

The density of spotted deer is expressed in pellet/km^2. Though there was no fixed pattern in seasonal density figures between years, the differences between

seasons with in an year were evident. The seasonal differences was found to be highly significant in 1995 ($\chi^2 = 585.3022$, df = 2, P< 0.000) and 1996 ($\chi^2 = 69.2711$, df = 2, P< 0.000) (Table 78 and Fig 15).

Table 78. Pellet density of spotted deer in Southern Region in different seasons

Season	Density /km^2	% CV	95 % CI Lower	Upper
1995				
Dry	985.00	27.55	411.72	1378.28
Wet-1	1749.00	29.30	744.58	2753.42
Wet-2	628.40	26.40	303.24	953.56
1996				
Dry	1287.01	31.35	496.19	2077.83
Wet-1	953.06	11.24	743.10	1163.02
Wet-2	1319.30	18.88	902.37	1929.00

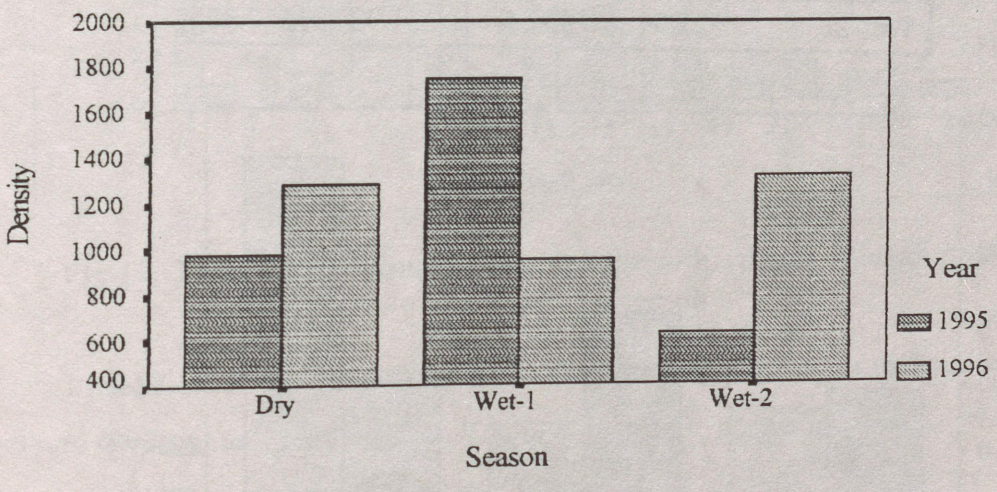


Fig 15. Pellet density of spotted deer in Southern region in different seasons

The density of spotted deer in Northern Range also showed seasonal variation (Table 79). This was significant between seasons in 1995 ($\chi^2 = 29.2681$, df = 2, P< 0.000) and 1996 ($\chi^2 = 354.4233$, df = 2, P< 0.000). The pellet density was high in

first wet season followed by second wet season and dry season in 1995. Pellet density in 1996 was high in second wet season followed by dry season and first wet season (Fig 16).

Table 79. Pellet density of spotted deer in Northern region in different seasons

Season	Density /km^2	% CV	95 % CI	
			Lower	Upper
1995				
Dry	192.32	64.01	55.77	663.22
Wet-1	301.57	49.74	90.03	1010.10
Wet-2	210.48	78.57	10.65	4159.20
1996				
Dry	160.30	76.38	8.62	2963.10
Wet-1	134.14	88.36	5.12	3537.80
Wet-2	527.94	38.65	221.92	1212.30

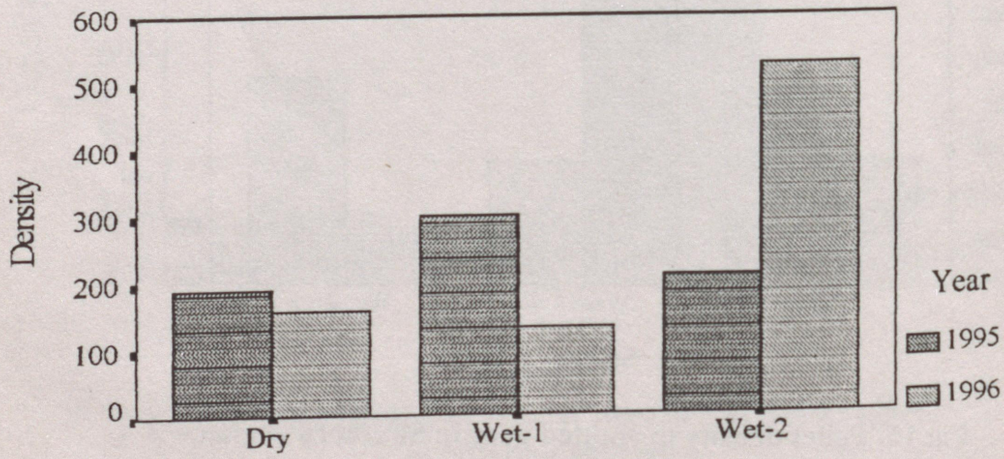


Fig 16. Pellet density of spotted deer in Northern region in different seasons

Sighting as well as indirect evidences of spotted deer in Central Range was low making the analysis impossible.

Group composition

Elephant

A total of 208 herds with 1985 individuals were sighted in Southern region and the herd size ranged from 1 to 38. Out of 208 sightings, 14.42% were loners (Fig 17). A total of 668 individuals in 126 herds were sighted in Northern region. The herds size ranged from 1 to 33 and only 3.89% of the sighting were of loners (Fig 18).

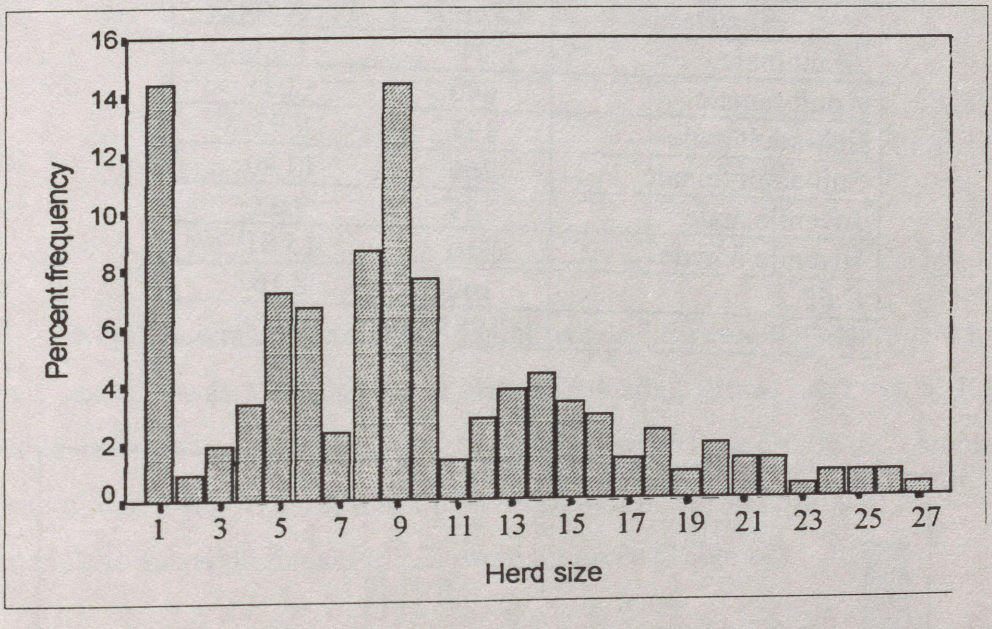


Fig 17. Percentage frequency distribution of herd size of elephants in Southern region

Proportion of age sex categories in the elephant population in Southern and Northern regions are presented in Table 80 and 81 respectively. A schematic presentation of various age-sex classes of elephants is also given in Figures 19 and 20. Adult females formed a major portion of the population (42.31%) in Southern Region followed by juvenile females (15.61%) and sub adult females (13.40%). The males formed about 1.05%, sub adult males 9.92% and juvenile males 9.52%. The proportion of calves was about 8.16%.

In Northern Region, adult females formed 46.71% of the population followed by sub adult females (16.32%). The males formed about 13.02% and sub adult males 7.19%. Juveniles and calves were not sexed and formed 9.88% and 2.40% respectively.

Table 80. Percentage frequency of age sex classes of elephants in Southern Region

Sex/class	Total	Percentage
Adult male	21	1.05
Adult female	840	42.31
Sub-adult male	197	9.92
Sub-adult female	266	13.40
Juvenile male	189	9.52
Juvenile female	310	15.61
Calf	162	8.16
Total	1985	100.00

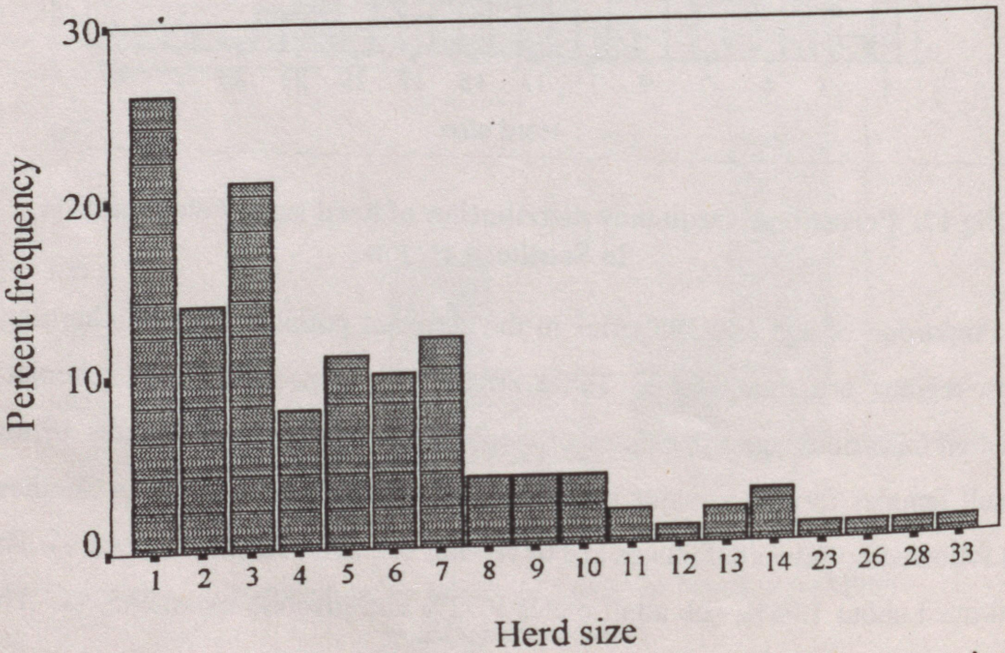


Fig 18. Percentage frequency distribution of herd size of elephants in Northern region

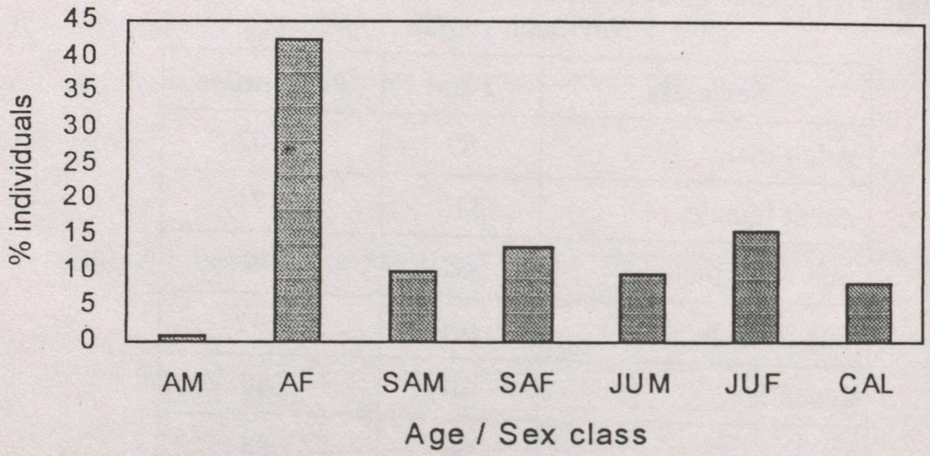
Table 81. Percentage frequency of age sex classes of elephants in Northern region

Sex/class	Total	Percentage
Adult male	87	13.02
Adult female	312	46.71
Sub-adult male	48	7.19
Sub-adult female	109	16.32
Juvenile	30	4.49
Calf	66	9.88
Unknown	16	2.40
Total	668	100.00

Overall sex ratio in Southern region was 1: 3.5 while the adult male to adult female sex ratio was 1: 40. Sub adult male to sub adult female ratio was 1: 1.35 and juvenile male to juvenile female 1: 1.64. The overall sex ratio of elephants in Northern region was 1: 3.12. Adult male to adult female sex ratio of 1: 3.59 and sub adult male to sub adult female 1: 2.27 were observed (Table 82).

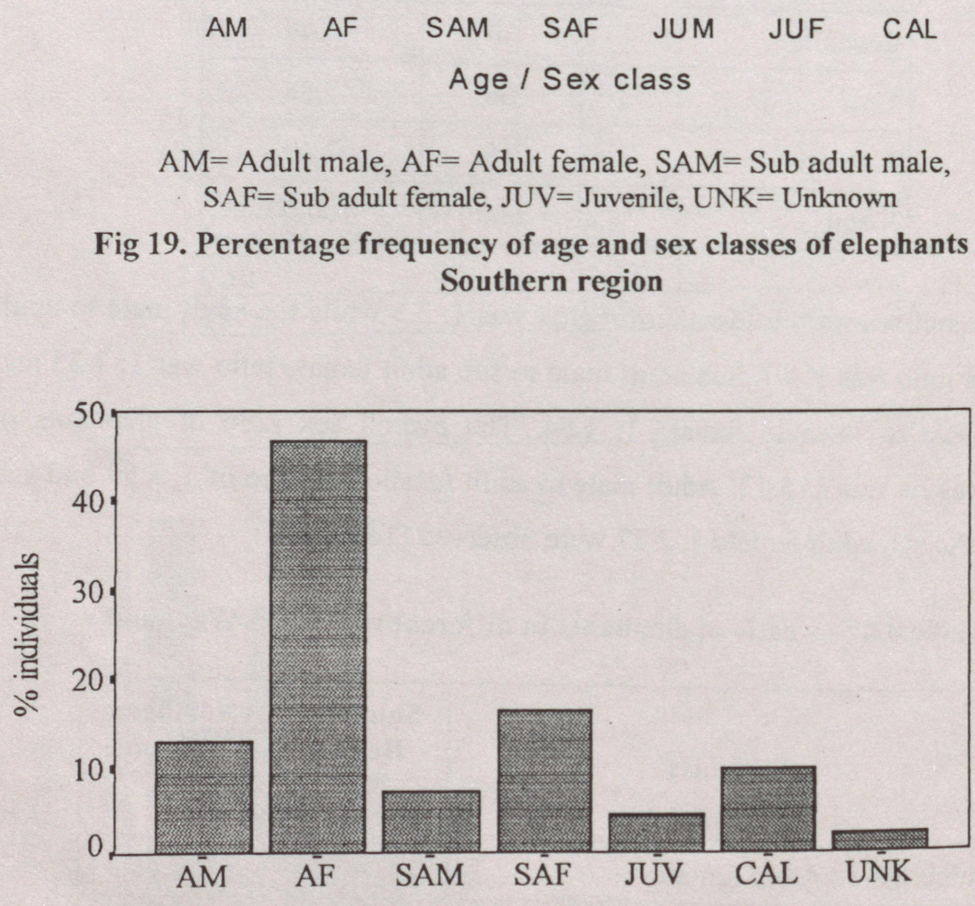
Table 82. Sex ratio of elephants in different regions in Wayanad

Sex/class	Southern Region	Northern Region
	Sex ratio	
Adult male : Adult female	1: 40.0	1: 3.59
Sub-adult male : Sub-adult female	1: 1.35	1: 2.27
Juvenile male : Juvenile female	1: 1.64	**
Over all	1: 3.50	1: 3.12



AM= Adult male, AF= Adult female, SAM= Sub adult male,
SAF= Sub adult female, JUV= Juvenile, UNK= Unknown

Fig 19. Percentage frequency of age and sex classes of elephants in Southern region



AM= Adult male, AF= Adult female, SAM= Sub adult male,
SAF= Sub adult female, JUM= Juvenile male, JUF= Juvenile female, CAL= Calf

Fig 20. Percentage frequency of age and sex classes of elephants in Northern region

Gaur

Only the completely classified herds had been taken for analysis of herd size and structure. A total of 495 animals in 62 herds were recorded were from Southern region (Fig 21) and a total of 364 in 56 herds from Northern region (Fig 22). The herd size ranged from 1 to 26 in Southern Region and 1 to 30 in Northern region. There were no direct sighting or indirect evidences of gaur in Central region.

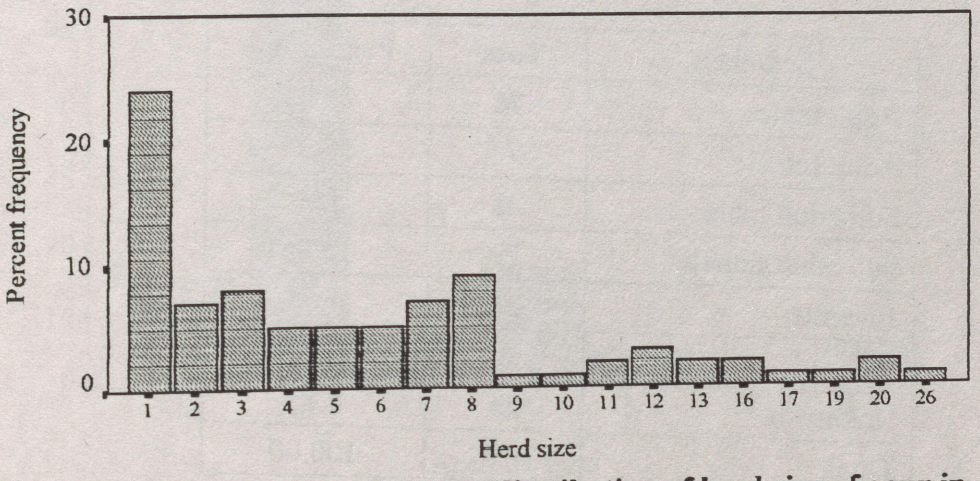


Fig 21. Percentage frequency distribution of herd size of gaur in Southern region

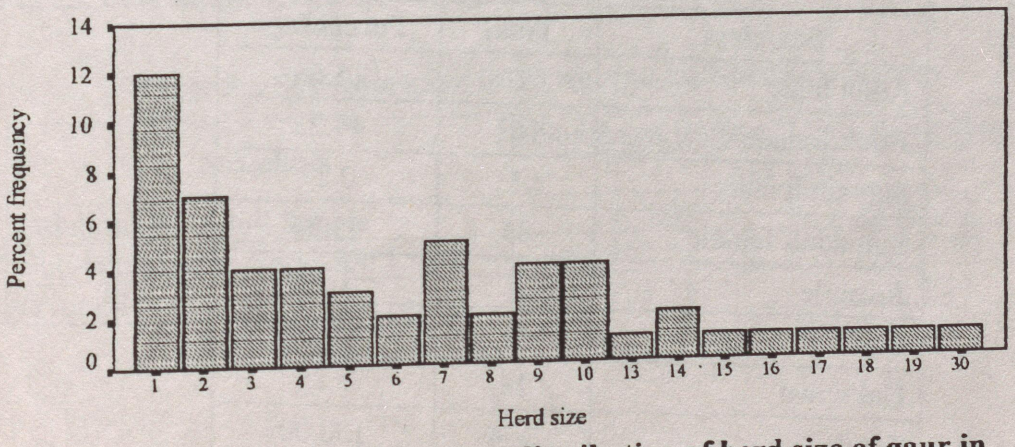


Fig 22. Percentage frequency distribution of herd size of gaur in Northern region

Proportion of age-sex categories of gaur population in Southern and Northern regions are presented Tables 83 and 84. A schematic presentation of percentage

frequency distribution of various age-sex classes of gaur is given in Figs 23 and 24. In both the regions, adult females formed major portion of the population followed by sub adult females. Adult males constituted 15.35% in the Southern region and 15.66% in the Northern region. Proportion sub adult males and juveniles were comparatively higher in the Southern region where as calves were higher in the Northern region.

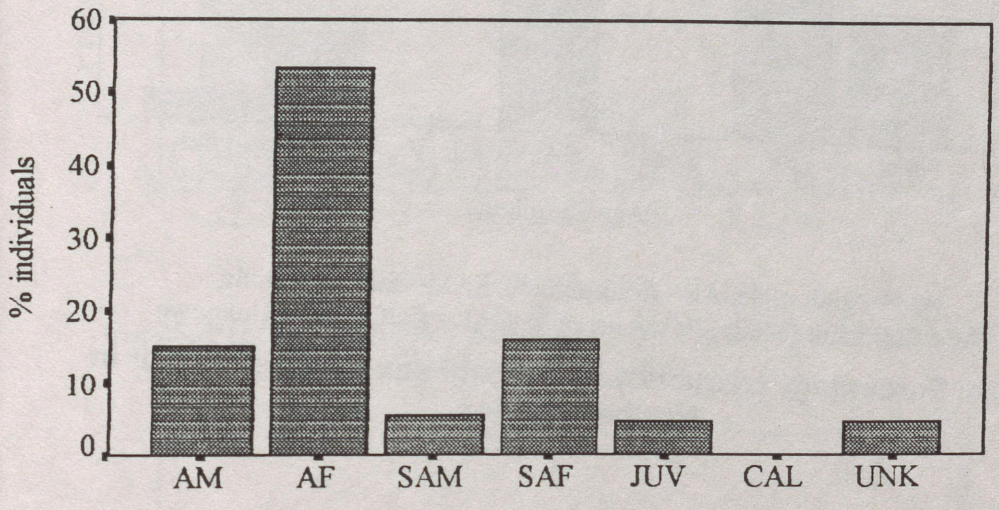
Table 83. Percentage frequency of age sex classes of gaur in Southern region

Sex/class	Total	Percentage
Adult male	76	15.35
Adult female	265	53.54
Sub-adult male	28	5.66
Sub-adult female	79	15.96
Juvenile	23	4.65
Calf	0	0.00
Unknown	24	4.85
Total	495	100.00

Table 84. Percentage frequency of age sex classes of gaur in Northern region

Sex/class	Total	Percentage
Adult male	57	15.66
Adult female	161	44.23
Sub-adult male	1	0.27
Sub-adult female	85	23.35
Juvenile	5	1.37
Calf	41	11.26
Unknown	14	3.85
Total	364	100.00

The sex ratio of gaur in Southern and Northern regions are summarized in Table 85. The overall male to female sex ratio in Southern region was 1: 3.31 compared to 1: 4.24 in Northern region. Adult male to female sex ratio of 1: 3.49 and sub adult sex ratio of 1: 2.82 were observed in Southern region. The sub adult sex ratio in Northern was highly skewed.

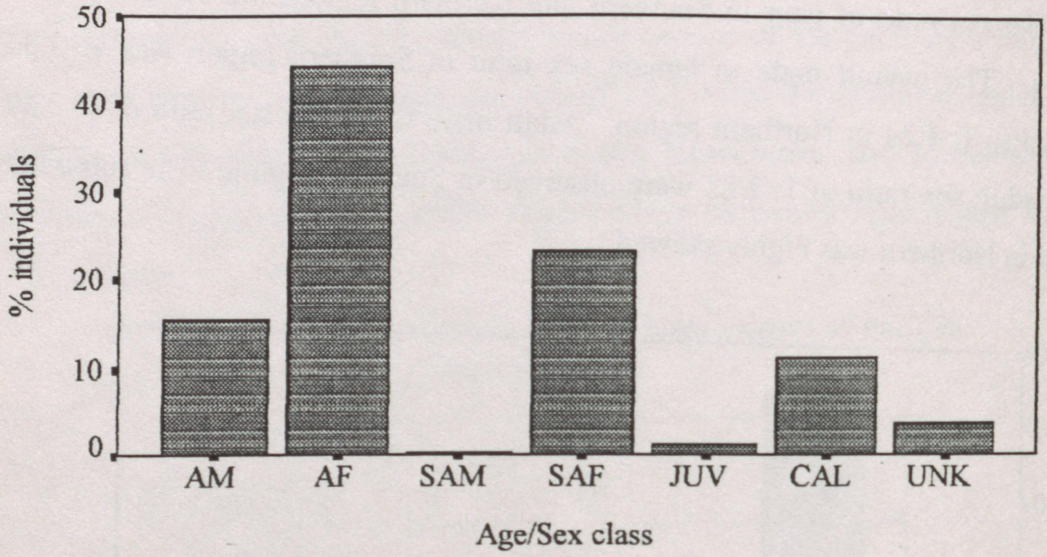


AM= Adult male, AF= Adult female, SAM= Sub adult male,
SAF= Sub adult female, JUV= Juvenile, CAL= Calf, UNK= Unknown

Fig 23. Percentage frequency of age and sex classes of gaur in Southern region

Table 85. Sex ratio gaur in Southern and Northern regions

Sex/class	Southern Region	Northern Region
	Sex ratio	
Adult male : Adult female	1: 3.49	1: 2.82
Sub-adult male : Sub-adult female	1: 2.82	1: 85.00
Over all	1: 3.31	1: 4.24



AM= Adult male, AF= Adult female, SAM= Sub adult male,
SAF= Sub adult female, JUV= Juvenile, CAL= Calf, UNK= Unknown

Fig 24. Percentage frequency of age and sex classes of gaur in Northern region

Sambar

A total of 637 animals were sighted in 231herds in Southern region. The herd size observed ranged from 1 to 11 (Fig 25).

In Northern region, a total of 128 individuals were sighted in 41 herds. The herd size to ranged from 1 to 11 (Fig 26). Only 27 animals in 9 herds were sighted in Central range. The herd size varied from 1 to 13 (Fig27).

In Southern region, adult females (42.86%) formed a major portion of the population followed by adult males (40.97%). The juvenile females were 7.06%, juvenile male 5.56% and fawns 2.83% of the population (Table 86 and Fig 28). The adult females dominated the population (60.94%) followed by adult male (26.56%) in Northern region also. The juvenile females were only 6.25% of the population. The percentage of fawns were only 1% of the population (Table 87 and Fig 29).

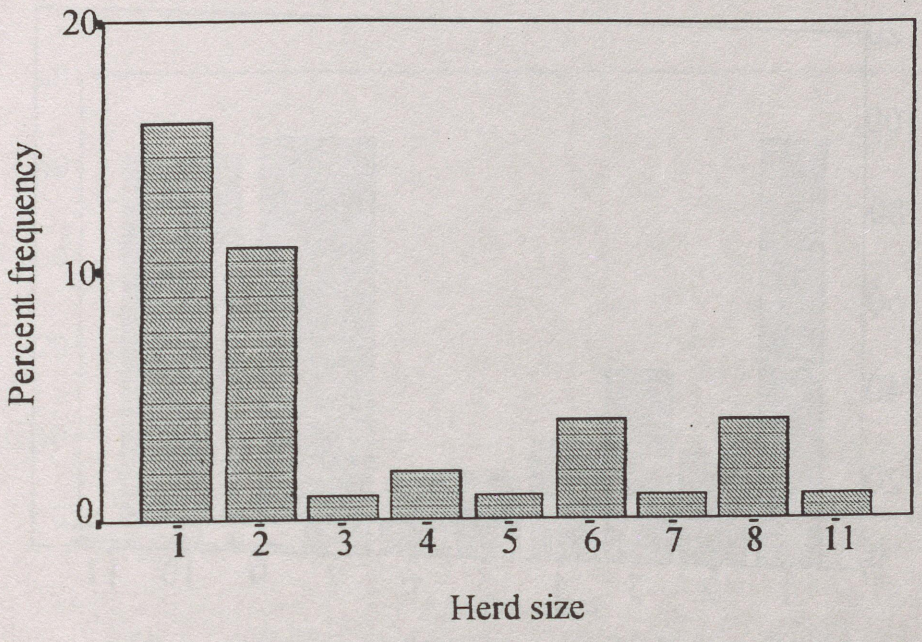


Fig 25. Percent frequency distribution of herd size of sambar in Southern region

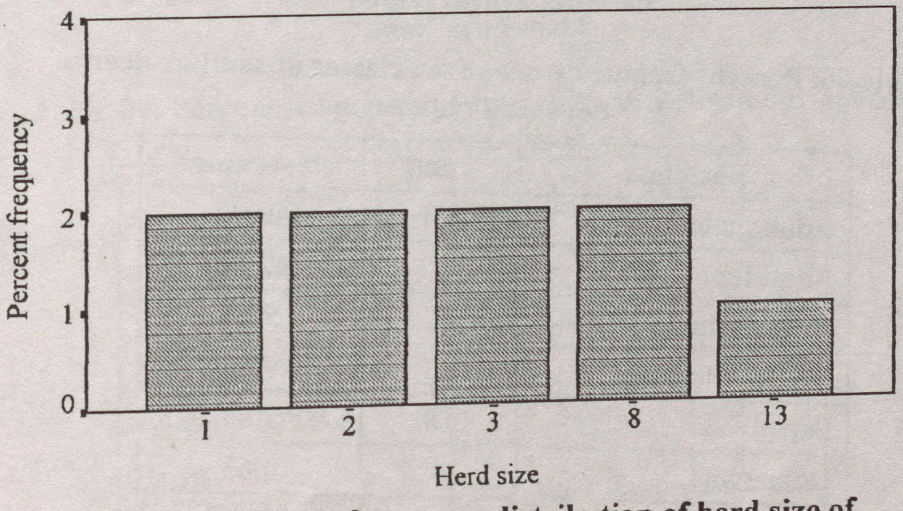


Fig 26. Percentage frequency distribution of herd size of sambar deer in Northern region

In Central ragion, adult females formed a major portion of the population (78.05%) followed by adult males (9.76%) and juvenile females (9.76%) and fawns are nearly 2.44% of the population (Table 88 and Fig 30).

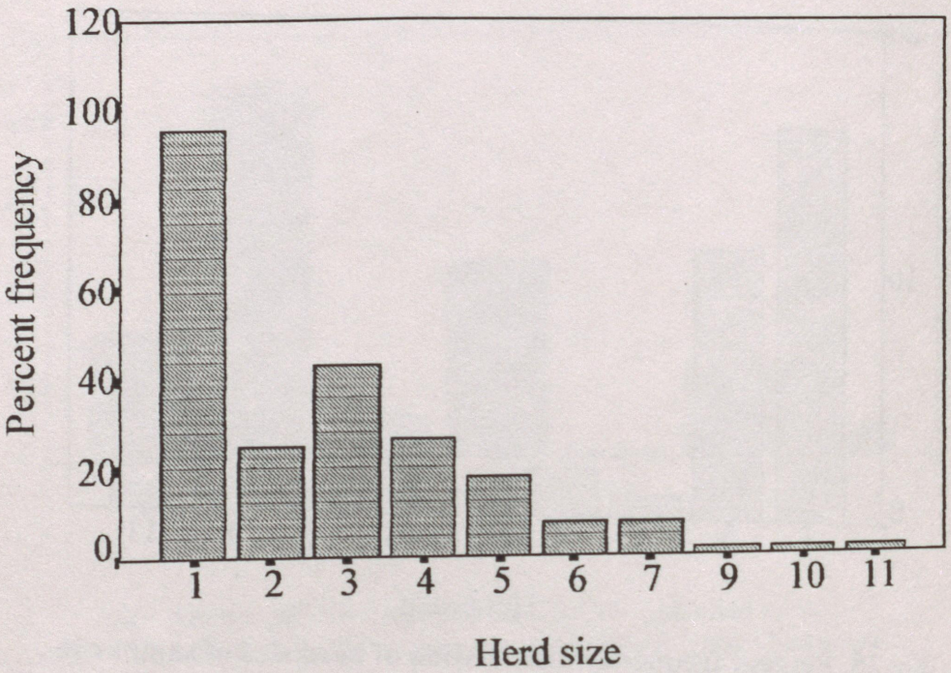
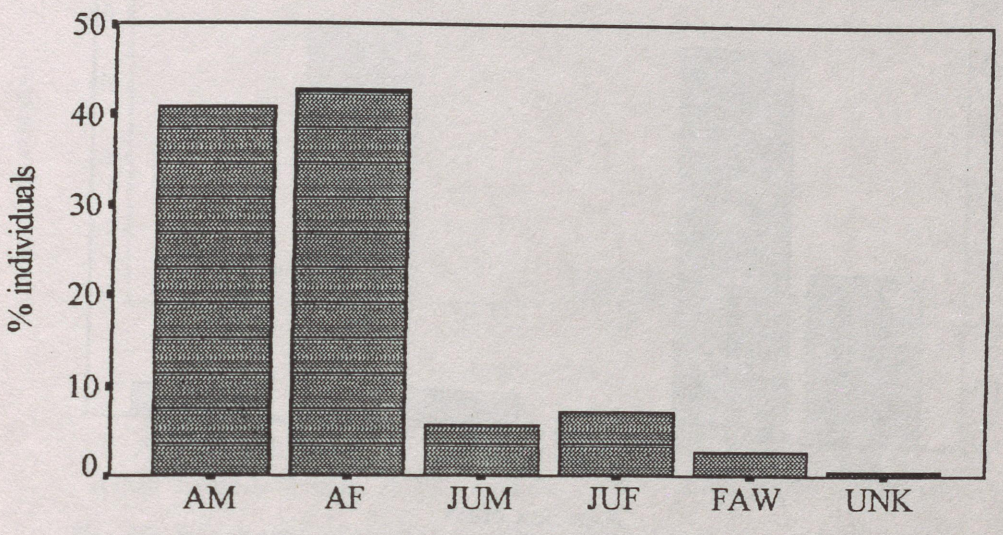


Fig 27. Percentage frequency distribution of herd size of sambar deer in Central region

Table 86. Percent frequency of age sex classes of sambar deer in Southern region

Sex/class	Total	Percentage
Adult male	261	40.97
Adult female	273	42.86
Juvenile male	36	5.65
Juvenile female	45	7.06
Fawn	18	2.83
Unknown	4	0.63
Total	637	100.00

Overall sex ratio of sambar in Southern region was 1: 1.07. It was 1: 2.53 and 1: 9 in Northern and Central regions respectively. Adult male to adult female sex ratio was 1: 1.05 in Southern, 1: 2.29 in Northern and 1: 8 in Central region (Table 89).



AM= Adult male, AF= Adult female, JUM= Juvenile male,
JUF= Juvenile female, FAW= Fawn, UNK= Unknown

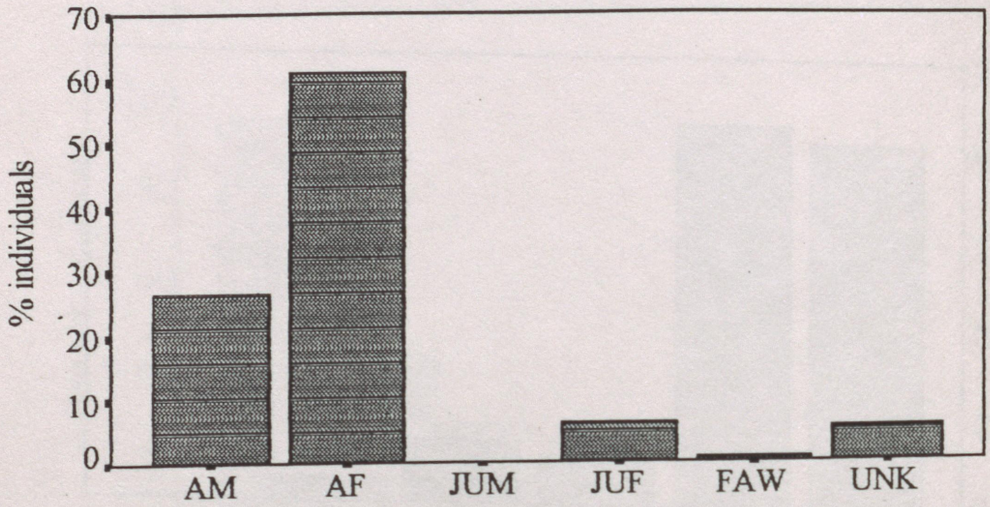
Fig 29. Percentage frequency of age and sex classes of sambar deer in Southern region

Table 87. Percent frequency of age sex classes of sambar deer in Northern region

Sex/class	Total	Percentage
Adult male	34	26.56
Adult female	78	60.94
Juvenile male	0	0.00
Juvenile female	8	6.25
Fawn	1	0.78
Unknown	7	5.47
Total	128	100.00

Spotted deer

A total of 1891 animals in 286 herds were sighted in Southern region during the study. This was 1810 in 69 herds in Northern and 188 in 38 herds in Central region.



AM= Adult male, AF= Adult female, JUM= Juvenile male,
JUF= Juvenile female, FAW= Fawn, UNK= Unknown

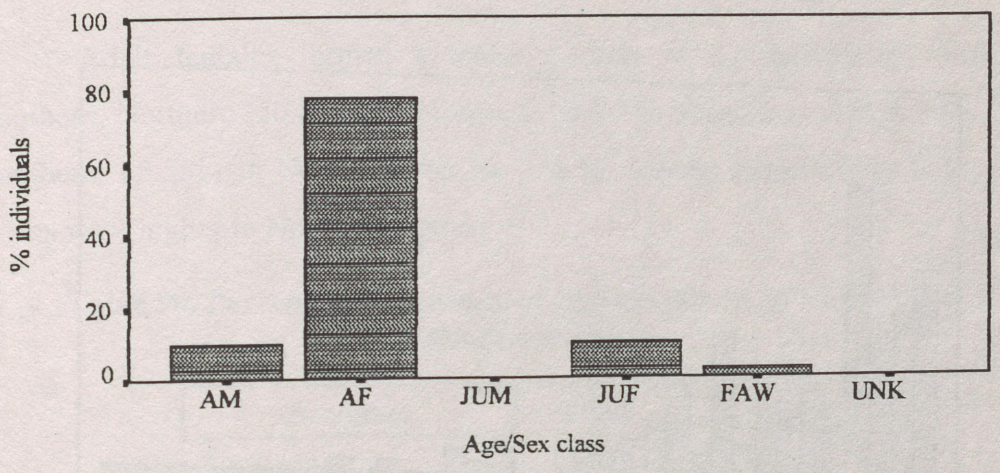
Fig 29. Percentage frequency of age sex classes of sambar deer in Northern region

Table 88. Percentage frequency of age sex classes of Sambar deer in Central region

Sex/class	Total	Percentage
Adult male	4	9.76
Adult female	32	78.05
Juvenile male	0	0.00
Juvenile female	4	9.76
Fawn	1	2.44
Unknown	0	0.00
Total	41	100.00

Table 89. Sex ratio sambar deer in different region in Wayanad

Sex/class	Southern Region	Northern Region	Central Range
	Sex ratio		
Adult male : Adult female	1: 1.05	1: 2.29	1: 8.00
Juvenile male: Juvenile female	1: 1.25	**	**
Over all	1: 1.07	1: 2.53	1: 9.00



AM= Adult male, AF= Adult female, JUM= Juvenile male,
JUM= Juvenile female, JUV= Juvenile, FAW= Fawn, UNK= Unknown,

Fig 30. Percentage frequency of age sex classes of sambar deer in Central region

Percentage frequency distribution of herd size in the Southern, Northern and Central regions are given in Figures 31, 32 and 33. The herd size was found to range from 1 to 26 in Southern region, 1 to 88 in Northern and 1 to 12 in Central regions.

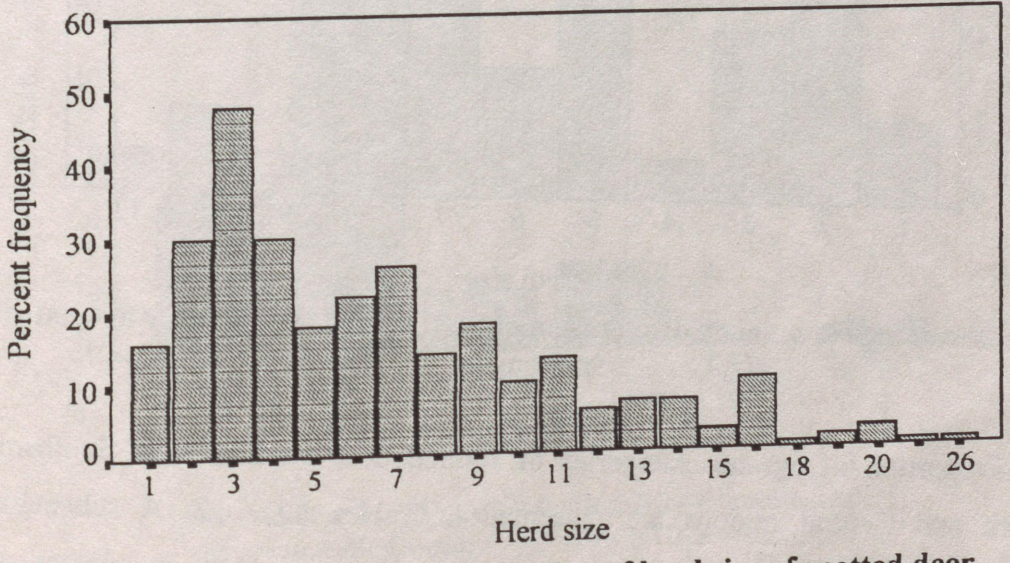


Fig 31. Percent frequency distribution of herd size of spotted deer in Southern region

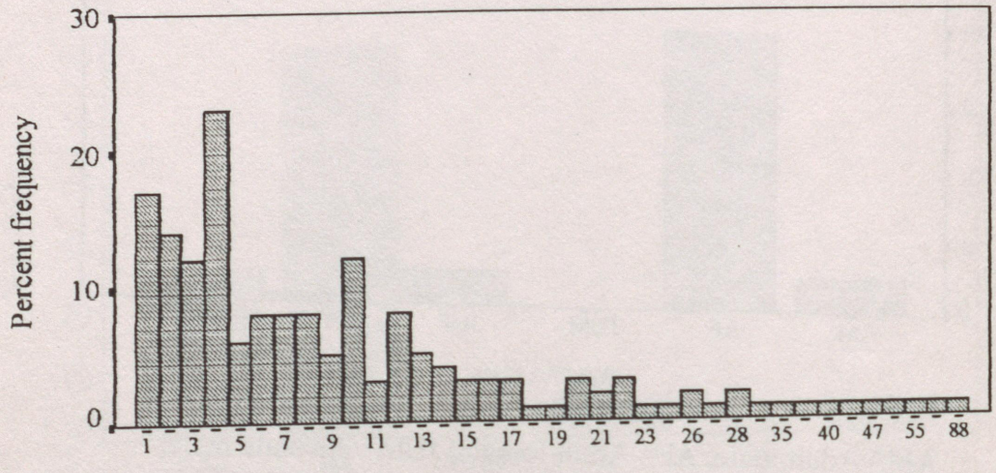


Fig 32. Percentage frequency distribution of herd size of spotted deer in Northern region

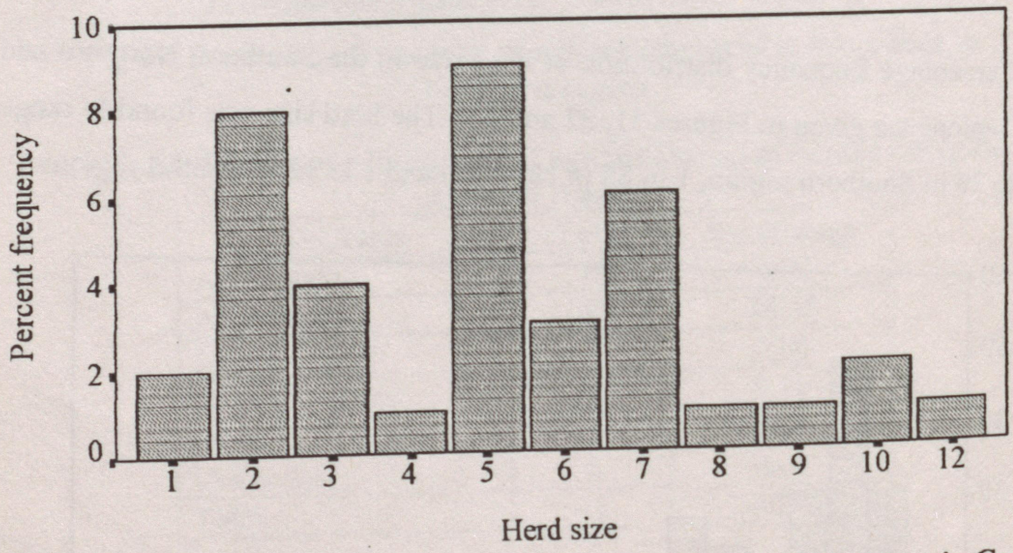


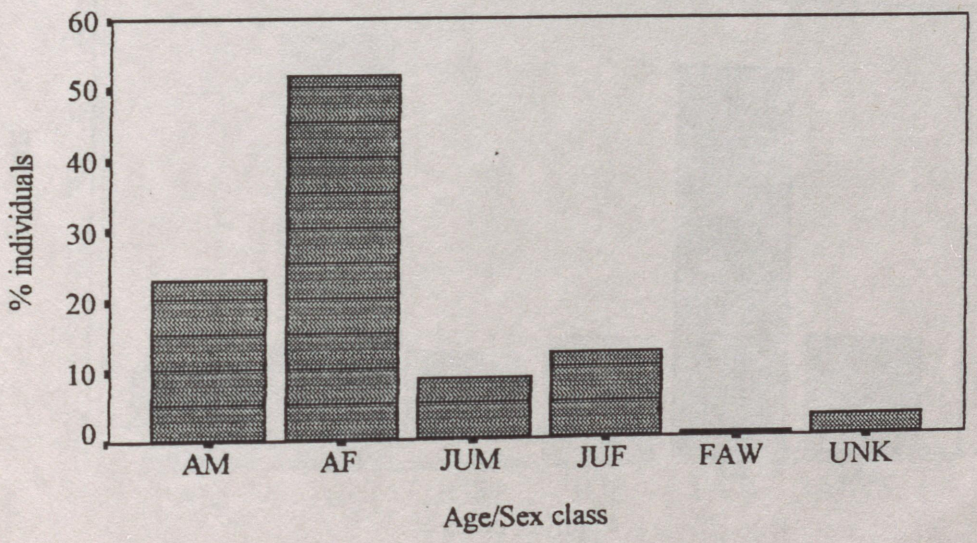
Fig 33. Percentage frequency distribution of herd size of spotted deer in Central region

Proportion of age-sex categories of spotted deer population in Southern, Northern and Central regions are presented in Tables 90 - 92. A schematic presentation of percentage frequency distribution of various age-sex classes of spotted deer in the regions is given in Figures 34, 35 and 36.

Adult females formed a major portion of the population (51.98%) in Southern, Northern (50.81%) and Central (60.64%). Adult males were about 23% in Southern, 15.58% in Northern and 16.49% in Central regions. The percentage of fawns were higher in Northern region.

Table 90. Percentage frequency of age sex classes of spotted deer in Southern region

Sex/class	Total	Percentage
Adult male	436	23.06
Adult female	983	51.98
Juvenile male	166	8.78
Juvenile female	234	12.37
Fawn	16	0.85
Unknown	56	2.96
Total	1891	100.00



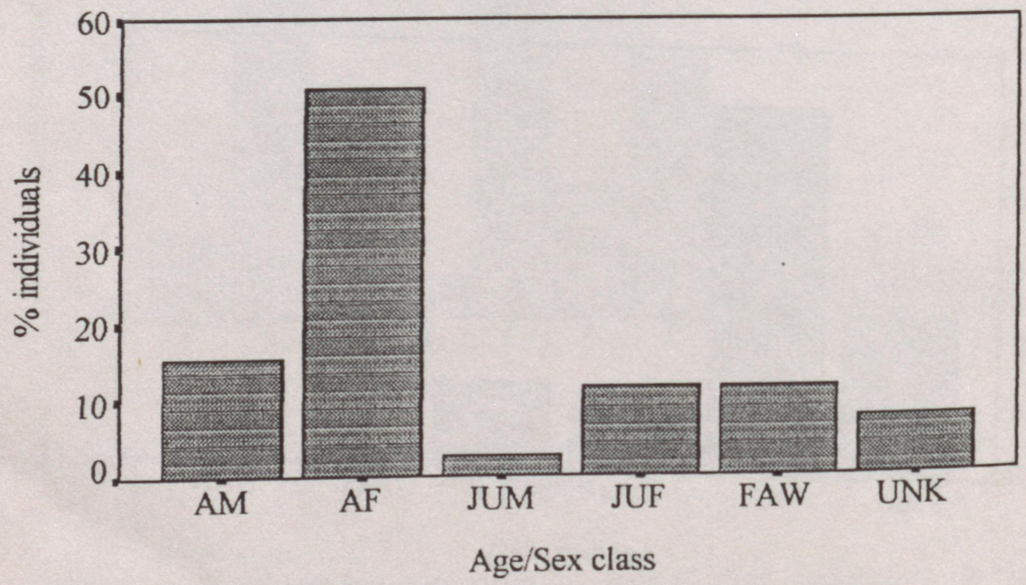
AM= Adult male, AF= Adult female, JUM= Juvenile male,
JUF= Juvenile female, FAW= Fawn, UNK= Unknown

Fig. 34. Percentage frequency of age and sex classes of spotted deer in Southern region

Table 91. Percentage frequency of age sex classes of spotted deer in Northern region

Sex/class	Total	Percentage
Adult male	282	15.58
Adult female	920	50.83
Juvenile male	48	2.65
Juvenile female	211	11.66
Fawn	211	11.66
Unknown	138	7.62
Total	1810	100.00

The sex ratio of spotted deer in Southern, Northern and Central regions are summarized in Table 93. The overall sex ratio was 1: 2.02 in Southern Region. Adult male to adult female was 1: 2.25 and juvenile male to juvenile female was 1: 1.41.



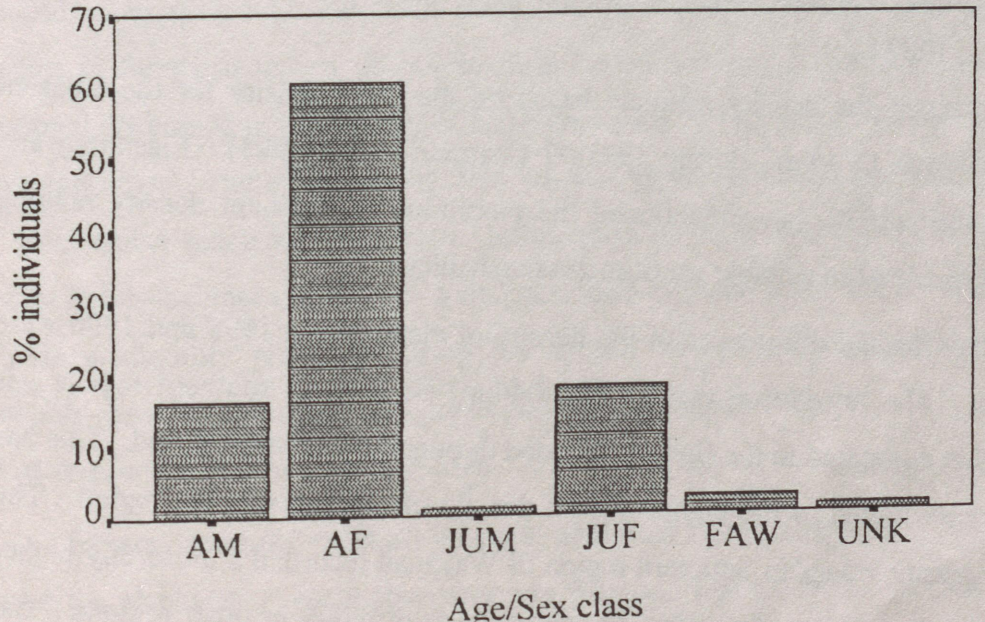
AM= Adult male, AF= Adult female, JUM= Juvenile male,
JUF= Juvenile female, FAW= Fawn, UNK= Unknown

Fig 35. Percentage frequency of age sex classes of spotted deer in Northern region

Table 92. Percentage frequency of age sex classes of spotted deer in Central region

Sex/class	Total	Percentage
Adult male	31	16.49
Adult female	114	60.64
Juvenile male	2	1.06
Juvenile female	34	18.09
Fawn	5	2.66
Unknown	2	1.06
Total	188	100.00

The sex ratio of 1: 3.43 was observed in Northern region. Adult male to adult female ratio was 1: 3.26 and juvenile male to female sex ratio was1: 4.40.



AM= Adult male, AF= Adult female, JUM= Juvenile male, JUF= Juvenile female, FAW= Fawn, UNK= Unknown

Fig 36. Percentage frequency of age sex classes of spotted deer in Central region

In Central region, overall sex ratio was 1: 4.48, adult male to adult female 1: 3.68 and juvenile male to juvenile female 1: 17.

Table 93. Sex ratio spotted deer in different regions in Wayanad

Sex/class	Southern Region	Northern Region	Central Range
	Sex ratio		
Adult male : Adult female	1: 2.25	1: 3.26	1: 3.68
Juvenile male : Juvenile female	1: 1.41	1: 4.40	1: 17.0
Over all	1: 2.02	1: 3.43	1: 4.48

Discussion

Density estimates

Density of elephants in all the regions showed annual differences .The estimate ranged from 1.02/km2 to 1.35/km2 in the Southern region. It was .26 to0.92 in Northern and 0.53 to 0.85 in Central region The crude density in Southern region was comparatively higher than reported for other areas (Sukumar,1985; Nair,*et. al* 1985; Easa, 1989 b)

However, the density estimate based on the dung density for the adjacent Mudumalai was 1.74/km2 during 1991-92 (Varman *et al.*, 1995). Eisenberg and Seindensticker (1976) have mentioned the possibility of elephant density ranging from 0.12 to 1/km2 in suitable south east Asian habitats.

The seasonal differences in the density of elephants in 1995 and 1996 were significant. The dry season density of 2.04/km2 in 1995 in southern region was much higher compared to the figures obtained throughout the study period. This has probably contributed to the higher overall density of elephants in the region. The seasonal density values in Southern region of Wayanad recorded a uniformly higher value in the dry season. However, the pattern was different in other regions. The dry season of 1995 and second wet season of 1996 had the highest density in Northern region. The central region had the highest density in first wet season. Studies in Africa (Buechner *et al.*, 1963; Leuthold, 1976b; Lewis 1987) and Asia

(Eisenberg and Lockhart 1972; Sukumar, 1985; Easa, 1989b; Sivaganesan, 1991; Desai and Baskaran, 1996) have shown the influences of food and water availability on density distribution of elephants. Seasonal distribution is also influenced by a number of proximate factors (Lamprey *et al.*, 1967; Bell, 1971; Jarman and Jarman, 1973; Western and Lindsay, 1984; Lamprey, 1985; Dublin and Douglas-Hamilton, 1987).

Varman *et al.*, (1995) reported a decrease in density of elephants in the adjacent Mudumalai during dry season and an increase in the subsequent wet season. The drying up of water sources in Mudumalai and Bandipur areas along with frequent occurrence of fire could be the factors leading to a higher density of elephants in Southern region during the dry season. This could be especially true in the wake of the extensive fire in Mudumalai and Bandipur in 1995. The perennial streams in the study area – Mavinhalla, Nulpuzha and Kurichiat thodu provide much needed water source for elephants during the pinch period in dry season. Density figures in Southern region do not seem to be influenced by the food availability Seasonal difference in the density of elephants in the Northern region within an year was significant. The difference in 1996 was not very evident though the dry season of 1995 had a much higher density. Information on food availability in Northern region indicate direct correlation with grass food availability in 1995. The higher browse availability recorded during the second wet season in Northern region probably explain the uniform density in different seasons in 1996.

Herd size, composition and structure

Several authors (< biblio >) have described the matriarchal social set up among the elephants. Present observation in Wayanad that the herds are centered on females along with sub-adults and juveniles confirms these findings.

Herd size is a measure of the ecological health and larger herd size reflects stressful condition (Laws, 1974). Eltringham (1977) has reported possibilities of larger herd size due to poaching pressure. Herd size frequency of elephants in the

Southern region showed a polymodal distribution with peaks occurring at 5, 9 and 14 with several minor peaks. The peaks were at 3,5 and 7 in Northern region. Similar observations have been reported for African (Laws, 1969; Laws *et al.*, 1975) and Asian elephants (Sukumar, 1985; Daniel *et al.*, 1987; Easa, 1989b). Smaller herds frequented more in the study area could be the reflection of the forested habitats (Peak *et al.*, 1974; Leuthold, 1976b). The least frequented larger herd size could be aggregation of different family units forming extended family (Laws *et al.*, 1975) and have no long-term cohesion (Ishwaran, 1984).

All male herds (bachelor herds) were not frequented in the study area. A herd of two males was observed only once in Southern region and a herd of three adults were observed once in Central region. Large sized male herds have been reported from Lake Manyara (Douglas-Hamilton, 1972), Murchison Falls (Laws *et al.*, 1975) and Seronera (Croze, 1974). McKay (1973) reported all male herds of 7 individuals in Lahugala in Sri Lanka. Sukumar (1985) observed such herds in his study area. Large sized all male herds could be an indication of the higher number of bulls in the population (Croze, 1974). Fewer occurrence of all male herds in the population could probably be an indication of the low proportion of males in the study area. The overwhelming proportion of solitary bulls could also be pointing to the low male proportion in the population in Wayanad Wildlife Sanctuary.

Gaur is a gregarious animal and the group is centered on the adult females (Vairavel, 1998). Proportion of solitaries in Southern region was higher compared to Northern region. Most of these were males. The tendency of bulls to be solitaries is considered to be a property of males of the genus *Bison* (Krasinska and Krasinski, 1978). However, observations in Parambikulam have also indicated a higher proportion of males among the solitaries of the *Bos* sp.. The most frequented group size of gaur in Southern region was 2, 3, 7 and 8 and in Northern region 2 and 7. However, largest herd size of 26 and 30 were observed the Southern and Northern

regions respectively. The larger groups could be aggregations of smaller units probably due to the environmental factors in these areas.

Sambar deer is considered to form small groups (Schaller, 1967). Herd size in different regions of Wayanad vary considerably where the solitaries dominate in the southern and northern regions. Solitaries formed about 60% of the sightings in Wilpattu National Park (Eisenberg and Lockhart 1972), 36% in Bandipur (Johnsingh, 1980), 48% in Periyar (Ramachandran *et al.*, 1980) and 25% in Parambikulam (Easa, unpublished information).

The average group size of chital at Kanha was between 5 and 10, and the largest group was of about 175 animals (Schaller, 1967). The more frequented groups in Chitwan National Park in Nepal were of 6-10 individuals and the largest group had 40 animals. (Seidensticker, 1976).The larger group sizes observed in Northern region could be aggregations during lean period.

Sex Ratio

Downing (1980) considered sex ratio as a measure of reproductive performance of the population. Sukumar (1989) has discussed in detail the possible influence of disparate sex ratio on the fertility of the population. Most mammalian populations are reported to have an adult sex ratio biased towards females. This has been attributed to the higher natural mortality of males. The dynamics of large mammal population are influenced by stochastic environmental protuberating long term population cycles (Wu and Botkin, 1980; Croze *et al.*, 1981). Advantages of the polygynous mammals have been discussed by Clutton-Brock *et al.*, (1982). Sukumar (1989) suggested that the operational adult sex ratio need not be as disparate as observed sex ratio in the elephant population. Further, considering the non seasonality of breeding in elephants, a disparate sex ratio can still ensure mating of almost all mature females. Cowan (1950) and Clutton-Brock *et al.* (1982) have mentioned a female biased adult sex-ratios in population close to carrying capacity.

Proportion of different age-sex classes in the elephant population in Wayanad indicates a shift towards the older age classes with adult, sub-adult and juvenile females contributing maximum. The calves form only 8.13% and 9.8% of the population in the two regions indicating a low recruitment or reduced number of breeding females. These could be normally taken as a negative trend in the population growth rate. However, conclusions arrived from the observed age distribution have been strongly criticized (Caughley, 1974 & 1977). Sukumar (1989) also showed the unreliability of such interpretation of age ratio without information on other parameters such as fertility and mortality rates. The sex ratio at stable age distribution depends on the magnitude of difference in mortality rate of male and female elephants (Sukumar, 1989).

The mortality figures for Mudumalai and Eastern Ghats have been reported to be 1.2% for adult-females and 14.5% for adult-males (Daniel *et al.*, 1987). Sukumar (1985) reported a mortality of 1.7% for females and 11.84% for males. The present observation of 3.28% and 29.17% for females and males respectively in the Southern region is considerably higher. Mortality was higher during summer. Observations also indicate a higher male mortality in summer in the region. This coincided with higher density within the area. Further, evidences from studies on cervids and sheep predict that adult or adolescent males are more likely to die during periods of food shortage than females of same age in several dimorphic species (Robinette *et al.*, 1957; Klein, 1968; Grubb, 1974). Increased human pressure leading human-elephant conflict could also be contribution to the problems as evident from the causes of mortality.

The increased density during dry season, decreased availability of quality forage during the period and the low percentage of area available – all exert pressure on the elephant population in Wayanad. Mortality rate was high during the dry season. Sukumar (1985) attributed 20% of the female and 65% of the male mortality

in South India to human beings. Daniel *et al.* (1987) reported 80.7% of the mortality due to human interference. In the Southern region, 11.54% of the mortality of males were due to poaching and 23.1% due to human-elephant conflict. In fact, these figures could be underestimates since the post mortem often fails to diagnose or pinpoint the cause of death since the carcass would be putrefied making it difficult to collect parts for laboratory examination. About 90% of the tusker carcasses examined had bullet injuries inflicted either during crop raiding or due to poaching attempts. Six out of 17 adult and sub adult tuskers observed in May, 1995 had bullet injuries.

The fertility rate of 0.19 per adult-female per year or a mean calving interval of 5.1 years have been calculated for the study area. Estimated mortality was 8.43% for males compared to 2.04% for females. Mortality was higher in the 7-10 years sub-adult category in both the males and females. Sukumar (1989) used simulation to predict population growth rate with different calving intervals. A high male–low female mortality with 1: 28.7 male-female sex ratio and calving interval of 5.5 years predict a growth rate of 1.08%. Sukumar (1989) suggested a possible widening adult sex ratio for a short term of about 5 years before narrowing down due to a higher mortality in the 7-10 and 10-15 age classes. As long as the female mortality is low, the population could still have capacity to increase or remain stable in spite of decreased fertility due to higher mortality rate (Sukumar, 1989). Considering the mortality of males in the population as high and those of females as low and with a mean calving interval of 5.19 years, the elephant population in Wayanad could be considered as healthy.

Schaller (1967) and Vairavel (1998) have reported distorted sex ratio of gaur, favouring females. This has been attributed to the high mortality rate among males (Krikrasinski, 1978; Vairavel, 1998) Adult females dominate the population of sambar deer in all the regions. Though there are variations in the proportion, the

number of adult males in the southern region is almost equal to adult female. Fewer numbers of fawns in the northern and central regions probably indicate slow recruitment to the population. Sex ratio of spotted deer in Chitwan was almost 1:1 (Seidensticker, 1976) and in Kanha, 1:1.4 (Schaller, 1967) Schaller (1967) attributed the disparate sex ratio to the selective predation on females. This seems to be true in the case of the populations in Wayanad, especially the Northern and Southern regions where the population is comparatively higher.

Considering the contiguity of Wayanad with larger extent of forests, the mammal population in the area could be considered as viable without the problems of loss of genetic variation. However, the deer population in the Central region is almost isolated and do not seem to be viable.

CHAPTER 7

DENSITY DISTRIBUTION AND HABITAT UTILIZATION OF SELECTED HERBIVORES

Introduction

Herbivore, especially the gregarious ones often respond to climatic changes and the resultant changes in the habitat by altering herd size and pattern of habitat utilization (McNaughton, 1985). Distribution pattern of large herbivores is influenced by resource availability such as food, shelter and water (Owen-Smith, 1988). Wild animals try to achieve the presumed goal of fitness maximisation by maintaining intake and avoiding environment stresses. This could be attained by selection of landscapes through migrations, home range placements or nomadism at behavioural frequencies of a few times in a year. Ranging behaviour of wild ungulates over wide geographical areas are normally in response to the temporal abundance and quality of forages (McNaughton, 1987). Watson and Moss (1970) have given examples to support that the dispersion of animals are related to food supply. Seasonal habitat selection has been reported in several species (Fuller, 1960; Shackleton, 1968; Shult, 1972; Dunckan, 1975; Owen-Smith, 1979; Krasinska *et al.*, 1987).

Methods

Density distribution

The methods followed for estimating the density of elephants in the study area is explained in detail in Chapter 6. The study area was divided into several blocks based on the vegetation types. Transects of 2 km length were laid in proportion to habitat size. Transects were placed at random so that they fall in areas along the border as well as inside the study area. These transects were covered in different seasons in 1994 and 1995, and the first two seasons in 1996. Information were collected on the indirect evidences (dung) of elephants (Barnes and Jensen, 1987).

Food availability

Food species of larger herbivores in the study area were identified through direct observation and by examination of feeding sites immediately after the animal left the location. The above ground biomass of food plants were estimated as follows:

The study area was divided into grids of 2 km^2 size on 1 : 50,000 scale topo sheets. These grids were identified in the field and a transect of 500 m length laid in each grid. Plots of 5 m^2 were laid at 100 m interval for browse species biomass estimation and 1 m^2 at 50 m. interval for grass.

Plant species within the sample plots were cut and food species segregated (Boutton *et al.*, 1988). The food species were then weighed in the field. These were later oven dried at constant temperature till a constant weight was obtained and then weighed for dry weight. Care was taken to have such biomass plots in all vegetation types in proportion to the size. The biomass of the food species were later estimated using the formula suggested by Wiegert (1962).

Analysis

Density distribution

The data from the blocks in the border areas were pooled and analysed for dung/pellet density estimates using computer program DISTANCE (Laake, *et al.*, 1994). Similarly, transect data for the interior areas were pooled together and analysed for the density estimates. Transect data from different habitats were also pooled together for density estimates in different habitats.

Food availability

The biomass data from the plots for each habitat type were pooled separately and analysed for food availability estimation in different habitats.

Results

Seasonal distribution of elephants in different habitats

Southern Region

Dung density and estimated elephant density in Southern region in different vegetation types in 1995 and 1996 are given in Tables 94 and 95 and Figures 37 and 38. Elephant density was higher in dry deciduous forest in dry season in both 1995 and 1996. Moist deciduous had the highest density in first and second wet seasons.

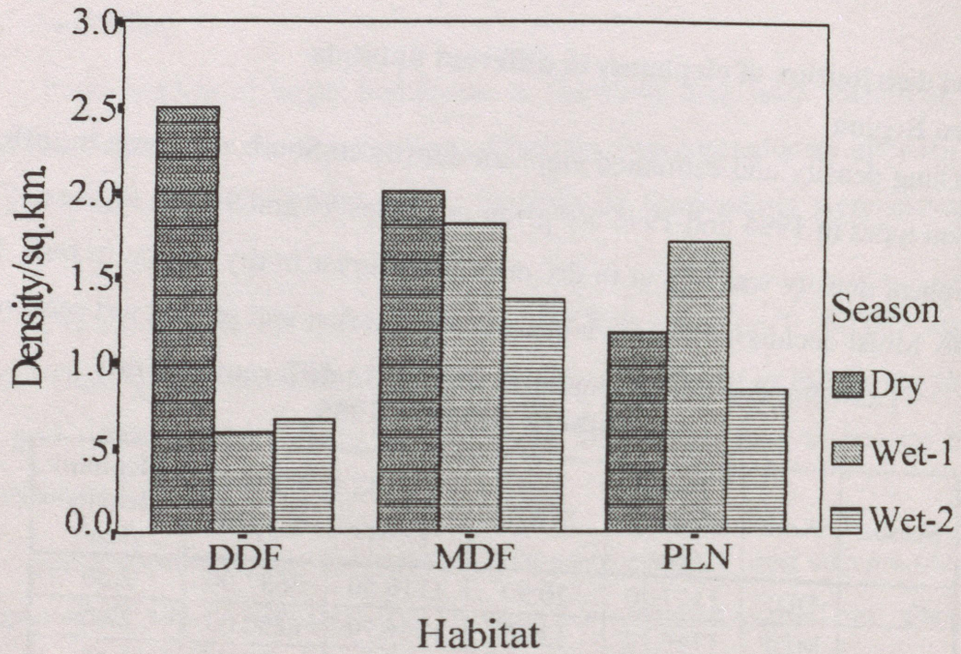
Table 94. Estimated elephants density in different habitats in Southern region in 1995

Season	Area	Dung density /km^2	% CV	95 % CI		Elephant density /km^2
				Lower	Upper	
Dry	DDF	2127.70	10.99	1716.50	2637.00	2.50
	MDF	1744.10	13.10	1346.70	2258.00	2.00
	PLN	1029.80	20.01	687.84	1541.00	1.18
Wet-1	DDF	127.03	14.59	94.87	170.00	0.59
	MDF	145.77	14.14	109.89	193.30	1.82
	PLN	136.79	18.57	93.87	199.30	1.71
Wet-2	DDF	303.03	11.18	242.78	378.20	0.67
	MDF	362.64	12.31	283.90	463.20	1.37
	PLN	226.29	21.82	144.49	354.40	0.85

DDF = Dry Deciduous Forests; MDF = Moist Deciduous Forests; PLN = Plantations

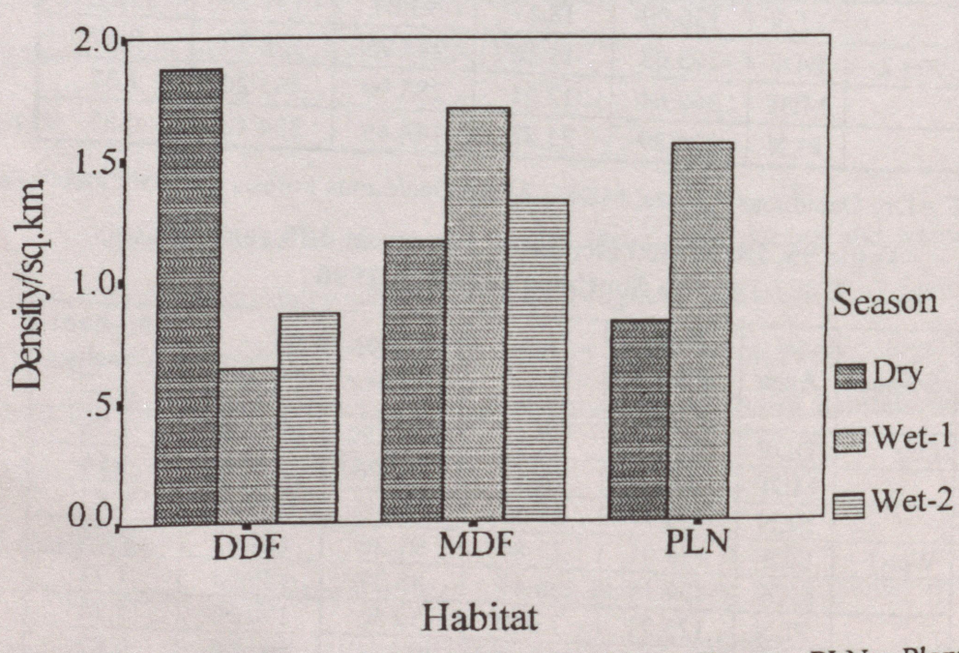
Table 95. Estimated elephants density in different habitats in Southern region in 1996

Season	Area	Dung density /km^2	% CV	95 % CI		Elephant density /km^2
				Lower	Upper	
Dry	DDF	1601.80	12.64	1251.50	2050.00	1.88
	MDF	1009.60	16.49	727.76	1400.00	1.16
	PLN	725.77	24.38	441.46	1193.00	0.83
Wet-1	DDF	138.04	23.87	91.26	184.82	0.64
	MDF	137.15	26.47	85.27	189.03	1.71
	PLN	125.21	33.49	59.56	190.86	1.56
Wet-2	DDF	395.44	20.41	262.40	595.94	0.87
	MDF	355.46	19.60	240.22	526.00	1.33



DDF = Dry Deciduous Forests; MDF = Moist Deciduous Forests; PLN = Plantations

Fig 37. Density of elephant in different habitat types in 1995 –Southern region



DDF = Dry Deciduous Forests; MDF = Moist Deciduous Forests; PLN = Plantations

Fig 38. Density of elephant in different habitat types in 1996 -Southern region

Northern Region

The estimated elephant density in Northern region (Tholpetty) in different vegetation types are given in Tables 96 and 97 and in Figures 39 and 40. Plantation areas had higher density in the dry season of 1995 where as moist deciduous recorded higher density in 1996. First and second wet seasons of 1995 recorded higher density in moist deciduous forests. There was no difference in elephant density between types in first wet season of 1996. However, there were marked differences in second wet season during the year.

Table 96. Estimated elephants density in different habitats in Northern region in 1995

Season	Area	Dung density /km^2	% CV	95 % CI		Elephant density /km^2
				Lower	Upper	
Dry	PLN	1349.30	48.45	519.20	3506.50	1.55
	MDF	125.00	40.82	47.83	326.70	0.14
Wet-1	PLN	61.91	45.61	23.78	161.17	0.77
	MDF	166.67	70.71	10.76	2581.10	2.08
Wet-2	PLN	85.50	27.33	48.84	149.67	0.32
	MDF	765.00	82.19	163.84	3572.00	2.88

MDF = Moist Deciduous Forests; PLN = Plantations

Table 97. Estimated elephants density in different habitats in Northern region in1996

Season	Area	Dung density /km^2	% CV	95 % CI		Elephant density /km^2
				Lower	Upper	
Dry	PLN	725.67	17.22	515.82	1020.90	0.83
	MDF	1411.70	19.37	959.45	2077.10	1.62
Wet-1	PLN	107.14	25.82	62.35	184.11	1.34
	MDF	111.11	35.36	50.36	245.17	1.34
Wet-2	PLN	208.33	18.90	141.95	305.76	0.78
	MDF	416.67	21.82	266.04	652.57	1.57

MDF = Moist Deciduous Forests; PLN = Plantations

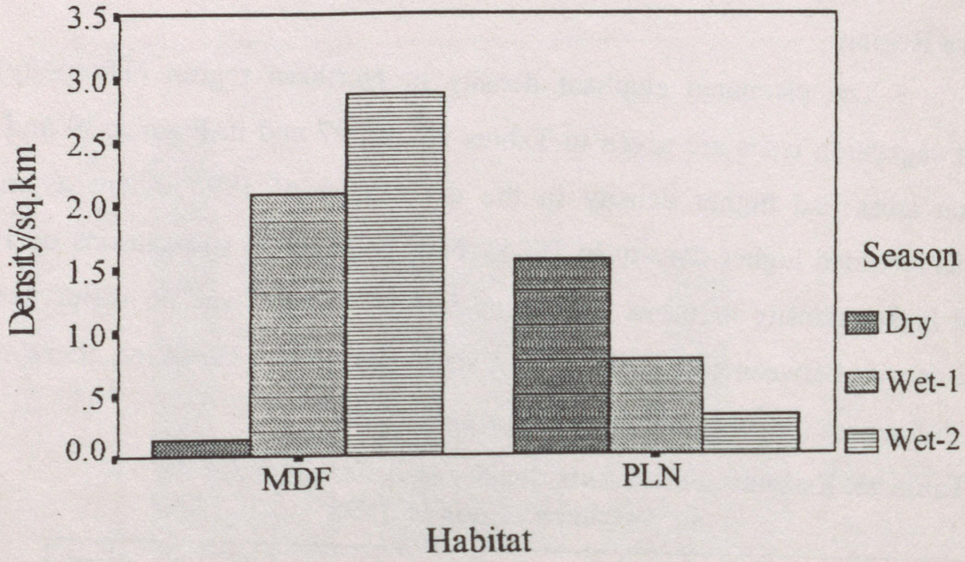
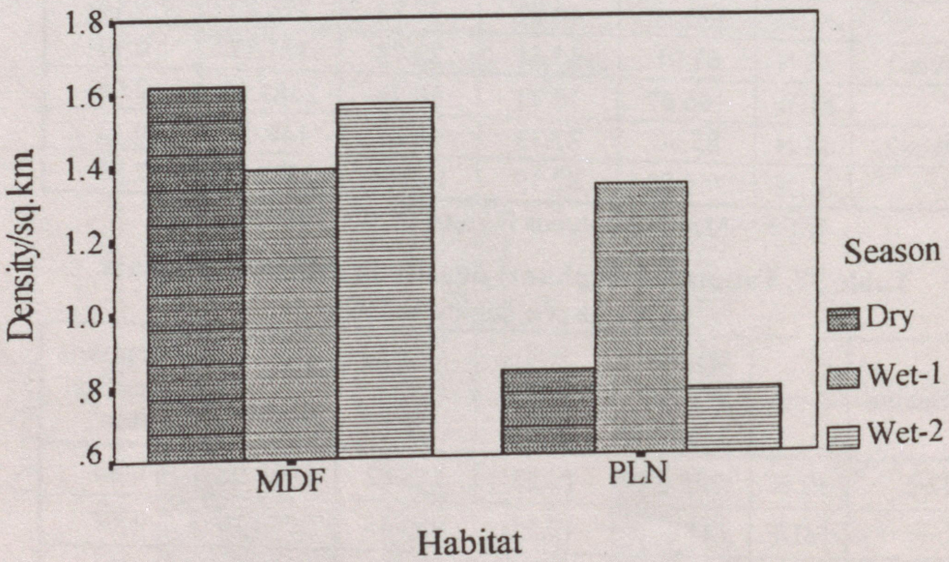


Fig 39. Elephant density in different habitat types in1995 in Northern region



MDF = Moist Deciduous Forests; PLN = Plantations

Fig 40. Elephant density in different habitat types in1996 in Northern region

Central Region

The estimated elephant density in different habitat types in the Central region is summarised in Tables 99 and 100. These are presented in Figures 41 and 42.

Elephant density was comparatively higher in moist deciduous forest in dry season and plantations in first wet season and second wet seasons in 1995. In 1996, moist deciduous had the higher density in dry and first wet seasons. Plantation had more elephants in second wet season.

Table 99. Density of elephants in different habitats in Central region in 1995

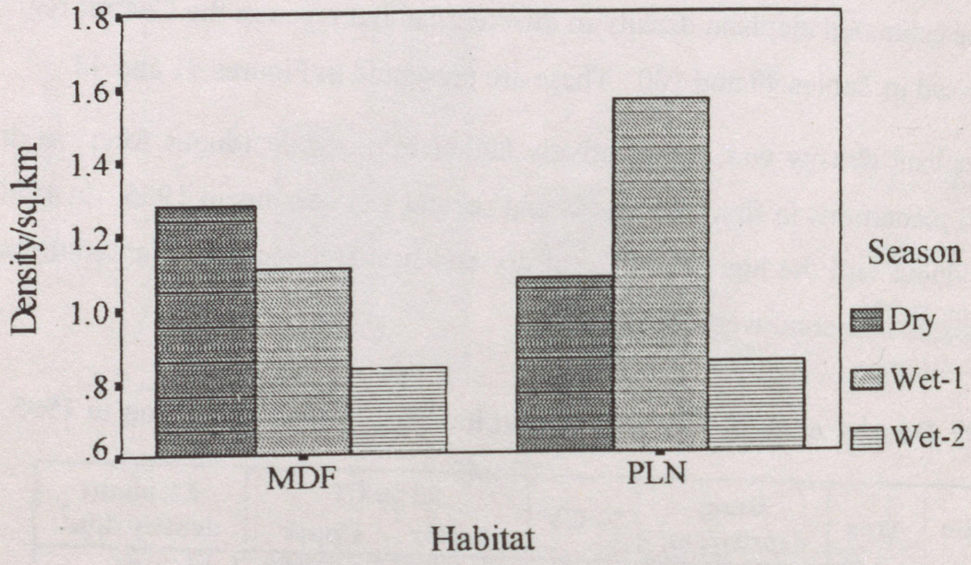
Season	Area	Dung density/km^2	% CV	95 % CI		Elephant density /km^2
				Lower	Upper	
Dry	PLN	946.55	16.72	678.69	1320.10	1.08
	MDF	1093.00	18.14	760.01	1572.00	1.25
Wet-1	PLN	125.00	26.73	71.16	219.58	1.56
	MDF	89.29	44.72	29.79	267.64	1.11
Wet-2	PLN	226.19	16.22	163.23	313.43	0.85
	MDF	223.21	20.00	148.44	335.66	0.84

MDF = Moist Deciduous Forests; PLN = Plantations

Table 100. Density of elephants in different habitats in Central region in 1996

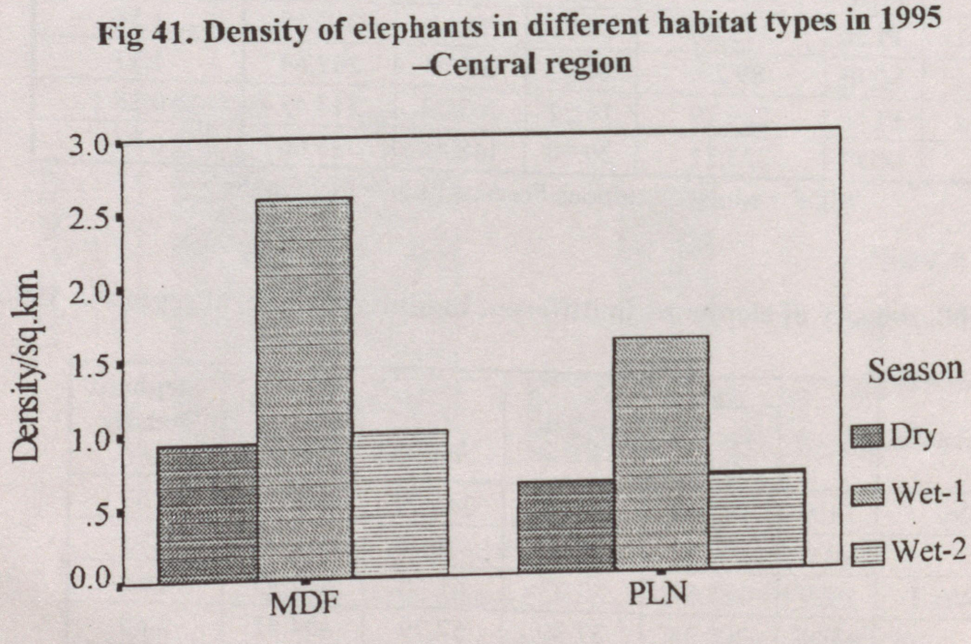
Season	Area	Dung density /km^2	% CV	95 % CI		Elephant density /km^2
				Lower	Upper	
Dry	PLN	547.41	22.65	345.94	866.21	0.63
	MDF	808.42	31.85	426.16	1533.60	0.93
Wet-1	PLN	128.57	33.33	61.70	267.93	1.60
	MDF	208.33	37.80	57.79	494.41	2.60
Wet-2	PLN	263.05	27.71	147.79	468.18	0.99
	MDF	178.57	44.72	59.57	535.28	0.67

MDF = Moist Deciduous Forests; PLN = Plantations



MDF = Moist Deciduous Forests; PLN = Plantations

Fig 41. Density of elephants in different habitat types in 1995 –Central region



MDF = Moist Deciduous Forests; PLN = Plantations

Fig 42. Density of elephants in different habitat types in 1996 –Central region

Seasonal distribution of gaur in different habitats

Southern Region

The dung density of gaur in Southern region in different vegetation types in 1995 and 1996 are given in Tables 101 and 102 and Figures 43 and 44.

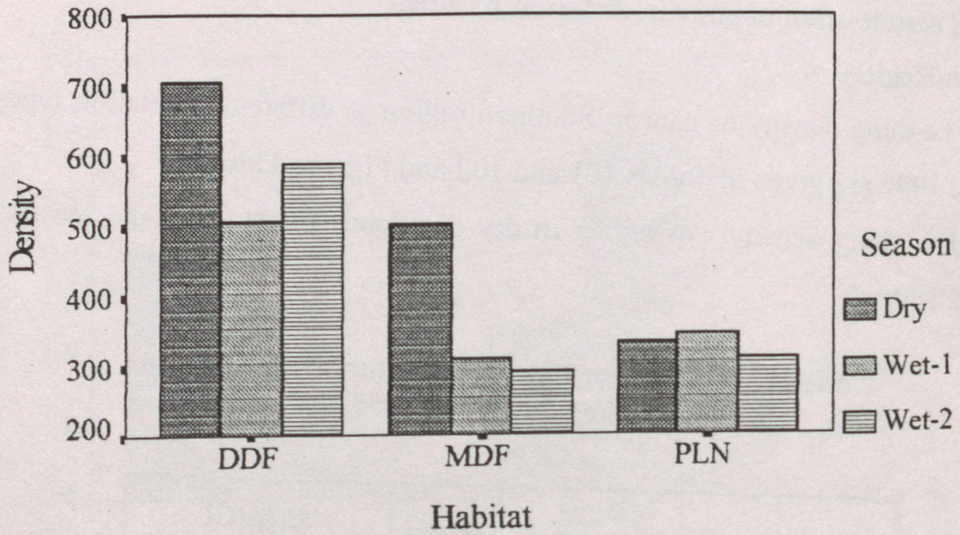
Gaur dung density was higher in dry deciduous forest in all the seasons in 1995 and 1996.

Table 101. Gaur dung density in different habitats in Southern region in1995

Season	Area	Dung density/km^2	% CV	95 % CI	
				Lower	Upper
Dry	DDF	708.11	20.93	417.62	998.60
	MDF	502.70	22.16	284.36	721.04
	PLN	332.84	27.35	154.42	511.26
Wet-1	DDF	508.19	24.99	259.28	757.10
	MDF	311.32	32.91	110.51	512.13
	PLN	345.54	25.90	170.13	520.95
Wet-2	DDF	590.06	28.10	265.08	915.04
	MDF	294.40	25.94	144.72	444.08
	PLN	310.00	27.72	141.55	478.45

Table 102. Gaur dung density in different habitats in Southern region in 1996

Season	Area	Dung density/km^2	% CV	95 % CI	
				Lower	Upper
Dry	DDF	556.35	20.43	333.57	779.13
	MDF	432.48	22.75	239.64	625.32
	PLN	291.10	28.93	126.04	456.16
Wet-1	DDF	600.12	24.23	315.12	885.12
	MDF	216.28	26.27	104.92	327.64
	PLN	231.91	24.44	120.82	343.00
Wet-2	DDF	644.99	25.89	378.43	1099.3
	MDF	478.01	26.40	277.65	822.98



DDF = Dry Deciduous Forests; MDF = Moist Deciduous Forests; PLN= Plantations.

Fig 43. Density of gaur dung in different habitat types in1995 Southern region

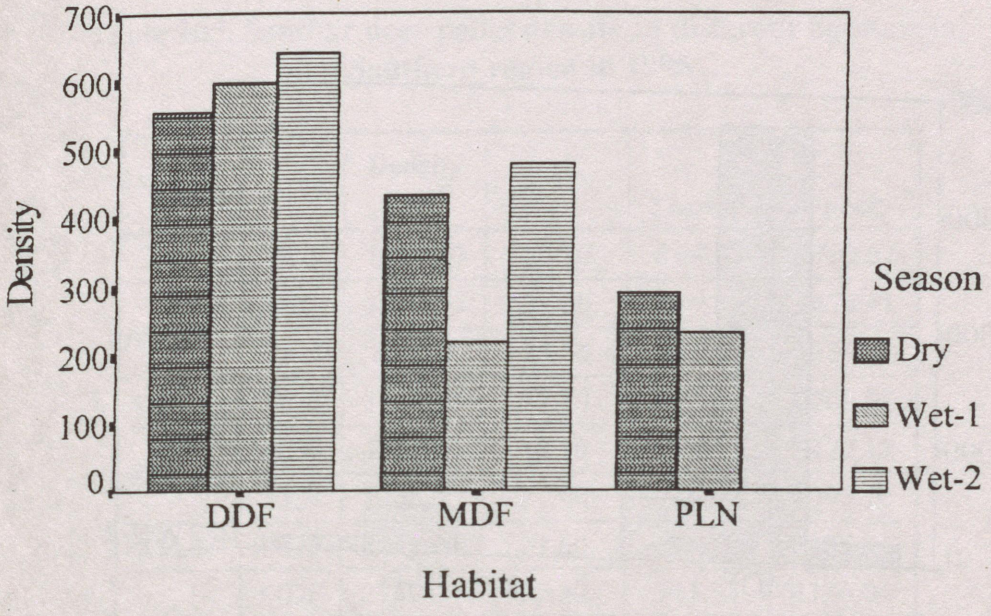
Northern Region

The gaur dung density in Northern region in different vegetation types in 1995 and 1996 are given in Table 103 and 104 and Figures 45 and 46.

Dung density of gaur was higher in moist deciduous forest in first wet and second wet seasons of 1995 and dry, first and second wet seasons of 1996.

Table 103. Gaur dung density in different habitats in Northern region in1995

Season	Area	Dung density /km^2	% CV	95 % CI Lower	Upper
Dry	MDF	208.33	37.80	87.788	494.41
	PLN	-	-	-	-
Wet-1	MDF	3764.3	83.50	372.05	38086.0
	PLN	423.22	53.86	135	1325.4
Wet-2	MDF	542.09	49.51	187.98	1563.2
	PLN	133.93	57.74	24.303	738.04



DDF= Dry Deciduous Forest; MDF = Moist Deciduous Forests; PLN = Plantations

Fig 44. Density of gaur dung in different habitat types in 1996 - Southern region

Density of sambar deer pellets in different habitats

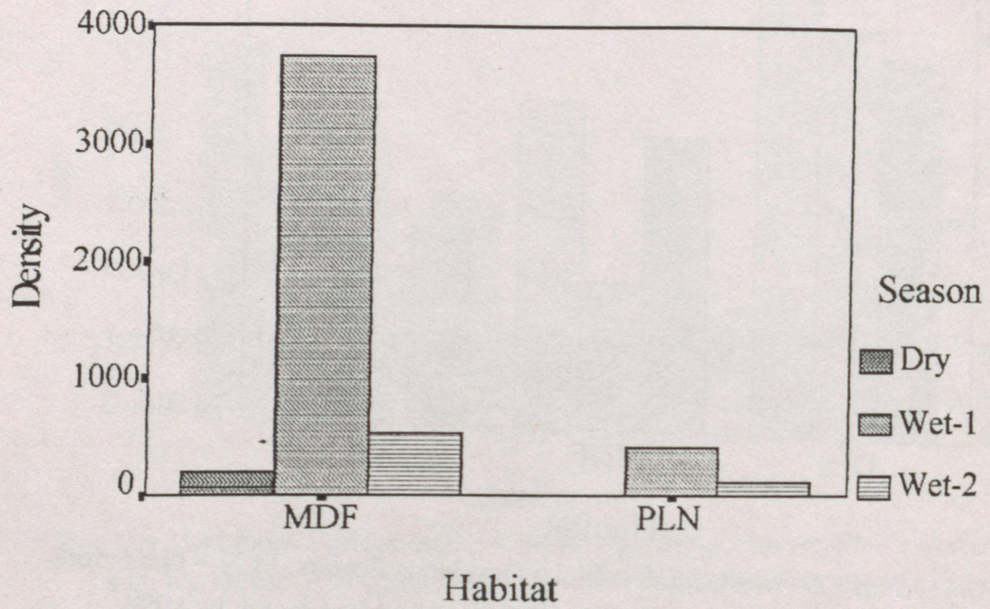
Southern Region

Pellet density of sambar deer in 1995 and 1996 in Southern region are given in Tables 105 and 106, and Figures 47 and 48. Higher density was recorded in dry deciduous forest in dry season and second wet season. Pellet density was comparatively higher in moist deciduous in first wet season in 1995. Density of sambar deer was more in moist deciduous forest in all the seasons in 1996.

Table 104. Gaur dung density in different habitats in Northern region in1996

Season	Area	Dung density /km^2	% CV	95 % CI Lower	Upper
Dry	MDF	211.27	35.12	98.816	451.70
	PLN	353.97	54.52	111.64	1122.3
Wet-1	MDF	16.502	50.00	4.4466	61.239
	PLN	216.35	33.33	103.82	540.84
Wet-2	MDF	167.21	67.08	24.038	1163.1
	PLN	833.58	32.95	418.66	1659.7

MDF = Moist Deciduous Forests; PLN = Plantations



MDF= Moist Deciduous Forest, PLN= Plantations

Fig 45. Density of gaur in Northern region in different habitat types in 1995

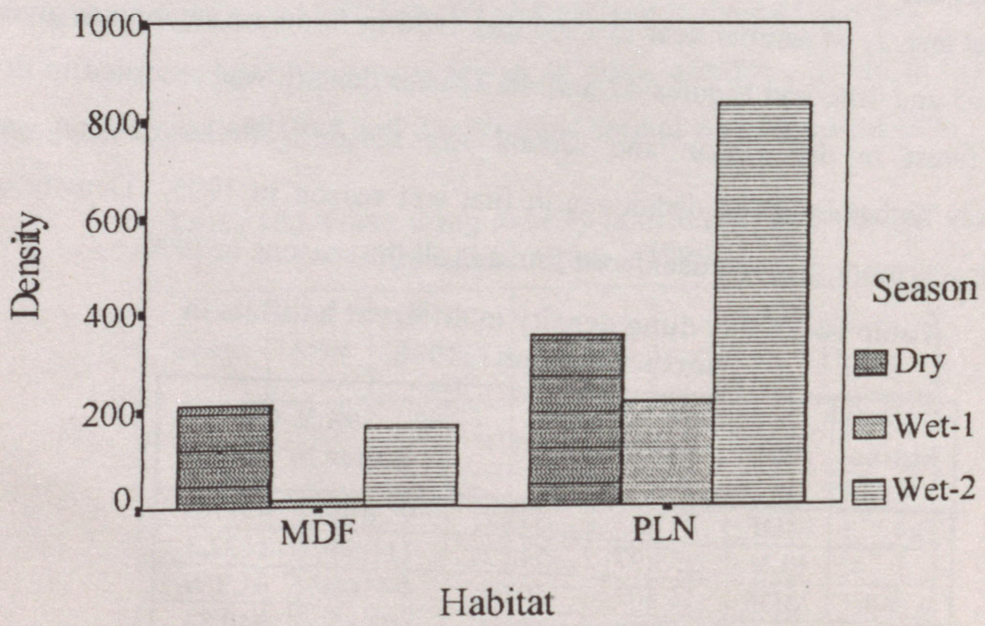


Fig 46. Density of gaur in Northern region in different habitat types in 1996

Table 105. Sambar deer pellet density in different habitats in Southern region in 1995

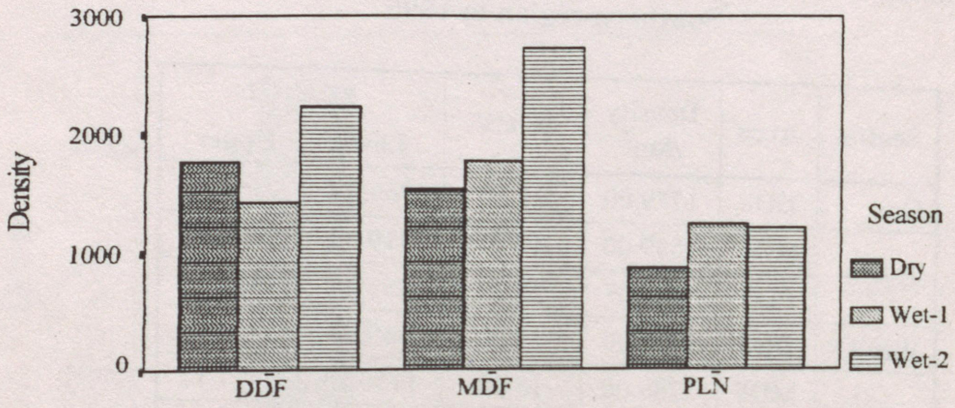
Season	Area	Density /km^2	% CV	95 % CI	
				Lower	Upper
Dry	DDF	1779.00	29.10	764.33	2793.67
	MDF	1549.00	37.20	419.59	2678.41
	PLN	895.20	25.30	451.29	1339.11
Wet-1	DDF	1435.00	27.20	669.97	2200.03
	MDF	1789.00	18.20	1150.83	2427.17
	PLN	1255.00	21.90	716.30	1793.70
Wet-2	DDF	2248.00	21.60	1296.29	3199.71
	MDF	2739.00	37.20	741.94	4736.06
	PLN	1230.00	39.60	275.32	2184.68

DDF = Dry Deciduous Forests; MDF = Moist Deciduous Forests; PLN = Plantations

Table 106. Sambar deer pellet density in different habitats in Southern region in 1996

Season	Area	Density /km^2	% CV	95 % CI	
				Lower	Upper
Dry	DDF	1008.20	28.98	435.53	1580.87
	MDF	1521.00	29.20	650.50	2391.50
	PLN	813.90	28.15	364.84	1262.96
Wet-1	DDF	1227.00	21.60	707.54	1746.46
	MDF	1581.06	23.00	868.32	2293.80
	PLN	747.90	46.40	67.73	1428.07
Wet-2	DDF	1213.20	34.21	578.15	2545.70
	MDF	1246.40	27.09	714.11	2175.50

DDF = Dry Deciduous Forests; MDF = Moist Deciduous Forests; PLN = Plantations



DDF = Dry Deciduous Forests; MDF = Moist Deciduous Forests; PLN = Plantations

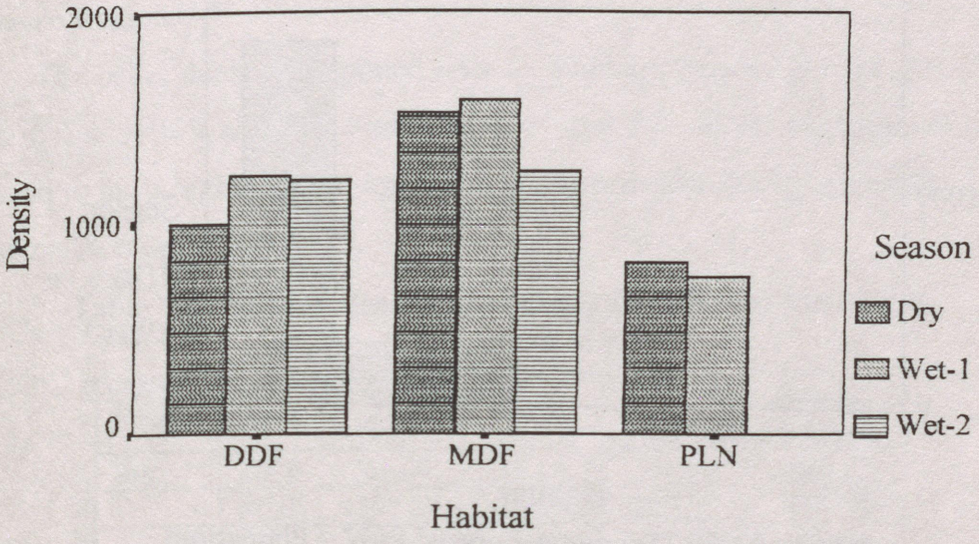
Fig 47. Density of sambar deer pellets in different habitats in 1995 - Southern region

Northern Region

The pellet density of sambar in Northern region in different vegetation types in 1995 and 1996 are given in Tables 107and 108, and Figures 49 and 50. Pellet density of sambar was high in teak plantation in dry and first wet seasons of 1995 and dry, first and second wet seasons of 1996.

Table 107. Sambar deer pellet density in different habitats in Northern region in 1995

Season	Area	Density /km^2	% CV	95 % CI	
				Lower	Upper
Dry	MDF	62.500	57.74	11.342	344.42
	PLN	239.42	86.60	9.5761	5986.1
Wet-1	MDF	20.833	100.00	.53040E-03	.81831E+06
	PLN	224.13	115.47	.18669E-02	.26909E+08
Wet-2	MDF	-	-	-	-
	PLN	1662.3	141.42	213.06	1296.9.0

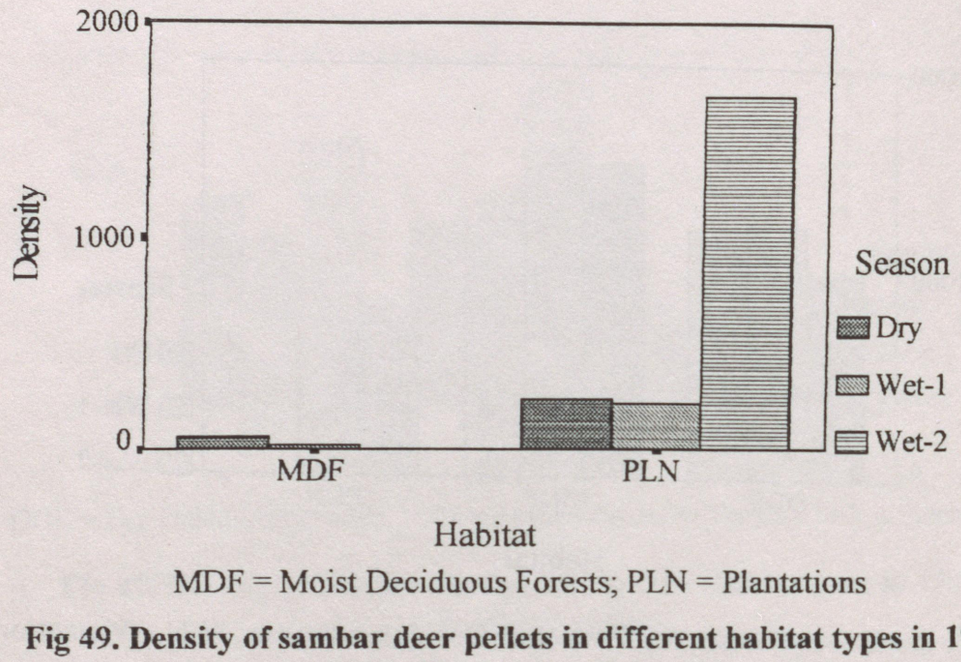


DDF = Dry Deciduous Forests; MDF = Moist Deciduous Forests; PLN = Plantations

Fig 48. Density of sambar deer pellets in different habitats in 1996 - Southern region

Table 108. Sambar deer pellet density in different habitats in Northern region in 1996

Season	Area	Density /km^2	% CV	95 % CI	
				Lower	Upper
Dry	MDF	62.500	57.74	11.342	344.42
	PLN	267.12	76.38	14.451	4937.6
Wet-1	MDF	-	-	-	-
	PLN	267.12	76.38	14.451	4937.6
Wet-2	MDF	167.21	67.08	24.038	1163.1
	PLN	833.58	32.95	418.66	1659.7



MDF = Moist Deciduous Forests; PLN = Plantations

Fig 49. Density of sambar deer pellets in different habitat types in 1995 - Northern region

MDF = Moist Deciduous Forests; PLN = Plantations

Fig 50. Density of sambar deer pellets in different habitat types in 1996 - Northern region

Spotted deer pellet density in different habitats

Southern Region

The pellet density of spotted deer in Southern region in 1995 and 1996 are given in Tables 109 and 110, and Figures 51 and 52. Moist deciduous forest was observed to have higher pellet density in dry season and dry deciduous in first wet and second wet seasons of 1995.

Table 109. Spotted deer pellet density in different habitats in Southern region in 1995

Season	Area	Density /km^2	% CV	95 % CI	
				Lower	Upper
Dry	DDF	750.00	22.54	418.66	1081.34
	MDF	1300.00	30.60	520.31	2079.69
	PLN	295.60	29.10	127.00	464.20
Wet-1	DDF	8866.00	33.00	3131.47	14600.53
	MDF	2284.00	38.80	547.06	4020.94
	PLN	3391.00	33.90	1137.88	5644.12
Wet-2	DDF	1150.00	36.00	338.56	1961.44
	MDF	640.00	48.40	32.87	1247.13
	PLN	385.80	39.40	87.87	683.73

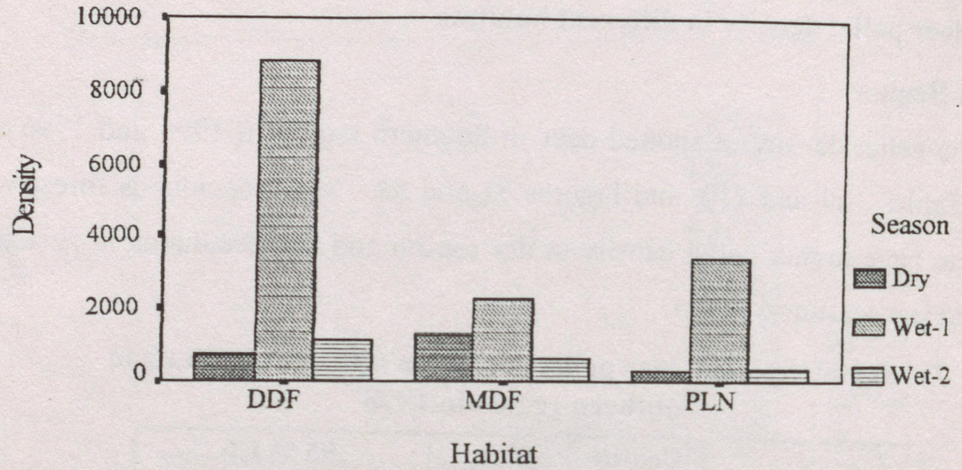
DDF = Dry Deciduous Forests; MDF = Moist Deciduous Forests; PLN = Plantations

In 1996, pellet density was higher in dry deciduous forest in dry and first wet seasons and moist deciduous in second wet season.

Table 110. Spotted deer pellet density in different habitats in Southern region in 1996

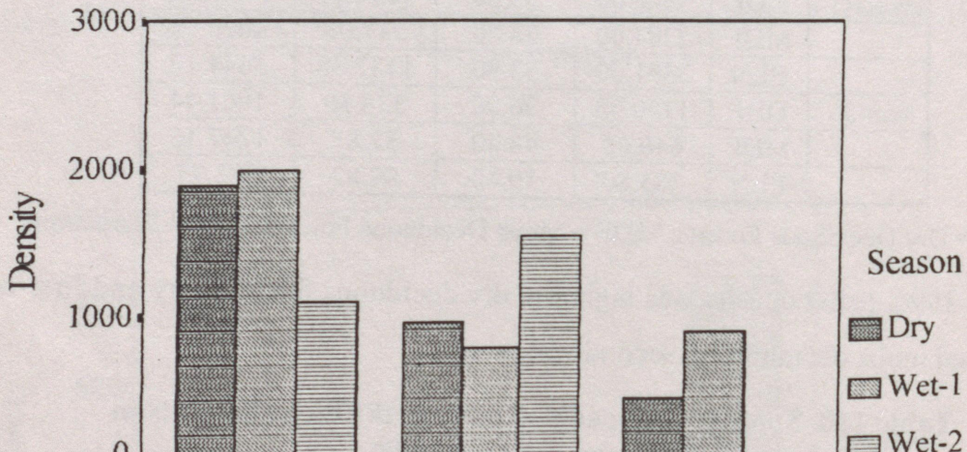
Season	Area	Density /km^2	% CV	95 % CI	
				Lower	Upper
Dry	DDF	1869.40	22.80	1034.00	2704.80
	MDF	945.87	34.82	300.34	1591.40
	PLN	425.07	30.64	169.80	680.34
Wet-1	DDF	1986.80	12.40	1503.93	2469.67
	MDF	768.10	22.41	430.72	1105.48
	PLN	876.26	27.98	395.71	1356.81
Wet-2	DDF	1097.20	42.06	451.30	2667.30
	MDF	1534.20	21.82	980.86	2399.70

DDF = Dry Deciduous Forests; MDF = Moist Deciduous Forests; PLN= Plantations.



DDF = Dry Deciduous Forests; MDF = Moist Deciduous Forests; PLN= Plantations.

Fig 51. Density of spotted deer pellets in different habitat types in1995 - Southern region



DDF = Dry Deciduous Forests; MDF = Moist Deciduous Forests; PLN= Plantations.

Fig 52. Density of spotted deer pellets in different habitat types in1996 - Southern region

Northern Region

The pellet density of spotted deer in Northern region in different vegetation types in 1995 and 1996 are given in Tables 111 and 112, and Figures 53 and 54. The

pellet density of spotted deer was high in Teak plantations in dry and second wet seasons of 1995, moist deciduous forest in dry season and plantation in first wet season of 1996.

Table 111. Spotted deer pellet density in different habitats in Northern region in 1995

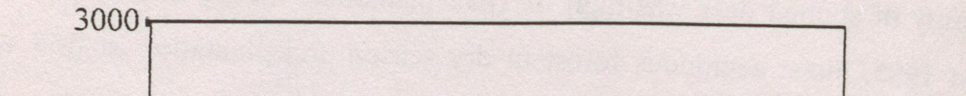
Season	Area	Density /km^2	% CV	95 % CI	
				Lower	Upper
Dry	MDF	179.27	82.19	8.1456	3945.3
	PLN	312.50	75.63	48.305	2021.7
Wet-1	MDF	-	-	-	-
	PLN	753.93	49.74	255.09	2525.3
Wet-2	MDF	190.95	127.02	.74529E-03	.48922E+08
	PLN	2493.4	141.42	319.59	19453.0

MDF = Moist Deciduous Forests; PLN = Plantations

Table 112. Spotted deer pellet density in different habitats in Northern region in 1996

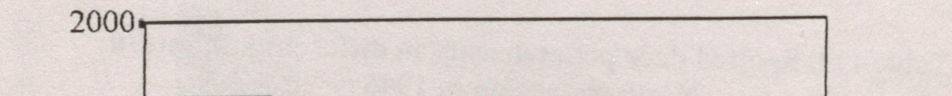
Season	Area	Density /km^2	% CV	95 % CI	
				Lower	Upper
Dry	MDF	1662.3	141.42	213.06	12969.0
	PLN	299.99	91.29	.15169E-01	.59326E+07
Wet-1	MDF	20.833	100.00	.53040E-03	.81831E+06
	PLN	205.15	102.23	.44103E-02	.95430E+07
Wet-2	MDF	-	-	-	-
	PLN	1319.9	38.65	574.79	3030.7

MDF = Moist Deciduous Forests; PLN = Plantations



MDF = Moist Deciduous Forests; PLN = Plantations

Fig 53. Density of spotted deer pellets in different habitat types in 1995 - Northern region



MDF = Moist Deciduous Forests; PLN = Plantations

Fig 54. Density of spotted deer pellets in different habitat types in 1996 - Northern region

Food species of different animals in the study area

The elephants in Wayanad were observed to feed and about 97 species of plants. The grasses dominate among them. About 92 plant species found to the food of sambar deer in the area and about 93 of spotted deer. Though gaur were observed on different location information of food species could not be collected.

Table 113. List of plants fed by elephants in Wayanad

Sl.No.	Family	Species
1	**Cyperaceae**	*Cyperus compressus*
2		*C. distans*
3		*C. exaltatus*
5		*C. pilosus*
6		*Fimbristylis dichotoma*
7		*F. littoralis*
8		*Kyllinga monocephala*
9		*Scleria laevis*
10		*Rhyncospora sp.*
11	**Poaceae**	*Arthraxon lanceolatus*
12		*Alloteropsis cimicina*
13		*Apluda mutica*
14		*Bambusa arundinacea*
15		*Brachiaria miliiformis*
16		*Capillipedium filiculmis*
17		*Chrysopogon aciculatus*
18		*Cymbopogon flexuosus*
20		*Cynodon dactylon*
21		*Cyrtococcum patens*
22		*Dactyloctenium aegyptium*
23		*Digitaria ciliaris*
24		*D. longiflora*
25		*D. setigera*

26		*Echinochloa colona*
27		*Eleusine indica*
28		*Eragrostis tenella*
29		*E. tenuifolia*
30		*E. unioloides*
31		*Eriochloa procera*
32		*Heteropogon contortus*
33		*Imperata cylindrica*
34		*Ischaemum indicum*
35		*I. rangacharianum*
36		*Oplismenus compositus*
37		*Oryza meyeriana* ssp. *granulata*
38		*Panicum notatum*
39		*P. indicum*
40		*P. maximum*
41		*Paspalidium flavidum*
42		*Paspalum punctatum*
43		*P. conjugatum*
44		*P. scrobiculatum*
45		*Pennisetum hohenackeri*
46		*Setaria palmifolia*
47		*S. pumila*
48		*S. intermedia*
49		*Sporobolus indicus*
50		*Themeda cymbaria*
51		*T. triandra*
52		*T. tremula*
53	**Scrophulariaceae**	*Scoparia dulcis*
54	**Hypoxidaceae**	*Curculigo orchioides*
55	**Asclepiadaceae**	*Hemidesmus indicus*
56	**Euphorbiaceae**	*Phyllanthus urinaria*

57	**Malvaceae**	*Sida acuta*
58		*Sida mysorensis*
59		*S. rhombifolia*
60		*Thespesia lampas*
61		*Urena lobata* ssp. *sinuata*
62		*U. lobata* ssp. *lobata*
63	**Mimosaceae**	*Mimosa pudica*
64	**Papilionaceae**	*Desmodium gangeticum*
65		*D. triangulare*
66	**Rhamnaceae**	*Zizyphus xylopyrus*
67	**Sterculiaceae**	*Helicteres isora*
68	**Tiliaceae**	*Triumfetta rhomboidea*
69		*Grewia hirsuta*
70	**Verbenaceae**	*Lantana camara*
71	**Zingiberaceae**	*Curcuma* sp.
72		*Globba marantina*
73	**Anacardiaceae**	*Mangifera indica*
74	**Bignoniaceae**	*Stereospermum colais*
75	**Bombacaceae**	*Bombax ceiba*
76	**Caesalpiniaceae**	*Bauhinia racemosa*
77	**Combretaceae**	*Terminalia alata*
78		*T. crenulata*
79		*T. paniculata*
80	**Dipterocarpaceae**	*Shorea roxburghii*
81	**Ebenaceae**	*Diospyros montana*
82	**Euphorbiaceae**	*Bridelia retusa*
83		*Emblica officinalis*
84	**Lecythidaceae**	*Careya arborea*
85	**Lythraceae**	*Lagerstroemia microcarpa*
86	**Malvaceae**	*Kydia calycina*
87	**Moraceae**	*Ficus bengalensis*

88	**Myrtaceae**	*Syzygium cumini*
89	**Oleaceae**	*Schrebera swietenioides*
90	**Papilionaceae**	*Dalbergia latifolia*
91		*Pterocarpus marsupium*
92	**Rubiaceae**	*Randia dumatorum*
93	**Sapindaceae**	*Schleichera oleosa*
94	**Sterculiaceae**	*Sterculia villosa*
95	**Tiliaceae**	*Grewia tiliaefolia*
96	**Verbenaceae**	*Gmelina arborea*
97		*Tectona grandis*

Table 114. List of plants fed by sambar deer in Wayanad

Sl.No	Family	Species
1	**Poaceae**	*Alloteropsis cimicina*
2		*Arthraxon lanceolatus*
3		*Arundinella purpurea*
4		*Axonopus compressus*
5		*Bambusa arundinacea*
6		*Brachiaria miliiformis*
7		*Capillipedium filiculamis*
8		*Centotheca lappacea*
9		*Chloris dolichostachya*
10		*Cynodon arcuatus*
11		*Cyrtococcum patens*
12		*Dactyloctenium aegyptium*
13		*Echinocloa colona*
14		*Eleusine indica*
15		*Eragrostis tenella*
16		*E. tenuifolia*
17		*E. unioloides*
18		*Eriochloa procera*
19		*Heteropogon contortus*

20		*Imperata cylindrica*
21		*Leersia hexandra*
22		*Oplismenus compositus*
23		*Oryza meyeriana* ssp. *granulata*
24		*O. rufipogon*
25		*Ottochloa nodosa*
26		*Panicum maximum*
27		*P. notatum*
28		*P. trypheron*
29		*Paspalidium flavidum*
30		*P. conjugatum*
31		*P. scrobiculatum*
32		*Sacciolepis indica*
33		*Setaria intermedia*
34		*S. palmifolia*
35		*S. pumila*
36		*Sporobolus indicus*
37		*Themeda cymbaria*
38		*T. triandra*
39	**Acanthaceae**	*Justicia simplex*
40	**Amaranthaceae**	*Achyranthus aspera*
41	**Balasaminaceae**	*Impatiens lenta*
42		*Impatiens sp.*
43	**Boraginaceae**	*Cynoglossum furcatum*
44	**Commelinaceae**	*Murdannia japonica*
45		*Cyanotis fasciculata*
46	**Compositae**	*Spilanthes radicans*
47		*Ageratum conyzoides*
48		*Elephantopus scaber*
49		*Emelia sonchifolia*
50		*Synedrella nodiflora*
51		*Tridax procumbens*

52		*Vernonia cinerea*
53		*Conryza bonariensis*
54		*Conyza stricta*
55		*Spilanthes paniculata*
56	**Cyperaceae**	*Mariscus pictus*
57		*Cyperus iria*
58		*C. pilosus*
59		*Fimbristylis dichotoma*
60	**Gentianaceae**	*Canscora diffusa*
61	**Hypoxidaceae**	*Curculigo orchioides*
62	**Malvaceae**	*Hibiscus lobatus*
63		*Sida acuta*
64		*S. alnifolia*
65		*S. rhombifolia*
66		*Thespesia lampas*
67		*Urena lobata* ssp. *lobata*
68		*U. lobata* ssp *sinuata*
69	**Mimosaceae**	*Mimosa pudica*
70	**Papilionaceae**	*Desmodium triflorum*
71	**Rubiaceae**	*Mitracarpus villosus*
72	**Hypoxidaceae**	*Curculigo orchioides*
73	**Papilionaceae**	*Desmodium triquetrum*
74		*D. velutinum*
75		*D. zonatum*
76		*D. gangeticum*
77		*D. triangulare*
78	**Rhamnaceae**	*Zizyphus oenoplea*
79		*Z. rugosa*
80	**Sterculiaceae**	*Helicteres isora*
81	**Verbenaceae**	*Lantana camara*
82	**Anacardiaceae**	*Mangifera indica*
83	**Combrctaceae**	*Terminalia paniculata*

84		*T. tomentosa*
85	**Euphorbiaceae**	*Emblica officinalis*
86	**Lecythidaceae**	*Careya arborea*
87	**Myrtaceae**	*Syzygium cumini*
88	**Oleaceae**	*Olea dioica*
89	**Salicaceae**	*Salix tetrasperma*
90	**Verbenaceae**	*Gmelina arborea*
91	**Tiliaceae**	*Grewia tilifolia*
92	**Malvaceae**	*Kydia calycina*

Table 115. List of plants fed by spotted deer in Wayanad

Sl.No	Family	Species
1	**Poaceae**	*Alloteropsis cimicina*
2		*Arthraxon lanceolatus*
3		*Axonopus compressus*
4		*Bambusa arundinacea*
5		*Brachiria miliiformis*
6		*Capillpedium filiculmis*
7		*Chloris dolichostachya*
8		*Cynodon arcuatus*
9		*Digitaria ciliaris*
10		*D. longiflora*
11		*Echinochloa colona*
12		*Eragrostis unioloides*
13		*E. tenuifolia*
14		*Eriochloa procera*
15		*Leersia hexandra*
16		*Oplismenus compositus*
17		*Oryza meyeriana* ssp. *granulata*
18		*O. rufipogon*
19		*Ottochloa nodosa*

20		*Panicum maximum*
21		*P. notatum*
22		*Paspalum conjugatum*
23		*P. scrobiculatum*
24		*Sacciolepis indica*
25		*Setaria intermedia*
26		*S. pumila*
27		*S. palmifolia*
28		*Sporobolus indicus*
29		*Themeda cymbaria*
30		*T. triandra*
31		*Arundinella purpurea*
32		*Dactyloctenium aegyptium*
33		*Digitaria setigera*
34		*Eleusine indica*
35		*Heteropogon contortus*
36		*Paspalidium flavidum*
37		*Cynodon dactylon*
38	**Acanthaceae**	*Justicia simplex*
39	**Amaranthaceae**	*Achyranthus aspera*
40	**Boraguiceae**	*Cynoglossum furcatum*
41	**Commelinaceae**	*Cyanotis fasciculata*
42		*Murdannia japonica*
43	**Compositae**	*Conyza stricta*
44		*C. ambigua*
45		*Acanthospermum hispidum*
46		*Ageratum conyzoides*
47		*Elephantopus scaber*
48		*Emilia sonchifolia*
49		*Synedrella nodifora*
50		*Tridax procumbens*
51		*Vernonia cinerea*

52		*Spilanthes radicans*
53		*S. paniculata*
54	**Cyperaceae**	*Mariscus paniceus*
55		*M. pictus*
56		*Cyperus iria*
57		*Fimbristylis dichotoma*
58	**Hypoxidaceae**	*Curculigo orchioides*
59	**Malvaceae**	*Hibiscus lobatus*
60		*Sida acuta*
61		*S. alnifolia*
62		*S. rhombifolia*
63		*Thespesia lampas*
64		*Urena lobata* ssp. *lobata*
65		*U. lobata ssp. sinulata*
66	**Mimosaceae**	*Mimosa pudica*
67		*Mitracarpus villosus*
68	**Acanthaceae**	*Phanlopsis imbricata*
69	**Rubiaceae**	*Mitracarpus villosus*
70	**Acanthaceae**	*Eranthemum montanum*
71	**Papilionaceae**	*Desmodium gangeticum*
72		*D. motorium*
73		*D. velutinum*
74		*D. zonatum*
75		*D. triquetrum*
76		*D. triangulare*
77		*D. triflorum*
78	**Rhamnaceae**	*Zizyphus rugosa*
79		*Z. oenoplea*
80	**Sterculiaceae**	*Helicteres isora*
81	**Verbenaceae**	*Lantana camara*
82	**Anacardiaceae**	*Mangifera indica*
83	**Combrctaceae**	*Terminalia paniculata*

84		*T. tomentosa*
85	**Euphorbiaceae**	*Emblica officinalis*
86	**Lecythidaceae**	*Careya arborea*
87	**Myrtaceae**	*Syzygium cumini*
88	**Oleaceae**	*Olea dioica*
89	**Rutaceae**	*Murraya exotica*
90	**Salicaceae**	*Salix tetrasperma*
91	**Verbanaceae**	*Gmelina arborea*
92	**Tiliaceae**	*Grewia tilifolia*
93	**Malvaceae**	*Kydia calycina*

Food availability

Southern Region

Table 116 shows the details of estimated of grass food biomass in different seasons. Seasonal grass food biomass varied irrespective of habitats in 1994. Food biomass was high during the first wet season (186g/m^2) and low during dry and second wet season. During 1995, the food biomass of grass in different seasons ranged between 120 gm/m^2 and 131 gm/m^2. Dry deciduous forest had the highest mean grass availability in 1994 and 1995 followed by moist deciduous and plantation.

Table 116. Availability of grass food species (gm. dry weight/m^2) – Southern region

Year	Habitat	Dry	%	Wet1	%	Wet2	%
1994	DDF	255.21	71.65	284.45	50.99	182.58	47.37
	MDF	95.20	26.73	188.94	33.87	147.95	38.38
	PLN	5.76	1.62	84.45	15.14	54.92	14.25
	Total	118.72	27.40	185.95	42.92	128.48	29.66
1995	DDF	220.09	55.73	216.48	56.01	218.90	61.17
	MDF	158.42	40.11	103.04	26.66	100.49	28.08
	PLN	16.42	4.16	66.96	17.33	38.48	10.75
	Total	131.64	34.66	128.83	33.92	119.29	31.41

DDF= Dry deciduous forests; MDF= M0oist deciduous forests; PLN= Plantations

The mean food biomass of browse species in the study area is given in Table 117. The browse food biomass in dry deciduous forests was ranging between 285 gm/m^2 and 481 gm/m^2 during 1994 and 1995. In most deciduous forest, the total food biomass was higher compared to dry deciduous forest and ranged between 1350 gm/m^2 1740 gm/m^2. The availability of browse species in plantation were almost equal to the availability in moist deciduous forest.

Table 117. Availability of browse food species (gm. dry weight/m^2) - Southern region

Year	Habitat	Dry	%	Wet1	%	Wet2	%
1994	DDF	386.24	12.24	284.45	8.44	480.89	15.97
	MDF	1350.10	42.77	1740.89	51.64	1489.59	49.47
	PLN	1420.40	45.00	1345.97	39.92	1040.86	34.56
	Total	1052.25	19.38	3371.31	62.11	1003.78	18.49
1995	DDF	436.15	14.75	334.83	11.14	390.99	12.05
	MDF	1420.20	48.02	1348.56	44.88	1424.78	43.91
	PLN	1101.14	37.23	1321.26	43.97	1428.91	44.04
	Total	985.83	32.12	1001.55	32.63	1081.56	35.24

DDF= Dry deciduous forests; MDF= Moist deciduous forests; PLN= Plantations

Northern Region

The Table 118 shows the availability of grass food biomass in Northern region. Total grass food biomass was more during the second wet season than the first wet season in 1994. This was more in dry season followed by second wet and first wet seasons in 1995. In 1994, grass biomass was higher in moist deciduous forest in second wet season. This was higher in plantation in all the seasons. Dry season in 1996 also had higher grass food biomass in plantations.

The availability of browse food biomass is shown in Table 119. Browse food biomass was highest in second wet season of 1994 and in dry season of 1995. In 1994, the browse biomass was more in plantation in second wet season. In 1995,

browse food biomass was more in moist deciduous in dry and first wet seasons and plantation in second wet season. In 1996 browse was more in plantation.

Table 118 Availability of grass food species (gm. dry weight/m^2) - Northern region

Year	Habitat	Dry	%	Wet1	%	Wet2	%
1994	MDF	-	-	-	-	51.89	67.53
	PLN	-	-	14.47	100.00	24.95	32.47
	Total	-	-	14.47	27.36	38.42	72.64
1995	MDF	64.33	40.86	20.56	45.60	24.20	45.70
	PLN	93.11	59.14	24.53	54.40	28.75	54.30
	Total	78.72	61.62	22.55	17.65	26.48	20.73
1996	MDF	32.48	47.13	-	-	-	-
	PLN	36.43	52.87	-	-	-	-
	Total	34.46	100.00	-	-	-	-

MDF= Moist deciduous forests; PLN= Plantations

Table 119. Availability of browse food species (gm. dry weight/m^2) - Northern region

Year	Habitat	Dry	%	Wet1	%	Wet2	%
1994	MDF	-	-	-		8.80	45.22
	PLN	-	-	1.69	100.00	10.66	54.78
	Total	-	-	0.85	8.03	9.73	91.97
1995	MDF	11.29	57.34	3.56	48.11	5.38	37.75
	PLN	8.40	42.66	3.84	51.89	8.87	62.25
	Total	9.84	47.61	3.70	17.90	7.13	34.49
1996	MDF	14.66	42.88	-	-	-	-
	PLN	19.53	57.12	-	-	-	-
	Total	17.10	100.00	-	-	-	-

MDF= Moist deciduous forests; PLN= Plantations

Central Region

The Table 120 shows grass food biomass estimated for different habitat and season. Grass biomass was higher in the second wet season than the first wet season in 1994. In 1995, the grass biomass is high in first wet season and low during the

second wet and dry seasons. In 1994, grass biomass was more in moist deciduous in first wet and plantation in second wet seasons. In 1995, It was more in plantation in dry and second wet seasons and moist deciduous forest in first wet season. It was high in moist deciduous in 1996.

Table 120.Availability of grass food species (gm. dry weight/m^2) - Central region

Year	Habitat	Dry	%	Wet1	%	Wet2	%
1994	MDF	-	-	48.23	59.73	49.59	49.50
	PLN	-	-	32.51	40.27	50.60	50.50
	Total	-	-	40.37	44.63	50.09	55.37
1995	MDF	29.52	48.86	64.06	52.87	54.93	46.17
	PLN	30.90	51.14	57.10	47.13	64.05	53.83
	Total	30.21	20.10	60.58	40.31	59.49	39.59
1996	MDF	49.35	52.00	-	-	-	-
	PLN	45.55	48.00	-	-	-	-
	Total	47.45	100.00	-	-	-	-

Table 121. Availability of browse food species (gm. dry weight/m^2) Central Range

Year	Habitat	Dry	%	Wet1	%	Wet2	%
1994	MDF	-	-	7.39	62.68	10.70	66.63
	PLN	-	-	4.40	37.32	5.36	33.37
	Total	-	-	5.90	42.35	8.03	57.65
1995	MDF	10.95	36.16	38.42	69.24	24.69	42.70
	PLN	19.33	63.84	17.07	30.76	33.13	57.30
	Total	15.14	20.80	27.75	38.12	29.91	41.09
1996	MDF	20.91	48.79	-	-	-	-
	PLN	21.95	51.21	-	-	-	-
	Total	21.43	100.00	-	-	-	-

MDF= Moist deciduous forests; PLN= Plantations

Table 121 shows the estimated browse food biomass in Central Range. Browse biomass was more in second wet season than the first wet season in 1994. In

1995 the browse food biomass is more in second wet season followed by first wet and dry seasons. In 1994, the browse food biomass was more in moist deciduous in first wet and second wet seasons. In 1995, food biomass was more in plantations in dry and second wet seasons and moist deciduous in first wet season. In 1996 food biomass was more in plantation in dry season.

Discussion

Mammals, especially the gregarious ones often respond to climatic changes and the resultant changes in the habitat by altering herd size and pattern of habitat utilization (McNaughton, 1985). Distribution pattern of large herbivores is influenced by resource availability such as food, shelter and water (Owen-Smith, 1988). Wild animals try to achieve the presumed goal of fitness maximisation by maintaining intake and avoiding environment stresses. This could be attained by selection of landscapes through migrations, home range placements or nomadism at behavioural frequencies of a few times in a year. Ranging behaviour of wild ungulates over wide geographical areas are normally in response to the temporal abundance and quality of forages (McNaughton, 1987). Watson and Moss (1970) have given examples to support that the dispersion of animals are related to food supply. Seasonal habitat selection has been reported in several species (Fuller, 1960; Shackleton, 1968; Shult, 1972; Dunckan, 1975; Owen-Smith, 1979; Krasinska *et al.*, 1987). A number of studies on elephants in Africa (Buss and Savidge, 1966; Watson and Bell, 1969; Williamson, 1975; Tchamba, 1993; Dublin, 1996) and Asia (McKay, 1973; Santiapillai *et al.*, 1984; Sukumar, 1985; Easa, 1989a; Sivaganesan, 1991) have also reported changes in distributional pattern in response to environmental changes leading to a shift in water and food availability. Elephant distribution has also been reported to be influenced by external factors such as extreme weather condition (Corfield, 1973), human settlements and cultivation (Lamprey *et al.*, 1967; Western and Lindsay, 1984) and poaching activity (Dublin and Douglas-Hamilton, 1987). Change in habitat preference of bison have been reported (Jaczewski, 1958;

Gill, 1967; Krasinski, 1978; Krasinski *et al.*, 1987). Weigum (1972) and Conry (1981) suggested abundance of grass, forbs and seral browse species in agricultural estates as the most important factors influencing gaur distribution in Central Pahang. Similar observations have been made by Vairavel (1998) in the case of gaur in Parambikulam Dinerstain (1979), Studying the habitat-animal interaction in Nepal conducted that changes in plant distribution and phenology affected ungulate food habits, energy budget, movement and seasonal distribution. Chital responded to seasonal changes by shifting the relative time spend in different habitats (Dinerstein, 1987).

The present study in Wayanad clearly showed a seasonal pattern in the distribution of elephants in different areas and habitats. These changes in the seasonal distribution were associated with several factors especially the food and water availability. Higher concentration of elephants had been observed in the bordering areas where dry deciduous forest was utilised to the maximum. Food availability study also indicated higher grass biomass in dry deciduous forests in Southern region throughout the year. Further, the perennial water sources in the Southern region are restricted to the border areas. Though, a few perennial water sources do occur in the interior areas, these are not freely approachable due to the habitation and related human activities. However no correlation between food availability and seasonal distribution could be observed in other regions. Water seems to be not a limiting factor in the Northern and Central regions. But the area available to elephants in the Central region is too small that no pattern could be expected. The natural forest in the Northern region cannot be considered as isolated and are seen in the midst of plantations also. This would explain the no-pattern observed in the area. Sukumar (1985) and Sivaganesan (1991) had also made similar shift in habitat utilisation in relation to food and water availability. Desai and Baskaran (1996) stressed the importance of water in the range use strategy of elephants in deciduous forest dominated areas.

The present study has shown the importance of grass in the diet of elephants. Though, the browse biomass was high in the interior areas of moist deciduous forests and plantations, the availability of water plays a crucial role in distribution of elephants in the Southern region in Wayanad. The low crude protein but rich in forage biomass areas have been used by elephants in dry season in Amboseli (Western and Lindsay, 1984). Studies in Mara by Dublin (1996) have pointed out that the elephant density during dry season was largely determined by water availability followed by food availability.

The increased density in moist deciduous and plantation dominated interior areas of the Southern region in the first wet season coincides with the fresh growth of grass and large scale water availability. The highly significant increase in the grass biomass in moist deciduous forest and plantation in the first and second wet seasons also supports the findings. The correlation coefficient shows a positive correlation between elephant density and bamboo young leaves its availability and soft textured grass during first wet season. A similar correlation was also observed between the elephant density and, grass and water availability in dry season, explaining largely the influence of these two factors in the density distribution of elephants in the study area.

Fire seems to play a major role in the distribution of elephants along with food and water availability. Density of elephants in 1995 was the highest in the Southern region during the study period. The dry season density of 2.78/km2 in dry deciduous forests during 1995 was quite unusual than expected. The extensive fire in the adjacent Mudumalai and Bandipur could have triggered a mass movement of elephant to the study area where fire, though occurred, were only in patches during the late dry and early first wet seasons. A decrease was observed in the density of elephants from the dry to first wet season throughout the study period. However, the reduction in 1995 was drastic (1.90/km2 to 0.44/km2). The fresh grass growth subsequent to the fire in the adjacent area would have definitely attracted a part of

elephants leaving the rest to move to the interior of the study area. The impact of fire in the adjacent area and the resultant high density has also led to a comparatively higher density in the inside area also in 1995.

Habitats surrounding the settlements are degraded as shown from the low grass biomass throughout as a result of cattle grazing, though the rainfall was higher in these moist deciduous dominated areas compared to dry deciduous forest. Desai and Baskaran (1996) have discussed the dual impact of human settlements on elephant habitats. It could be due to habitat loss through conversion for human use or avoidance of human use areas by elephants in the normal home range. Moist deciduous and plantation areas in the interior of the Southern region had been increasingly used in first wet season followed by a decrease in second wet season. The trend in the border areas in Southern region where dry deciduous forest is dominant, was just the reverse. This seasonal movement could be explained by the optimal foraging theory developed to explain movements of foraging animals (Pyke, 1983). The higher density during dry season forced the animal to go for quantity compromising the quality. In the following wet seasons, the strategy seemed to be changing to attain higher quality food intake. Changes in density within wet seasons could be due to a decreasing rate of food intake as a result of depletion in quantity or decline in quality because of continuous use of the patches as explained in the marginal value theorem of Charonav (1976). Gaur, sambar deer and spotted deer though show seasonal differences in habitat utilization do not seem to follow a pattern.

The elephants in the study area showed seasonal movement and shift in habitat utilisation in relation to food and water availability, an also the occurrence of fire in the adjacent areas. The Southern region of Wayanad thus is a dry season refuge for the elephants. However, the Northern region have comparatively higher density during first wet season.

The density distribution of sambar deer in Wayanad, as evident from the density of pellets in different regions does not seem to follow any type of pattern. However, there is a general tendency for increased concentration in the first wet and second wet season in the Southern region. The habitat requirements of the species vary considerably. The availability of food plants, places for resting, wallowing and drinking differs in abundance and distribution pattern according to the climatic changes. The types of variation are clearly evident in tropical dry deciduous forest. Moreover, cervids in general are reported to be highly sensitive to water deprivation (Berwick, 1974). The density distribution has also been observed to be influenced by environmental factors in Parambikulam (Easa unpublished information). Observations in Wayanad though do not agree completely with the reports from elsewhere, seem to indicate a pattern where the environmental factors also play a role.

CHAPTER 8
CROP RAIDING

Introduction

Declaration of protected areas and the subsequent regulation led to the denial of access to the resources to the local people. Fragmentation and depredation resulting from the dependence by the people in enclosures and fringes have contributed to the increased incidence of human-wildlife conflict. Information on various aspects of crop raiding would help in formulating suitable mitigative measures and policy decisions. Information on various aspects of crop raiding *viz.*, the extent, animals involved effectiveness of protection methods and economic implications were collected from Wayanad.

Methods

Settlement selection for study on crop raiding

The study area has sixty-nine enclosures and forty seven settlements in the periphery. These are of different legal status such as revenue, leased, patta and forest lands. The surrounding vegetation types and protection methods employed differ according to the location. The types of crops cultivated also vary depending on the area..

Protection methods

Crop protection methods employed in the field during the study period were recorded and classified as follows:

1. **Ordinary Fencing and Guarding (OF+GU)**: The fields were fenced using different materials like bamboo, barbed wires, thorns, hedgerows, *etc.* This type of protection includes guarding at night by people from machans (platforms on trees) or guard sheds on ground with fire and sound making devices like tins, drums, etc.

2. Special Protection (SP): This is similar to ordinary fencing but used along with several other animal scaring devices. Trip wires with explosive crackers are the special protection devices used in most of the places. . This method is employed only during the reproductive phase of paddy. Guarding at night is avoided.

3. Electric Fencing (EF): Electric fences were installed by Forest Department around some of the settlements in the study area using energizers which generate very short pulses of high voltage current and the animal coming in contact with such wires get a strong shock but are not harmed. Some of these were maintained properly by the people themselves and some were not maintained, hence the effect varied.

4. Trenches (TR): the Forest Department dug Trenches around some of the settlements. These trenches are maintained annually.

Twenty nine settlements were selected in the study area based on the location of settlements, surrounding vegetation types, location of the settlement and types of protection method employed (Fig. 55). These settlements were distributed in six Forest Ranges *viz*., Tholpetty, Begur, Chedleth, Kurichiat, Sulthan Bathery and Muthanga. Details of selected settlements are given in Table 122. Data on crop raiding were collected from these settlements over a period of three years during 1994-1996

Cultivation in selected settlements

About 66.5% of the total land in the selected settlements were under seasonal crops and the remaining under perennial crops (referred as wet and dry lands respectively).

Seasonal crops

The study area had the maximum rainfall during southwest monsoon and planting of seasonal crops began at the onset of monsoon in May and harvest was completed by November or December. Among the seasonal crops, paddy (*Oryza*

sativa), the staple food crop of the people was grown to a larger extent in all the selected settlements. Paddy was sown during the middle of May or first week of June depending on the pre-monsoon rains and the onset of monsoon. By mid or late

Table 122. Details of settlements selected for crop raiding studies

Sl. No	Settlement	Protection method	Major crops cultivated
1	Alathur	OF+GU	Coffee, Paddy, Tapioca, Plantain
2	Appapara	EF+GU	Paddy, Ginger, Pepper, Coconut, Plantain
3	Arakunji	OF+GU	Ginger, Coffee, Paddy
4	Begur river side	EF+GU	Ginger, Paddy, Rubber, Tapioca
5	Begur Range office side	EF+GU	Paddy, Tapioca, Ginger, Coffee
6	Chetti alathur	OF+GU	Ginger, Paddy, Tapioca, Plantain, Pepper
7	Chekadi	EF+TR	Coconut, Ginger, Jack fruit tree, Paddy, Plantain
8	Cheriyamala	OR+GU	Arecanut, Paddy, Pepper, Plantain, Coffee
9	Chullikad	CR+GU	Arecanut, Coconut, Ginger, Paddy, Plantain
10	Emmady	EF+GU	Coconut, Plantain, Tapioca, Paddy, Ginger
11	Kallumukku	EF	Coffee, Ginger, Paddy
12	Konduvady	CR+GU	Coconut, Paddy, Pepper, Rubber
13	Kottavayal	CR+GU	Paddy, Ginger, Plantain
14	Kumizhi	EF	Coffee, Ginger, Paddy, Tapioca
15	Kuppadi	EF	Coffee, Plantain, Ginger, Tapioca
16	Kurichiat	EF	Paddy, Tapioca, Ginger
17	Mathalampatta	CR+GU	Coconut, Ginger, Paddy, Pepper, Plantain, Arecanut
18	Nedumthana	TR	Ginger, Plantain, Pepper
19	Narimundakolly	EF+GU	Paddy, Ginger, Plantain
20	Nulpuzha	OF+GU	Coffee, Ginger, Paddy, Pepper, Plantain
21	Polanna	CR+GU	Paddy, Plantain, Rubber
22	Ponkuzhy	OF+GU	Ginger, Paddy, Plantain, Tapioca
23	Puthiyoor	EF+GU	Ginger, Paddy, Tapioca
24	Puthussery	CR+GU	Paddy, Plantain, Ginger, Tapioca
25	Punchavayal	CR+GU	Ginger, Coffee, Paddy
26	Thirulakunnu	EF+GU	Paddy, Tapioca, Ginger
27	Vakeri	CR+GU	Paddy, Ginger, Plantain
28	Vattathur	CR+GU	Paddy, Ginger, Plantain
29	Veluvalli	CR+GU	Coconut, Paddy, Ginger, Plantain

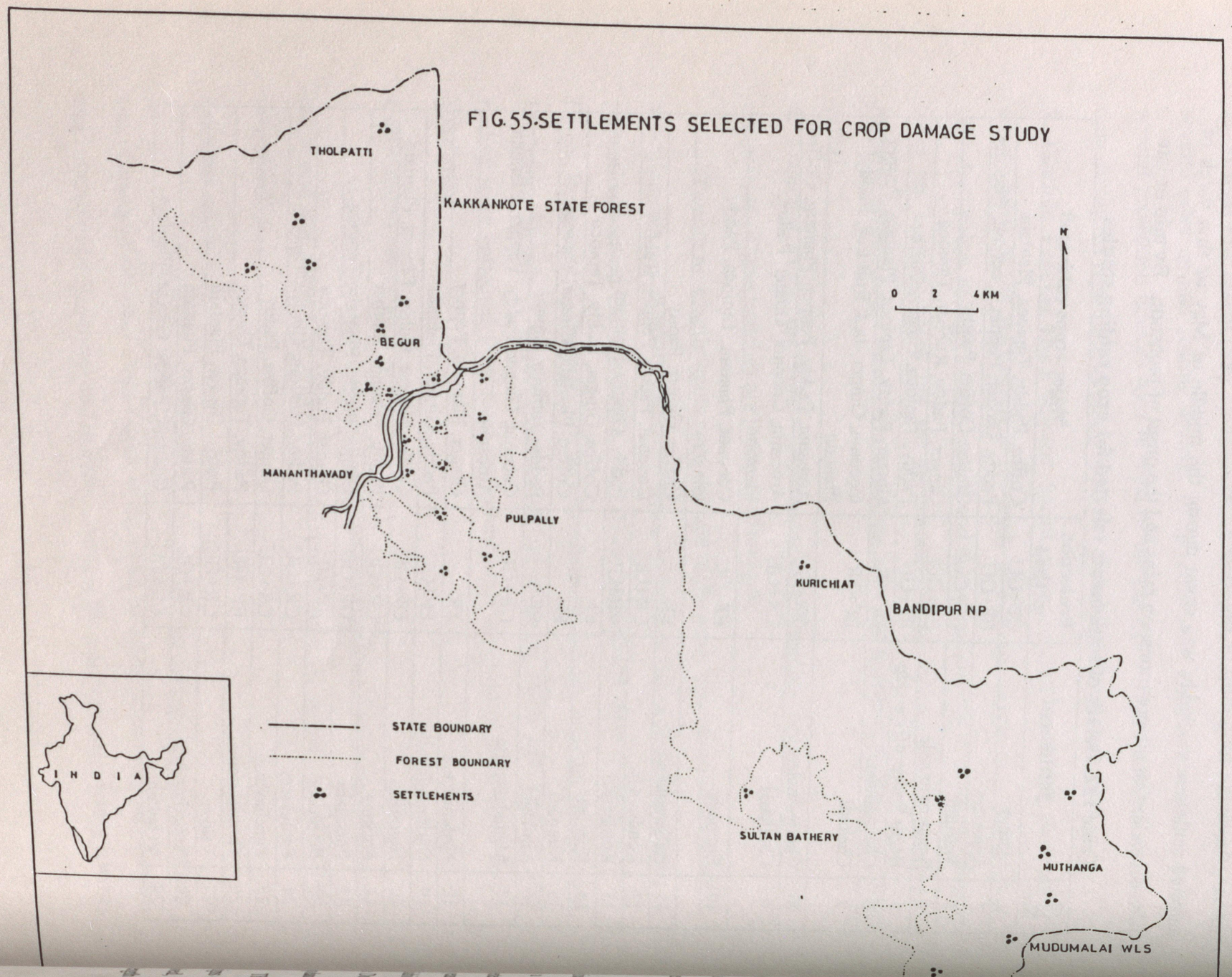


FIG. 55-SETTLEMENTS SELECTED FOR CROP DAMAGE STUDY

September, paddy flower and the harvest was between November and December, and sometimes it may be extended to first and second week of January, depending on the planting season.

Ginger (*Zingiber officinale*) and plantains (*Musa paradisiaca*) constituted the other seasonal crops. These were cultivated in the wet lands. Tapioca (*Manihot utilisima*) was cultivated only to a lesser extent in the study area.

Perennial crops

Dry land constituted about 33.5% of the total in the selected settlements in the Southern region and 41.89% in Central region. The cash crops such as coffee (*Coffea arabica*) and pepper (*Piper nigrum*) were the dry perennial crops cultivated throughout the study area. Along with coffee and pepper, coconut (*Cocos nucifera*) and arecanut (*Areca catechu*) (referred as mixed crops) were also cultivated by farmers.

Coffee, pepper, coconut and arecanut were cultivated in the dry land mostly in mixed cultivation. Mono-cultivation of coffee, pepper and arecanut constituted only a small portion in the settlements. Tapioca was planted during May and harvested during December. Plantain was available evenly in all the months round the year. Paddy constituted a larger proportion of the edible crops (>90%). Availability of paddy during May was only below 10% and increased to 87% in June. During the harvest season, the availability decreased to less than 5%.

Crop damage

The selected settlements were visited twice in a month and visually checked for signs of damage. Information was collected on crop damaged, animal species involved, pheno-phase and height of the crop. Total area damaged (in m^2, based on the length and breadth of the damaged area) was also recorded.

Percentage of damage due to feeding and trampling was recorded separately by laying a number of $1m^2$ plots for paddy and ginger, and by actual count for other crops. Plots of same size were laid in undamaged areas also for comparison and estimation of the quantum of damage. An area was considered damaged due to trampling if it occurred while the elephant was moving through the crop field without feeding or just walking across the field in the course of their movement between different feeding points or while being driven away by people from the crop field before feeding. The area trampled by elephants while moving was considered as damage due to feeding if there was any sign of feeding. Phenology of crops, especially of paddy was noted as vegetative (before flowering) and reproductive (in flower/fruits/grains).

Secondary data were also collected from the villagers during each visit for information on date of raiding, time, animal species involved and number of individuals. Information on the sex of the animal, identification (if possible) and number of individuals were also collected during the visit. If tracks of calves or juveniles were found in the field, the raiding was considered as that of a herd. Fresh tracks were followed and the elephants observed for information on the sex, age group, number and identification marks.

Crop raiding and spatial pattern of habitual crop raiders (only males) were studied during 1995 in Southern region. Identified bulls were monitored regularly and information collected on the location, frequency of crop raiding in each settlement and distance between the habitual crop raiders. The nearby settlements were also visited subsequently for collecting information on the damages caused by these.

Analysis

Economic loss

In the case of plantation crops such as coffee, pepper, plantain, tapioca, coconut and arecanut, the actual number of plants damaged and their age were collected based on the method suggested by Sukumar (1985). The number of years of yield lost to the farmer is the same as the age at which the tree was damaged as he has to plant another sapling in its place and nurture it to the same stage. Hence, age of the plant was multiplied with the expected total annual yield of the damaged plant to calculate the economic loss. This was added to the establishment cost such as planting and other maintenance charges.

Extent of damage to paddy and ginger was calculated using the total area damaged. These were converted into per unit area (ha.). The crop lost per acre of damage was calculated in terms of potential expected yield. Potential yield was arrived at from the yield obtained from the crops left undamaged in the same field or from the surrounding field.

Quantity damaged

The actual quantity of paddy damaged/day/elephant was calculated as suggested by Sukumar (1985) as shown below:

$$q_i = \frac{a_d \times Y}{e}$$

Where a_d = areas of the field damaged

Y = expected potential yield in terms of quintal

e = number of elephant raiding crops

For each settlement, the quantity of crops damaged was calculated using the formula $E \times F \times Q$, Where E = mean raiding group size of elephants

F = frequency of raiding

Q = weighted mean quantity damaged / day / elephant in a village

The market value of the crops collected from State agency or/and wholesale dealers did not differ significantly between years. Hence, an average was taken for

the years and tabulated for the purpose of calculation (Table 123). The cost for seeds, ploughing, fertilizers, pesticides, fencing, guarding at night, labour, irrigation etc. for paddy and ginger cultivation alone were computed and was about 20 % of the total yield. This was added to the total loss.

Table 123. Density, yield and value of crops cultivated in the study area

Crop	Density/ha	Average Yield/ha	Value (Rs)
Paddy	523640	39.5 q.	500/q.
Ginger	79040	395.2 q.	1000/q.
Plantains	741	Rs.40/plant	29640/ha.
Tapioca	2470	123.5 q.	200/q.
Coconut	124	6200.0 Nos.	4/ No.
Coffee (Alone)	865	18.5 q.	4000/q.
Coffee (Mixed)	494	9.9 q.	4000/q.
Pepper (Alone)	988	24.7 q.	7000/q.
Pepper (Mixed)	618	14.8 q.	7000/q.
Arecanut	1235	Rs.30/plant	37050/ha.

Manslaughter by elephants in the study area

Information on manslaughter by elephants in the study area was collected with the details such as name, sex and age of the persons killed, the place of encounter, the activity of the victim and those accompanying, circumstances of the encounter, sex of the elephant and the nature of injury. All the analyses were done using SPSS for Windows Release 6.0 (Anonymous, 1987).

Results

Crop damage

Elephant, wild boar, gaur, sambar deer, spotted deer and bonnet macaque were the major crop raiders in the area. Among these, elephants were responsible for 75.85% of the crop raiding (Fig 56). The damage was mostly by feeding and trampling. The extent of damage by wild boar (10.40%), gaur (9.79%), sambar

(1.83%) barking deer (0.61%), bonnet macaque (0.92%) and spotted deer (0.61%) were comparatively negligible. The differences in the frequency of raiding by animals were significant ($\chi^2 = 842.63$, $df = 5$, $P < 0.000$).

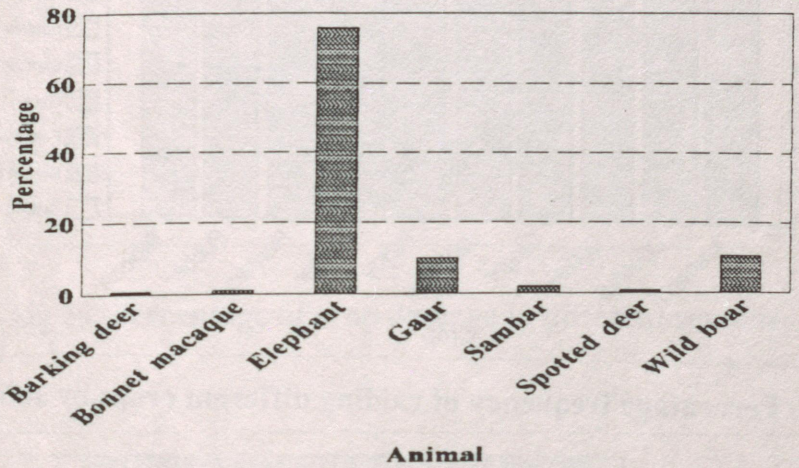


Fig 56. Percentage frequency of crop raiding in Wayanad by animals

Analyses for the crops damaged by different animals indicate that paddy was the most vulnerable among the crops (73.39%) followed by ginger (7.65%), coconut (4.59%), tapioca (4.28%), plantain (3.67%), arecanut (0.61%), coffee (3.36%), jack tree (0.31%), pepper (1.53%) and rubber (0.61%) (Fig 57). Percentage frequency of damage on paddy by elephant was about 70%. Most of these were due to trampling followed by feeding. Ginger (8.47%), coconut (6.05%), tapioca (3.23%), plantain (4.84%), arecanut (0.81%), coffee (3.63%), jack tree (0.4%), pepper (1.61%) and rubber (0.4%) were also damaged by elephant (Fig 58).

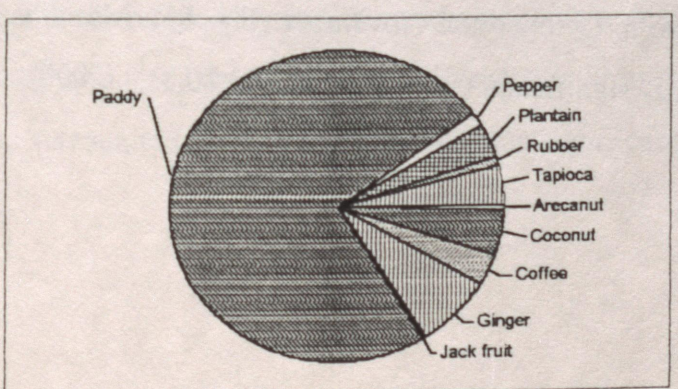


Fig. 57. Percentage frequency of crops raided by animals in Wayanad

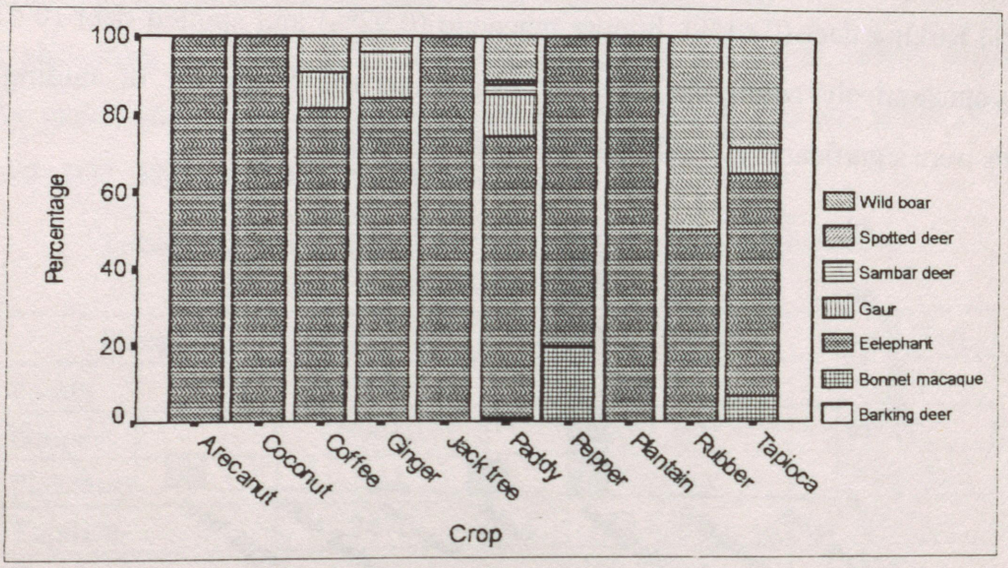


Fig 58. Percentage frequency of raiding different crops by animals

Analysis for seasonal incidences of crop raiding indicates that 86.54% of crop raiding was during rainy season and the rest (13.46%) in summer (Fig 59). The difference was highly significant (χ^2 = 174.68, *df* = 1, P < 0.000). Incidence of crop raiding by elephant was also high in rainy season (86.29%). Animals had an increased tendency to raid crops in reproductive phase compared to vegetative phase (Fig. 60). However, there were significant variations depending on the crop. Chi-square test indicates that the variation is statistically significant. Crop raiding incidences were higher (99.08%) in enclosures compared to thesettlements in periphery (0.92%). Analyses for monthly distribution of raids indicate that frequency of raiding was more in October and November (Fig. 61). Monthly variation in crop raiding is statistically significant. (χ^2 = 353.01, *df* = 10, P < 0.000).

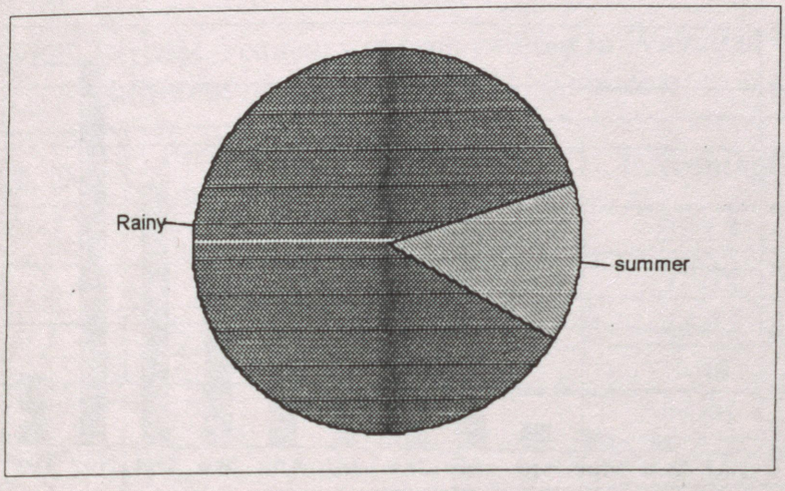


Fig 59. Percentage of crop damage in different seasons

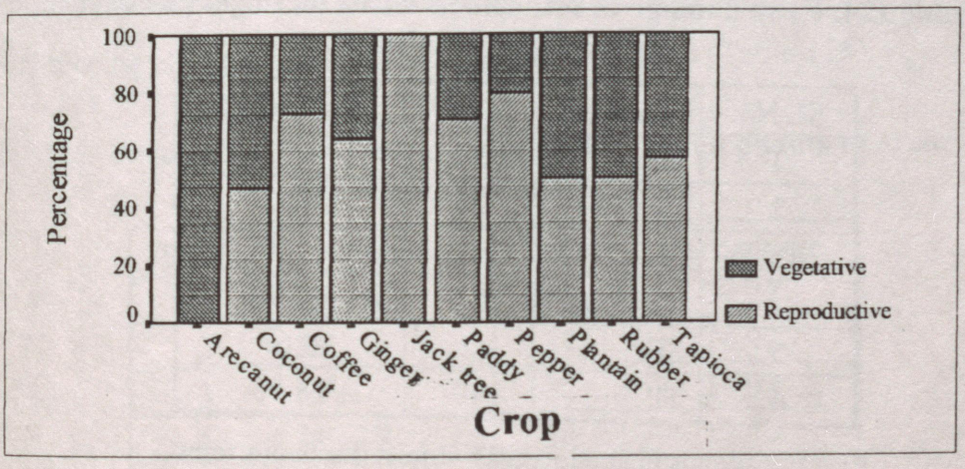


Fig. 60. Crop damage in different phenological stages

The settlements surrounded by moist deciduous with teak plantations were subjected more to crop raiding (Table 124). The difference in crop-raiding incidence between settlements surrounded by different habitats was significant. (χ^2 = 205.82, *df* = 5, P < 0.000).

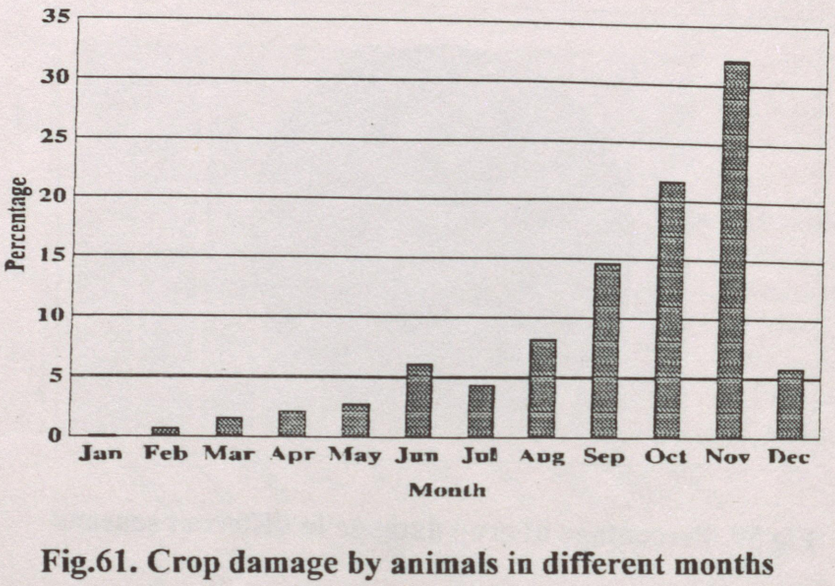


Fig.61. Crop damage by animals in different months

Table 124. Crop damage in settlements based on the nature of the surrounding habitat

Sl. No.	Habitat	Total	Percentage
1	EP	22	6.73
2	EP+TP	30	9.17
3	MD	103	31.50
4	MD+TP	121	37.00
5	SE	2	0.61
6	TP	49	14.98

EP= Eucalyptus plantation, MD= Moist deciduous forest,
SE= Semi evergreen, TP= Teak plantation

Protection methods Vs crop raiding

There is a significant difference in the number of crop raiding incidences in settlements under different protection methods (χ^2 = 133.31, *df* = 5, P = < 0.000). Trench was observed to be more effective to prevent crop raiding. The frequency of raiding was more in areas where ordinary fencing, or crackers and guarding were used (Table 125).

Table 125. Percent frequency of crop raiding in Wayanad under different protection methods by animals

Sl. No.	Protection methods	Incidence of crop raiding	Percentage
1	CR+GU	108	33.03
2	EF	50	15.29
3	EF+GU	47	14.37
4	EF+TR	31	9.48
5	OF+GU	88	26.91
6	TR	3	0.92

CR= Crackers, GU= Guarding, EF= Electric fencing, Of= Ordinary fencing, TR= Trench

In the case of elephant, trench was observed to be more effective to prevent or control crop raiding. The frequency of raiding was more in the areas where ordinary fencing or crackers and guarding were employed (Table 126).

Table 126. Percentage frequency of crop raiding by elephants in areas under different protection methods

Sl. No.	Protection	Total	Percentage
1	CR+GU	85	34.27
2	EF	37	14.92
3	EF+GU	37	14.92
4	EF+TR	30	12.10
5	OF+GU	56	22.58
6	TR	3	1.21

CR= Crackers, GU= Guarding, EF= Electric fencing,
OF= Ordinary fencing, TR= Trench

Herds were raiding more in the settlements having trenches. Even though the trenches and electric fencing together found to be effective, it is not found to deter the solitary elephants. (Fig 62)

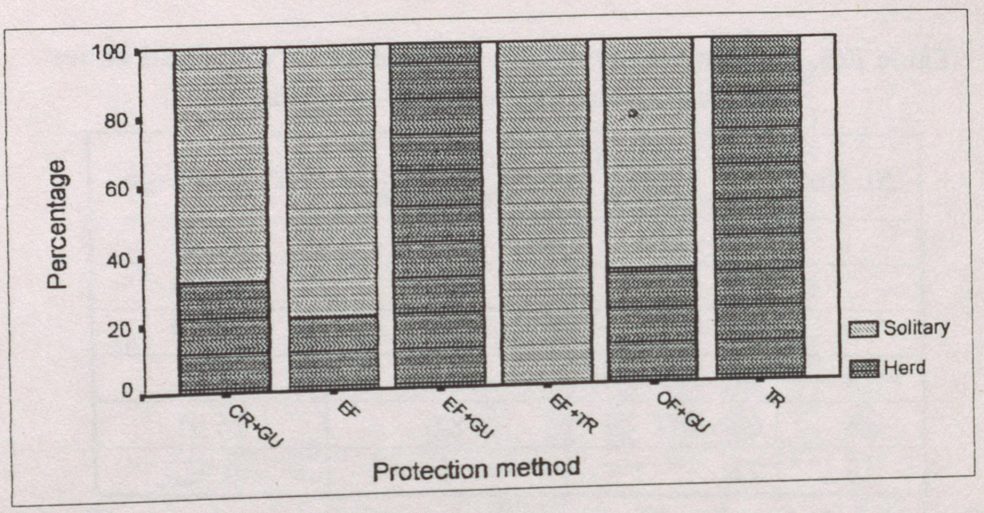


Fig 62. Percentage of raids by herds and solitary elephant in areas under different protection methods

Crop raiding incidences were higher in Southern region than Central and Northern regions. However, analysis show that crop raiding was more in Chedleth Range of Central region, followed by Muthanga, Tholpetty and Sulthan Bathery. Crop damage was comparatively less in Kurichiat and Begur Ranges (Fig 63.).

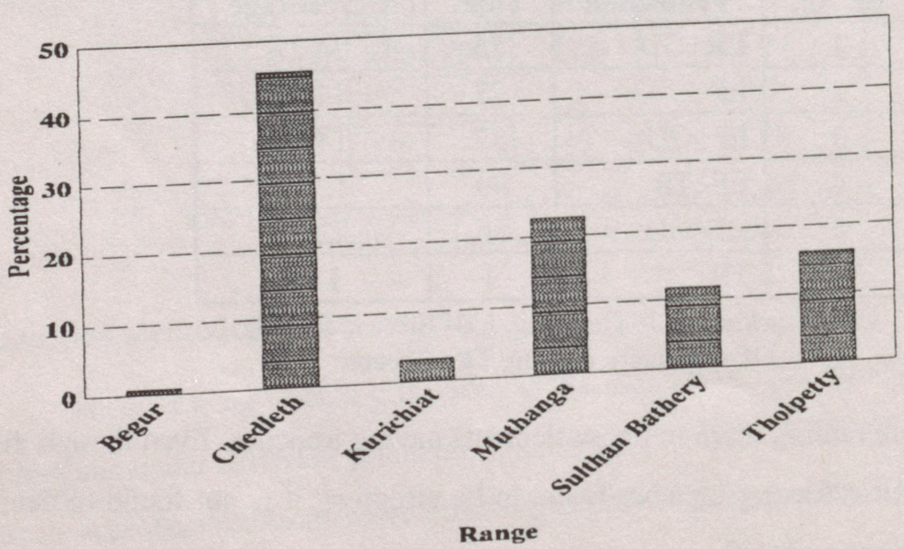


Fig. 63. Percentage frequency of crop raiding in different Ranges

Among the settlements selected for the study, frequency of raids was more in Chegadi, Cheriyamala, Kumizhi, Chettiyalathur and Ponkuzhi (Fig 64). The difference was highly significant ($\chi^2 = 238.78$, $df = 16$, $P < 0.000$).

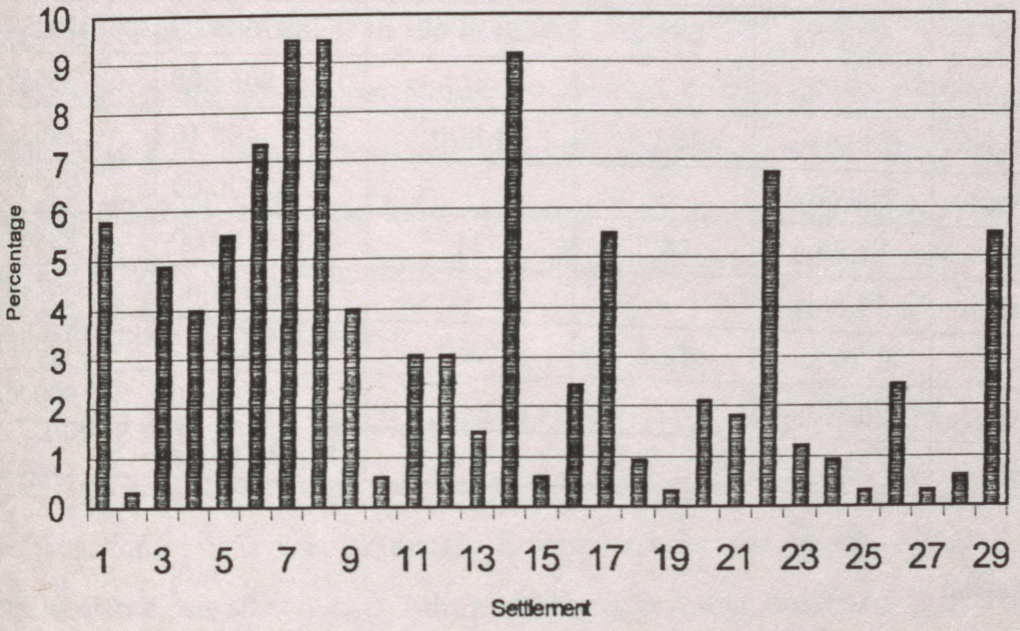


Fig. 64. Percentage frequency of crop raiding in different settlements

1= Alathur, **2**= Appapara, **3**= Arakunchi, **4**= Begur river side, **5**= Begur Range office side, **6**= Chetti alathur, **7**= Chekadi, **8**= Cheriyamala, **9**= Chullikkad, **10**= Emmaddy, **11**= Kallumukku, **12**= Konduvadi, **13**= Kottavayal, **14**= Kumizhi, **15**= Kuppadi, **16**= Kurichiat, **17**= Mathalampatta, **18**= Nedumthana, **19**= Narimundakolli, **20**= Noolpuzha, **21**= Polanna, **22**= Ponkuzhy, **23**= Puthiyoor, **24**= Puthusserry, **25**= Punchavayal, **26**= Thirulakunnu, **27**= Vakeri, **28**= Vattathur, **29**= Veluvalli

Economic loss

During the study period, a total area of 45.03 ha. of paddy and 6.11 ha of ginger was damaged by different animals. A higher proportion of the economic loss was due to damage of paddy and ginger by different animals (Table 127). This is true in the case of elephants also. A total economic loss of Rs. 42,43,203.47 was estimated due to crop damage by different animals. About 89% of economic loss was due to elephants.

Table 127. Economic loss due to animals for three years (1994-1996)

Crop	Area damage	Average yield /ha. (100 kg)	Loss of production (100 kg)	Economic loss (Rs)	Loss/ hectare
Paddy	45.03 ha	39.5	1778	1067368.00	23703.49
Ginger	6.11 ha	395.2	2414.67	2897606.00	474239.93
Plantain	168 Nos	-	-	8064.00	35568.00
Tapioca	0.115 ha	123.5	14.20	3408.10	29635.65
Coconut	218 Nos	-	-	52320.00	29760.00
Coffee	1.68 ha	18.5	31	149184.00	88800.00
Arecanut	54 Nos	-	-	1994.00	45596.20
Pepper	0.26 ha	14.8	6.60	55459.37	213305.00
Rubber	26 Nos	-	-	7800.00	90000.00
				42,43,203.47	

Discussion

Analysis of the data in Wayanad indicates that elephants were involved in about 75% of the crop raiding and paddy was the most affected crop. Crop raiding was higher in rainy season especially in the reproductive phase of the crops. Settlements surrounded by moist deciduous forests and those with teak plantations were more prone to crop raiding.

A number of factors influence crop raiding behaviour of elephants. Sukumar (1989), Balasubramanian *et al.*, (1995) and Kumar and Sathyanarayana (1995) have dealt with these factors while studying crop raiding elephants. Sukumar (1989) listed the factors as those related to movement pattern, availability of water and food, reduction, fragmentation and degradation of habitat, and the difference in the palatability and nutritive value of crops compared to the natural food species.

Elephants' far ranging behaviour and larger requirement of the resources often lead them into contact with cultivation in the fragmented forests (Sukumar, 1988). Increased elephant population and local over abundance resulting in habitat degradation were also reported to lead to crop raiding (Desai, 1997). A pattern of density distribution was evident in the Southern and Northern regions in the study area. Elephant in the study area showed a distinct pattern of movement with increased density in the peripheral region during dry season. The interior areas, where the settlements are located have an almost equal density during the first and second wet seasons. Density figure in the Southern region of Wayanad was higher compared to similar elephant ranges.

Straying of elephants has also been observed in Wayanad. On one occasion, four elephants strayed out from the forest in Padri into Panamaram area through coffee plantations. This was ultimately driven back by the forest officials. In another incidence, an adult tusker followed the same route, surrounded by moist deciduous forests, killed a person and ultimately was shot dead by police. It is possible that these areas had been the traditional elephant paths much before the conversion and settlements started. Further, the forest areas surrounding the settlements are degraded to a greater extent because of the dependence of people for cattle grazing, fire wood collection and similar activities (Chapter 5).

Analyses of food availability data from areas surrounding the settlements have also indicated the impact of these activities on the habitat. Food availability study also indicated low grass biomass in areas surrounding the settlements. Conversions of natural forest into plantations have also contributed to the degradation considerably. This is clearly evident in the eucalypts plantation, where the under growth is dominated or fully occupied by *Lantana sp.* and *Eupatorium sp.* Increased rate of crop raiding in the settlements surrounded by natural forest mixed

with plantation especially of teak indicate the degradation of habitat as a possible causative factor for crop raiding. Degradation of habitats has been reported to lead to a futile search for non-existent food sources ending up in crop raiding (Desai, 1997).

The elephant habitat in the study area, though not fragmented in the strict sense of the term, is disturbed due to the scattered nature of the settlements. Movement of people during daytime forces the elephants to confine themselves to smaller undisturbed patches and put them under stress and strain. The situation is worse in the Central region where the area available for elephant is comparatively low and these are almost fragmented due to the settlements all along Kabini, the connecting link with the adjacent area.

Among the wet land crops, paddy was the dominant one extensively cultivated in all the settlements selected for the study. Paddy was also the crop, which was damaged most by elephants and other animals. The damage to ginger and dry crops except coconut were mostly due to trampling, more often while going for paddy. Damage to paddy by elephant during vegetative phase was almost exclusively due to trampling. Paddy in reproductive phase were fed and thus damaged. Sukumar (1985) has mentioned the high nutrient value and digestibility coupled with less toxins as possible reasons for preference for paddy.

Palatability of paddy was also higher compared to matured grasses in second wet season. Crude protein content of paddy in inflorescence was higher than the short grass available in moist deciduous forests surrounding the settlements. Sukumar (1989 & 1990) has reported higher calcium and sodium content in the mature paddy. Present observations of high intensity of raiding during the reproductive phase could also be due to the sudden increase of sucrose and amino acids in the developing grains of paddy. Observations in Southern region have

revealed that habitual crop raider spent less time for feeding in the wild (Balasubramanian, 1998). This also indicates the possibility of meeting the nutritional requirements within the short period of raiding from the highly nutritious crops.

In the study area, the frequency of crop raiding by males was higher than those by the herds. Success in attempts were also more in the case of males. Similar observations have been made by Sukumar (1989) and Kumar and Sathyanarayana (1995). Males due to their solitary nature can very well stay over days together in the areas surrounding settlements compared to the herds with juveniles and calves.

Balasubramanian (1998) observed no significant difference in herd size of elephants in the natural and crop raiding herds. Sukumar (1985) observed herd formation even among the bulls while raiding crops. Datye and Bhagawat (1995a) observed an increased mean herd size among the elephant raiding crops. It may be probable that the herds in the study area do not go purposefully for crop raiding and more often raid once coming into contact with the cultivated area. Present observation in the study area also indicated a positive correlation between the size of settlement and frequency of crop raiding because of the increased perimeter available in the larger settlement

Considering the factors discussed above, the habit of the animal seems to play an important role in crop raiding behaviour in the study area. In one incidence, an adult bull in the company of another adult bull tried to break open a live wire fence but retreated on getting the shock. But the other adult bull broke the fence and both raided the field. The bull, which failed, was later reported to be raiding crops all alone even in the live wire fenced settlements. Habitual crop raiders stay around the settlements and continuously raid irrespective of the protection methods employed. These elephants even follow a spacing pattern among them and once

chased move to the next settlement to repeat the process. These observations indicate the possibility of acquiring the crop raiding habit through learning process and possibly act in combination with all the proximate factors discussed earlier.

Sukumar (1985) estimated a loss of Rs. 1.9 lakhs during 1981-82 in nine settlements and the per hectare loss was Rs. 59. The per hectare loss incurred in Dharmapuri Forest Division of Tamil Nadu was between Rs. 134.11 and Rs. 145.54. The per hectare economic loss in Wayanad is comparatively more than other areas studied. A much higher loss has been reported from Malaysia by Blair *et al.* (1979) and Blair (1980) where the damage has been on perennial crops such as oil palm, coconut or rubber. The damage to cash crops in the study area could be one of the reasons for the higher rate of economic loss. But, estimation without cash crops also show a higher economic loss compared to other crop raiding areas. A preliminary comparison made with the compensation paid by authority indicate that most of the raids go unreported and loss unclaimed due to several reasons.

Electric fencing was found to be the most efficient protection method, if properly maintained. But the habitual crop raiders break open electric fences and raid the crops. Properly maintained electric fencing coupled with guarding was found to be more effective against habitual crop raiders. Most of the settlements, where electric fencing were erected in the middle of the study showed a decrease in crop raiding incidences.

Human deaths due to elephants in the study area were less compared to Dalma in Bihar (Datye and Bhagawat, 1995c) or NorthEast (Lahiri-Choudhury, 1980). Attitude of the people seems to contribute a lot while projecting the problem of crop raiding in Wayanad. Francis (1994) has mentioned crop raiding as a common phenomenon in the erstwhile Wayanad where swamps were under cultivation. He has described the innumerable number of '*machans*' raised by the

tribal communities as one of the characteristic features of Wayanad. Intrusions of the area by the settlers who are unused to wildlife and intolerant to the ways of wildlife have also influenced the attitude of the tribals. The changes in the vegetation of the area as a result of increased settlements, cultivation and relationships between communities also contributed to the socio-economic changes, which have not been proved to be too good for wildlife, especially the elephants.

Recommendations

1. The present study revealed that elephants were responsible for most of the crop depredation in Wayanad. Regular monitoring of habitual crop raiders would help in studying their behavioural ecology.
2. The scattered settlements within the forest are hindrances to the free movement of wildlife. Majorities of the settlers within the Sanctuary have expressed their willingness to be resettled. Measures may be taken for resettling the interior enclosures thereby consolidating areas ensuring free movement of wildlife.
3. The importance of browse species including bamboo as food species of herbivores has been revealed in the present study. Measures may be taken to protect the existing browse species and enhance their availability in the habitat. This would mean reconsideration of the existing practice of bamboo extraction and action plans for enrichment of habitat.
4. The existing vayals (marshy areas) should be maintained through appropriate technique to ensure growth of palatable grass.
5. The number of live stock within the forest should be reduced.
6. Eco-development programmes may be taken up for alternate source to the people depending on the forest that would reduce their impact on the habitat to a great extent.
7. Electric fencing was found to be the most economic and effective control measures if maintained properly. Trenches though effective would cost more for maintenance.
8. Compensation for damages due to wildlife is not a permanent solution to the problem. However, timely action for compensating the loss due to crop raiding would help in building up a good rapport with the people.

References

Alatalo, R.V. 1981. Problem in the measurement of evenness in ecology. *Oikos.* 37: 199-204.

Allaway, J.D. 1979. Elephants and their interactions with people in the Tana river region of Kenya. Ph.D. Thesis, Cornell University.

Altmann, J. 1974. Observational study of behaviour-sampling methods. *Behaviour.* 49: 227-267.

Anonymous. 1987. SPSS/PC+ Trends for the IBM PC/XT/AT and PS/2. SPSS Inc. Chicago, Illinois, USA.

Appayya, M. K. 1992. Elephant damage problems and measures for mitigation in Karnataka. *My Forest.* 29(3): 257-261.

Balasubramanian, M., N. Baskaran, S. Swaminathan and A. A. Desai. 1995. Crop raiding by Asian elephant, *Elephas maximus* in the Nilgiri Biosphere Reserve, South India. In: **A week with Elephants**: Proceedings of the International Seminar on Asian elephants. (Eds.) J.C. Daniel and S.H. Datye. Oxford University Press, New Delhi.

Balasubramanian, M. 1998. An Ecological Study on Asian Elephant in Wayanad Wildlife Sanctuary with emphasis on crop damage. Ph D.Thesis submitted to FRI (Deemed University), Dehra Dun.

Barnes, R.F.W. and K.L. Jensen. 1987. How to count elephants in forests. *IUCN African Elephant and Rhino Specialist Group Technical Bulletin* 1: 1-6.

Barnes, R.F.W., S. Azika and B. Asamoah-Boateng. 1995. Timber, Cocoa and crop-raiding elephants: A preliminary study from southern Ghana. *Pachyderm* 19: 33-38.

Bell, R.H.V. 1971. A grazing ecosystem in the Serengeti. *Sci. Am.* 224: 86-93.

Bist, S. S. 1996. Man-elephant conflict: Causes and control measures. *Zoo's Print.* 11: 43-46.

Blair, J. A. S. and N. M. Noor. 1981. Elephant barriers for crop defense in Peninsular Malaysia: the FELDA experience. *The Planter* 57: 289-312.

Blair, J.A.S., G.G. Boon and N.M. Noor. 1979. Conservation or cultivation: the conformation between the Asian elephant and land development in Peninsular Malaysia. *Land Dev. Digest.* 2: 27-59.

Blouch, R.A. and K. Simbolon. 1985. Elephant in North Sumatra. IUCN/WWF Report No. 9, Project 3033, Bogor.

Bohra, H.C. and S.P. Goyal 1991. Crop damage by the Chinkara Gazelle in the Arid Region of Western Rajasthan. Abstracts of paper presented in the First National Symposium on Unconventional pests: Control Vs Conservation and National Seminar on Animal Behaviour. The University of Agricultural Sciences, Bangalore.

Boutton, W.T., L.L. Tieszen and K.S. Imbamba. 1988. Biomass dynamics of grassland vegetation in Kenya. *Afr. J. Ecol.* 26: 89-101.

Bratton, S.P. 1975. The effect of the European Wild boar (*Sus scrofa)* on Gray beech Forest in the Great Smoky Mountains. *Ecology*. 56(6): 1356-1366.

Brownlow, M.J.C. 1994. Towards a framework of understanding for the integration of forestry with domestic pig (*Sus scrofa domestica)* and European Wild boar *(Sus scrofa scrofa)* husbandry in the United Kingdom. *Forestry (Oxf.)* 67(3): 189-218.

Buechner, H.K., I.O. Buss, W.M. Longhurst and A.C. Brooka 1963. Numbers and migaration of elephants in Murchison falls National Park, Uganda. *J. Wildl. Manage.* 27: 36-53.

Burnham, K.P., D.R. Anderson. and J.L. Laake. 1980. Estimation of density from line transect sampling of biological populations. *Wildl. Monogr*. 72: 1-202.

Buss, I.O. 1961. Some observations on food habits and behaviour of the African elephant. *J. Wildl. Manage.* 25: 131-148.

Caufield, C. 1984. Indonesia's great exodus. *New Scientist*. 17 May, 1984. 25-27.

Caughley, G. 1974. Bias in aerial survey. *J. Wildl. Manage*. 38: 557-562.

Caughley, G. 1977. Analysis of Vertebrate Populations. John Wiley & Sons, London.

Champion, H.G. and S.K. Seth. 1968. A revised survey of forest types of India. Government of India. Delhi.

Charnov, E.L. 1976. Optimal foraging: the marginal value theorem. *Theor. Pop. Biol.* 9: 129-136.

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

Chauhan, N.P.S. and R. Singh. 1990. Crop damage by over-abundant populations of Nilgai and Black buck in Haryana (India) and its management. Proc. 14th Vertebr. Pest. Conf. (L.R. Davis and R. E. Marsh, Eds.) University of California , Davis.

Clement, Markham, R. 1866. Report on coffee planting district of Wayanad.

Clutton-Brock, T.H., F.E. Guinness and S.D. Albon. 1982. Red Deer: The Behaviour and Ecology of Two Sexes. Chicago University Press, Chicago.

Conry, P.J. 1981. Habitat selection and use, movements and home range of Malayan gaur *Bos gaurus* hubbacki in Central Pahang, Malaysia. M.S. Thesis, University of Montana, Missoula.

Corfield, T. 1973. Elephant mortality in Tsavo National Park, Kenya. *E. Afr. Wildl. J.* 11: 339-368.

Cowan, I. McT. 1950. Some vital statistics of big game on over-stocked mountain range. Transactions of the North American Wildlife Conference. 15: 581-588.

Croze, H. 1974. The Seronera bull problem. I. The elephants. *E. Afr. Wildl. J.* 14: 265-283.

Croze, H., A.K.K. Hillman and E.M. Lang. 1981. Elephants and their habitats: How do they tolerate each other. In: Dynamics of Large Mammal Populations. (Eds.) C.W. Fowler and T.D. Smith, pp.297-316. John Wiley & Sons, New York.

Cumming, D.H.M., R.F. Du Toit and S.N. Stuart (Eds.). 1990. African Elephants and Rhinos: Status survey and conservation Action Plan. IUCN/SSC African Elephant and Rhino Specialist Group. IUCN, Gland, Switzerland. 72 pp.

Daniel, J.C., A.A. Desai, N. Sivaganesan and S.R. Kumar. 1987. Study of the ecology of some endangered species of wildlife and their habitats. The Asian Elephant. Bombay Natural History Society, Bombay.

Datye, S.H. and A.M. Bhagwat. 1995a. Estimation of crop damage and the economic loss caused by elephants and its implications in the management of elephants. In**: A week with Elephants**: Proceedings of the International Seminar on Asian elephants. (Eds.) J.C. Daniel and S.H. Datye. Oxford University Press.

Datye, H.S. and A.M. Bhagwat. 1995b. The status and conservation of Asian elephant *(Elephas maximus)* in the state of Bihar, India. In: **A week with Elephants**: Proceedings of the International Seminar on Asian elephants. (Eds.) J.C. Daniel and S.H. Datye. Oxford University Press, New Delhi.

Datye, S.H. and A.M. Bhagwat. 1995c. Man-elephant conflict : A case study of human deaths caused by elephants in parts of Central India. In: **A week with Elephants**: Proceedings of the International Seminar on Asian elephants. (Eds.) J.C. Daniel and S.H. Datye. Oxford University Press, New Delhi.

Desai, A.A. 1997. The Indian Elephant: Endangered in the land of Lord Ganesha. NCSTC-Hornbill Natural History Series, Mumbai.

Desai, A.A. and N. Baskaran. 1996. Impact of human activities on the ranging behaviour of elephants in the Nilgiri Biosphere Reserve, South India. *J. Bombay nat. Hist. Soc.* 93: 559-569.

Desai, A.A. and V. Krishnamurthy. 1992. Elephants in Meghalaya State, India: Status, conservation and conflict with agriculture. In: **The Asian Elephant: Ecology, Biology, Diseases and Management.** Proceedings of the National Symposium on Asian elephants. (Eds.) E.G. Silas, M. Krishna Nair and G. Nirmalan. Kerala Agriculture University, Trichur.

Dennett, D. Jr. 1965. Statewide Wildlife investigations: field testing methods used to prevent crop damage by deer. La. Wildlife and Fisheries Commission.

Devaraj, P. 1994. Socio-economic aspects of elephant damage problems in Andaman. Abstract of paper presented in the workshop on wildlife damage problem and control. Wildlife Institute of India, Dehra Dun, India.

Dey, S.C. 1991. Depredation by wildlife in fringe areas of North Bengal Forests with special reference to elephant damage. *Indian Forester* 117: 10.

Dinerstein, E. 1979. An ecological survey of the Royal Karnali - Bardia Wildlife Reserve, Nepal. Part II: Habitat/Animal interaction. *Biol. Conserv.* 16: 265-300.

Dinerstein, E. 1987. Deer, Plant phenology and succession in the Lowland Forests of Nepal. In: (Ed) C.M. Wemmer. Biology and Management of the Cervidae. Smithsonian Institution Press. Washington DC.

Douglas-Hamilton, I. 1972. On the ecology and behaviour of the African Elephant, D. Phil thesis, University of Oxford, England.

Downing, R.N. 1980. Vital statistics of animal populations. In: Wildlife management technique manual (4th edition). (Ed.) S.D. Schemnitz. The Wildlife Society, Washington DC.

Dubey, Y and A.R. Rahmani. 1994. Damage by Black buck in a Jau, *Hordeum vulagare* field in Atrauli, Aligarh District. Abstract of the paper presented in the Workshop on Wildlife Damage problems and control held at Wildlife Institute of India, Dehra Dun.

Dublin, H.T. 1996. Elephants of the Masai Mara, Kenya: Seasonal habitat selection and group size patterns. *Pachyderm* 22: 25-35.

Dublin, H.T. 1995. Vegetation dynamics in the Serengeti-Mara ecosystem: the role of elephants, fire and factors. In: Serengeti II: Dynamics, Management and Conservation of an Ecosystem. (Eds.) A.R.E. Sinclair and P. Arcese. University of Chicago Press. Pp. 71-90.

Dublin, H.T. and I. Douglas-Hamilton. 1987. Status and trends of elephants in the Serengeti-Mara ecosystem. *Afr. J. Ecol.* 25: 19-33.

Dunckan, P. 1975. Topi and their food supply. Ph.D. thesis, University of Nairobi, Nairobi.

Easa, P.S. 1989a. Certain Aspects of Ecology and Ethology of the Asian elephant (*Elephas maximus* Linn.) in Parambikulam Wildlife Sanctuary, South India. Ph. D. Thesis, University of Kerala, Trivandrum, 199 pp.

Easa, P.S. 1989b. Factors influencing the home range and movement of Asian Elephant (*Elephas maximus*) in Parambikulam Wildlife sanctuary. In: Proceedings of First Kerala Science Congress, 436-441. (Ed.) N.B. Nair. 26-28 February. State Committee on Science, Technology and Environment, Thiruvananthapuram.

Easa, P.S. 1994. **Project Elephant. Management Plan for Elephant Reserves in Kerala.** Kerala Forest Research Institute, Peechi, Kerala.

Easa, P.S. 1998. A survey of Reptiles and Amphibians in Kerala part of Nilgiri Biosphere Reserve, KFRI Research Report No.148. Kerala Forest Research Institute, Peechi, Trichur.

Easa, P.S. and C.P. Shaji. 1997. Freshwater fish diversity in Kerala part of Nilgiri Biosphere Reserve. *Curr. Sci.* 73(2): 180-182.

Easa, P.S. and S.C. Basha. 1994. Man-wildlife conflict - A case study of the Wayanad Wildlife Sanctuary, Southern Western Ghats, Kerala. Abstract of paper presented in the workshop on wildlife damage problem and control. Wildlife Institute of India, Dehra Dun.

Eisenberg, J.F. and M. Lockhart. 1972. An ecological reconnaissance of Wilpattu National Park, Ceylon. Smithsonian Contribution of Zoology, Number 101, Smithsonian Institution Press, Washington.

Ekobo, A. 1995. Elephant in the Lobeke forest, Cameroon. *Pachyderm* 19: 73-80.

Eltringham, S.K. 1977. The numbers and distribution of elephant, *Loxodonta africana* in the Rwenzori National Park and Chambura Game Reserve, Uganda. *E. Afr. Wildl. J.* 15: 19-36.

Fernando, A.B. 1990. Past and present interactions, location and intensity. Proceedings of the seminar on the conservation for elephants of Sri Lanka. Colombo, Sri Lanka. Dept. of Wildlife Conservation, Ministry of Lands, Irrigation and Mahaweli Development and USAID.

Francis, W. 1994 (reprint). The Nilgiris. Madras District Gazetteers. Asian Educational services New Delhi.

Fuller, W.A. 1960. Behaviour and social organisation of the wild bison of Wood Buffalo National Park. *Canad. Arctic.* 13: 1-19.

Genov, P. 1984. Food preferences of wild boar with regard to various potato cultivators. *Colloq. Inst. Natn. Recherche Agron.* 22: 201-204.

Ghosh, D.K. 1994. Crop depredation around Jaldapara Sanctuary by *Rhinoceros unicornis* - an indicative trend. Abstract of paper presented in the Workshop on Wildlife damage problems and control, Wildlife Institute of India, Dehra Dun.

Ghosh, D.K. 1996. Crop depredation around Jaldapara Sanctuary by *Rhinoceros unicornis* - an indicative trend. *Indian Forester.* 122(10): 884-896.

Gill, J. 1967. The physiological properties of the European bison. Acta Theriol. 12: 349-360.

Gopinathan, V. 1990a. Crop damage by elephants in Wayanad. In: The Proceedings of the Elephant Symposium, Kerala Forest Department (Wildlife Wing), Thiruvananthapuram.

Gopinathan, V. 1990b. The First Management Plan for Wayanad Wildlife Sanctuary (1990-1991 to 1999-2000). Kerala Forest Department, Thiruvananthapuram.

Grubb, P. 1974. Population dynamics of the Soay sheep. In Island Survivors: the Ecology of the Soay Sheep of St. Kilda. (Eds.) P.A. Jewell, C. Milner and J.M. Boyd, pp. 242-272. Athlone Press, London.

Heip, C. 1974. A new index measuring evenness *J. Marine biological association* 54: 555-557.

Hill, M.O. 1973b. Diversity and evenness: A unifying notation and its consequences. **Ecology**. 61: 237-249.

Hoare, R.E. 1995. Options for the control of elephants in conflict with people. *Pachyderm* 19: 54-63.

Hussain, S. 1993. Elephantine problem: Rogues stalk the Northeast. *The Week* (Weekly Magazine), September 26, 1993.

Imperial Gazatter of India. 1908. Provincial series, Vol.2. Madras Government Press, 348pp.

Indurkar, R.N., Tyagi, D.K., Gujar, S.M. and V.B. Patil. 1994. The Black buck-Farmer interface in Ahmednagar and Shaolapur districts of Maharashtra. Abstract of the paper presented in the Workshop on Wildlife Damage problems and control held at Wildlife Institute of India, Dehra Dun.

Ishwaran, N. 1984. The ecology of the Asian elephant (*Elephas maximus* L.) in Sri Lanka. Ph.D thesis (Unpublished), Michigan State University.

Jachmann, H. 1991. Evaluation of four survey methods for estimating elephant densities. *Afr. J. Ecol.* 29: 188-195.

Jaczewski, Z.1958. Reproduction in the European bison, *Bison bonasus* L., in reserves. *Acta Theriol.* 1: 333-376.

Jarman, M.V. and P.J. Jarman, 1973. Daily activity of Impala. *E. Afr. Wildl. J.* 11: 75-92.

Jarman, P.J. and A.R.E. Sinclair. 1979. Feeding strategy and the pattern of resource - partioning in ungulates. In: (Eds.) Sinclair, A.R.E. and M.Norton - Griffiths. **Serengeti. Dynamics of an ecosystem**. University of Chicago Press, Chicago, USA.

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. *Biol. Conserv.* 68(2): 149-154.

Kiiru, W. 1995. The current status of human-elephant conflict in Kenya. *Pachyderm* 19: 15-19.

Klein, D.R. 1968. The introduction, increase and crash of reindeer on St. Mathew Island. *J. Wildl. Manage.*, 32: 350-367.

Kothari, A. P. Pande, S. Singh, and D Variava, 1989. Management of National Parks and Sanctuaries in India: A Status Report, Indian Institute of Public Administration, New Delhi.

Kothari, A., S.Suri and N. Singh. 1995. Conservation in India: A new direction, *Economic and Political Weekly.* 2755-2767.

Kotwal, P.C. 1994. Bustard Vs Black buck- the conservation paradox. A case study of G.I.B. sanctuary, Karera. Abstract of the paper presented in the Workshop on Wildlife Damage problems and control held at Wildlife Institute of India, Dehra Dun.

Krasinska, M., K. Cabon-Raczynska and Z.A. Krasinski. 1987. Strategy of habitat utilization by European bison in the Bialowieza Forest. *Acta Theriol.* 32:147-202.

Krasinski, Z.A. 1978. Dynamics and structure of European Bison population in the Bialowieza Primeval forest. *Acta Theriol.* 23: 3-48.

Krasinski, M., K. Cabon-Raczynska and Z.A. Krasinski. 1987. Strategy of habitat utilisation by European bison in the Bialowieza Forest. *Acta Theriol.* 32: 147-202.

Kristiansson, H. 1985. Crop damge by wild boars in Central Sweden. *Trans. Congr. Int. Union Game Biol.* 17:605-609.

Kumar, S.R. and A.A. Desai. 1992. Elephant translocation in Tamil Nadu, using the drive method. In: **The Asian Elephant: Ecology, Biology, Diseases and Management**. Proceedings of the National Symposium on Asian elephants. (Eds.) E.G. Silas, M. Krishna Nair and G. Nirmalan. Kerala Agriculture University, Trichur.

Kumar, S., A.A. Rahmani. and Y.N. Rao. 1994. Crop-damge by Black buck (*Antelopa cervicapra*) around the Great Indian Bustard Sanctuary, Nannaj (Solapur), Maharashtra. Abstract of the paper presented in the Workshop on Wildlife Damage problems and control held at Wildlife Institute of India, Dehra Dun.

Kumar, S.R. 1995. Study of peripheral population of the Asian elephant (*Elephas maximus*): Interaction with habitats and people in Hosur and Dharmapuri Forest Divisions, Tamil Nadu, South India. In: **Ecology of the Asian elephant,** Final report, Bombay Natural History Society, Bombay.

Kumar, S.R. and M.C. Sathyanarayana. 1995. Crop raiding patterns in Hosur and Dharmapuri Forest Divisions, Dharmapuri District, Tamil Nadu. In: Abstracts of the papers presented in the International Seminar on Asian Elephants. (Eds.) J.C. Daniel and H.S. Datye. Bombay Natural History Society, Bombay.

Laake, J.L., S.T. Buckland, D.R. Anderson and K.P. Burnham. 1994. Distance users guide, version 2.1. Colorado Co-operative fish and wildlife Research Unit. Colorado University, Fort Collins, USA.

Labudzki, L. 1991. Seasonal dynamics of damages by wild boar (*Sus scrofa*) to agricultural fields in West Central Poland. *Trans. Congr. Int. Union Game Biol.* 20(1): 117-124.

Labudzki, L. And Wiazelko, M. 1991. Seasonal dynamics of crop damage caused by wild boar in the research area Zielonka. *Z. Jagdwiss.* 37(4): 250-257.

Lahiri-Choudhury, D.K. 1975. A report on the problem of elephant depredation in Jalpaiguri Forest Division and part of Madarihat Range of Coochbehar Forest Division. A report submitted to West Bengal Forest Department, Calcutta. Mimeo.

Lahiri-Choudhury, D.K. 1980. An interim report on the status and distribution of elephants in Northeast India. In: **The status of the Asian Elephant in the Indian Sub-continent**. IUCN/SSC report. (Ed.) J.C. Daniel. Bombay Natural History Society, Bombay.

Lamprey, H.F. 1985. Masai impact on Kenya savannah vegetation: A remote sensing approach. Ph.D. Thesis. University of Birmingham.

Lamprey, H.F., P.E. Glover, M.I.M. Turner and R.H.V. Bell. 1967. The invasion of the Serengeti National Park by elephants. *E. Afr. Wildl. J.* 5: 151-166.

Laws, R.M. 1969. The Tsavo Research Project. *Journal of Reproduction and Fertility* (Suppl.) 6: 495-531.

Laws, R.M. 1970. Elephants as agents of habitat and landscape change in East Africa. *Oikos* 21: 1-15.

Laws, R.M. 1974. The behaviour, dynamic and management of elephant populations. In: Behaviour of Ungulates and its relation to Management (Eds.) V. Geist and F.Walther, IUCN Publication New Series 24.

Laws, R.M. and I.S.C. Parker. 1968. Recent studies on elephant populations in East Africa. *Symp. Zool. Soc. Lon.* 21: 319-359.

Laws, R.M. I.S.C. Parker and R.C.B. Johnstone. 1975. Elephants and their habitats. Clarendon Press, Oxford.

Leuthold, W. 1976. Age structure of elephants in Tsavo National Park, Kenya. *J. Appl. Ecol.* 13: 435-444.

Leuthold. W. 1977. Spatial organisation and strategy of habitat utilisation of elephants in Tsavo national Park, Kenya. *Z. Saugetierkunde* 42: 358-379.

Leuthold. W, and J.B. Sale. 1973. Movements and patterns of habitat utilisation of elephants in Tsavo National Park, Kenya. *E. Afr. Wildl. J.* 11: 369-384.

Lewis, D.M. 1987. Elephant response to early burning in monpane woodland, Zambia. *S. Afr. J. Wildl. Research* 17: 33-39.

Logon, W. 1951. A collection of treaties, Engagements and other papers of importance. 286-289.

Macchi, E; Orsi, U.G; Perrone, A. and Durio, P. 1992. Wild boar (*Sus scrofa*) damages in Cuneo Province (Piedmont, Italy NW). "Ongules/Ungulates 91", Proceedings of the International Symposium, Touglouse, France,

Septemper 2-6, 1991. Francois Spitiz, Georges Janeaus, Georges Gonzalez, and Stephane Aulagnier, editors. pp. 431-433.

Malik, I. 1994. Coping with commensal Rhesus in India. Abstract of paper presented in the Workshop on Wildlife damage problems and control, held at Wildlife Institute of India, Dehra Dun.

Manakadan, R. 1994. Crop damge by Black buck (*Antelopa cervicapra*) at Rollapadu Wildlife Sanctuary, Andhra Pradesh. Abstract of the paper presented in the Workshop on Wildlife Damage problems and control held at Wildlife Institute of India, Dehra Dun.

McKay, G.M. 1973. **Behaviour and ecology of the Asiatic elephant in South Eastern Ceylon,** Smithsonian Contribution to Zoology, Number 125, Smithsonian Institution Press, Washington DC.

McNaughton, S.J. 1985. Ecology of a grazing ecosystem. The Serengeti. *Ecol. Monogr.* 55: 259-294

McNaughton, S.J. 1987. Adaptation of herbivores to seasonal changes in nutrient supply. In: The nutrition of herbivores. (Eds.) J.B. Hacker, and J.H. Ternoth. Academic Press, Sydney, Australia.

Meagher, M. 1989. Evaluation of boundary control for Bison of Yellowstone National Park. *Wildl. Soc. Bull.* 17(1): 15-19.

Mishra, H.R. 1982. Balancing human needs and conservation in Nepal's Royal Chitwan National Park. *Ambio.* 11: 246-251.

Mishra, J. 1971. An assessment of annual damage to crops by elephants in Palamau District, Bihar. *J. Bombay nat. Hist. Soc.* 68: 307-310.

Moore, W.G and Folk III . R.H. 1978. Crop damage by White-tailed Deer in the Southeast. *Proc. Annu. Conf. Southeast. Assoc. Fish Wildl. Agencies.*32: 263-268.

Murthy, R.S. 1994. A case study of man-animal conflict in Sarguja and Raigarh District of Madhya Pradesh (India). Abstract of paper presented in the workshop on wildlife damage problem and control. held at Wildlife Institute of India, Dehra Dun.

Mussa, P.P. and Debernardi, M. 1990. Research on damages caused by wild boars (*Sus scrofa*) in piemont and proposal of intervention. *Ann. Fac. Med. Vet. Torino.* 33: 281-290.

Naik, R.N. 1994. Stray elephant damage - Case study. Abstract of paper presented in the workshop on wildlife damage problem and control. held at Wildlife Institute of India, Dehra Dun.

Nair, P.V. and M. Gadgil. 1978. The status and distribution of elephant populations of Karnataka. *J. Bombay nat. Hist. Soc.* (*Suppl.*) 75: 1000-1016.

Nair, P.V., K.K. Ramachandran, V.S. Vijayan, P.S. Easa and P.V. Balakrishnan. 1985. **An ecological study in Periyar Tiger Reserve with special reference to wildlife**. Research Report No. 24. Kerala Forest Research Institute, Peechi, Trichur, Kerala.

Ngure, N. 1995. People-elephant conflict management in Tsavo, Kenya. *Pachyderm* 19: 20-25.

Olivier, R.C.D. 1978a. On the ecology of the Asian elephant. Ph.D. Thesis, University of Cambridge, England.

Olivier, R.C.D. 1978b. Distribution and status of the Asian elephant. *Oryx* 14: 379-424.

Onoyama, K; Akagawa, T and Karita, Y. 1990. Crop damage by Ezo Sika Deer (*Cervus nippon yesoensis*), damage-reducing methods used and their effectiveness revealed by a questionnaire survey. *Res. Bull. Obihiro Univ. Ser.* 17(1): 57-67.

Osborn, F.V. and Rasmussen. 1995. Evidence for the effectiveness of an oleo-resin Capsicum aerosol as a repellent against wild elephants in Zimbabwe. *Pachyderm* 20: 55-64.

Osborn, F.V. 1996. The ecology and deterrence of crop-raiding elephants, Research Progress. *Pachyderm* 22: 47-49.

Owen-Smith, N. 1979. *S. Afr. J. Wildl. Res.* 9: 102-110.

Owen-Smith, N. 1988. **Megaherbivores**. Cambridge University Press, Cambridge.

Peak, J.M., R.E. Lersche and D.R. Stevens. 1974. Dynamics of Moose aggregations in Alaska, Minnesota and Montana. *J. Mammal.* 55: 126-137.

Pielou, E.C. 1975. **Ecological diversity** Wiley, New York.

Prakash, I and H.C. Bohra. 1994. Economic losses due to wild animals in the Thar desert. Abstract of the paper presented in the Workshop on Wildlife Damage problems and control held at Wildlife Institute of India, Dehra Dun.

Pyke, G.H. 1983. Animal movements: An optimal foraging approach. In: The Ecology of animal movement. (Ed.) I.R. Swingland and P.J. Greenwood. pp. 7-31. Clarendon Press, Oxford.

Ramachandran, P.V. 1990. Migration of elephants in Wayanad Wildlife Sanctuary. In: The Proceedings of the Elephant Symposium, Kerala Forest Department (Wildlife Wing), Thiruvananthapuram.

Rao, V.V. and J.V.R. Rao. 1994. Crop raiding by Black buck: behavioural and ecological implications. Abstract of the paper presented in the Workshop on Wildlife Damage problems and control held at Wildlife Institute of India, Dehra Dun.

Ratcliffe, P.R. 1991. Wildlife management. Forestry Commission Hand Book, 6. Forestry practices Ed. By B.G. HIBBERD, HMSO ,London.

Reddy, C.A. 1994. Elephant depredation on human settlements and crop around Pakhui Wildlife Sanctuary. Abstract of the paper presented in the workshop on wildlife damage problem and control. held at Wildlife Institute of India, Dehra Dun.

Robinette, W.L., J.S. Gashwiler, J.B. Low, and D.A. Jones. 1957. Differential mortality by sex and age among mule deer. *J. Wildl. Mange.*, 21: 1-16.

Said, M.Y., R.N. Chunge, G.C. Craig, C.R. Thouless, R.F.W. Barnes and H.T. Dublin. 1995. African Elephant Database 1995. IUCN, Gland, Switzerland. 225 pp.

Sale, J.B. 1997. **An elephant conservation plan for Sabah.** Report prepared for the Government of Sabah under UNDP Project, Sabah Environmental Management Plan. Wildlife Department, Kota Kinabalu.

Santiapillai, C. 1987. **Action plan for Asian elephant conservation. A country by country analysis - A compilation**. World Wide Fund for Nature, Indonesia.

Santiapillai, C. 1994. Elephant mortality in Sri Lanka. *Gajah* 12: 48-54.

Santiapillai, C. 1996. Mitigation of human-elephant conflicts in Sri Lanka. *Gajah* 15: 1-7.

Santiapillai, C. and W.S. Ramono. 1993. Why do elephants raid crops in Sumatra. *Gajah* 11: 54-55.

Santiapillai, C. and H. Suprahman. 1984. The distribution of elephant (*Elephas maximus* L.) and an assessment of its depredation in Sumatra. WWF/IUCN 3133 No.8, Bogor.

Santiapillai, C. and M. de Silva. 1994. An action plan for the conservation and management of elephant (*Elephas maximus*) in Sri Lanka.

Santiapillai, C., M.R. Chambers and N. Ishwaran. 1984. Aspects of the ecology of the Asian elephant, *Elephas maximus* L. in the Ruhuna National Park, Sri Lanka. *Biol. Conserv.* 29: 47-61.

Schallar, G.B. 1967. **The deer and tiger**: the study of wildlife in India. The university of Chicago Press, Chicago.

Seidensticker, J. 1976. Ungulate populations in Chitawan Valley, Nepal. *Biol. Conserv.* (10): 183-210.

Seidensticker, J. 1984. **Managing elephant depredation in agricultural and forestry projects**. A World Bank Technical Paper. ISSN 0253-7494. The World Bank, Washington D.C., USA.

Shackleton, D.M. 1968. Comparative aspects of social organisation of American bison. The University of Western Ontario, London.

Shaji, C.P. and P.S.Easa. 1997. Freshwater fish diversity in Wayanad, keral, South India. *J. Zool. Soc. Kerala.* 5(1&2): 30-36

Shanmuganathan, K. 1985. Elephants in Tamil Nadu - A Status Report. Office of the Addl. C.C.F., Tamil Nadu.

Shannon, C.E and Weiner, W. 1949. **Mathematical theory of communication**. University of Illinois Press Urbana.

Sharma, D. 1994. Tree damage by Indian Crested Porcupine. Abstract of paper presented in the Workshop on Wildlife damage problems and control, held at Wildlife Institute of India, Dehra Dun.

Sheldon, A.L. 1969. Equitability indices dependence on the species count. *Ecology* 50: 466-467.

Shult, M.J. 1972. American bison behaviour patterns at Wind Cave National Park. Ph.D. Thesis, Iowa State University.

Siktel, B. S. 1994. Wildlife damage in and around protected areas and outside forests. Abstract of paper presented in the Workshop on Wildlife damage problems and control, held at Wildlife Institute of India, Dehra Dun.

Simpson, E.H. 1949. Measurement of diversity *Nature*. 163: 688.

Singh, V.B. 1978. The elephant in U.P. (India) - A re-survey of its status after 10 years. *J. Bombay nat. Hist. Soc.* 75: 71-82.

Singh, R. and N.P.S Chauhan. 1991a. Assessment of damage to winter crops ('Rabi') by Nilgai in Nahar and Kairu areas of Haryana (India). Abstracts of paper presented in the First National Symposium on Unconventional pests: Control Vs Conservation and National Seminar on Animal Behaviour. The University of Agricultural Sciences, Bangalore.

Singh, R. and N.P.S. Chauhan 1991b. Economic aspect of crop losses by Nilgai and Blackbuck in Haryana. Abstracts of paper presented in the First National Symposium on Unconventional pests: Control Vs Conservation and National Seminar on Animal Behaviour. The University of Agricultural Sciences, Bangalore.

Singh , V.P. and P.K. Dixit 1994. Agricultural crop damage by wild animals close to Dudwa National Park. Abstract of paper presented in the Workshop on Wildlife damage problems and control, held at Wildlife Institute of India, Dehra Dun.

Sivaganesan, N. 1991. Ecology and conservation of Asian Elephant, *Elephas maximus* with special reference to habitat utilisation in Mudumalai Wildlife Sanctuary. Tamil Nadu, South India. Ph.D. Thesis submitted to Bharathidasan University, Trichy, Tamil Nadu.

Smith, A.K.K.H., E. de. Merode, A. Nicholas, B. Buls and A. Ndey. 1995. Factors affecting elephant distribution at Garamba National Park and surrounding reserves, Zaire, with a focus on human-elephant conflict. *Pachyderm* 19: 39-48.

Stromayer, K.A.K. and A. Ekobo. 1992. The distribution and number of forest dwelling elephants in extreme South-eastern Cameroon. *Pachyderm* 15: 9-14.

Sukumar, R. 1985. **Ecology of the Asian elephant, *Elephas maximus* and its interaction with man in south India**. Ph.D. Thesis submitted to Indian Institute of Science, Bangalore.

Sukumar, R. 1989. **The Asian Elephant: Ecology and Management**. Cambridge University Press, Cambridge.

Sukumar, R. 1988. Male-female differences in foraging on crops by Asian elephants. *Anim. Behav.* 36: 1233-1235.

Sukumar, R. 1990. Ecology of Asian Elephants in southern India. II. Feeding habits and crop-raiding patterns. *J. Trop. Ecol.* 6: 33-53.

Tchamba, M.N. 1993. Number and migration pattern of Savannah Elephants (*Loxondonta africana africana*) in Northern Cameroon. *Pachyderm* 16: 66-71.

Tchamba, M.N. 1995. The Problem elephants of Kaele: A challenge for elephant conservation in northern Cameroon. *Pachyderm* 19: 26-32.

Thomas, J., S.A. Sabu Jahas and P.S. Easa. 1997. Status and distribution of reptiles in Wayanad, Kerala. *Cobra* 28: 25-30.

Thouless, C.R. 1994. Conflict between humans and elephants on private land in northern Kenya. *Oryx*, 28: 119-129.

Thouless, C.R. 1995a. Long distance movements of elephants in northern Kenya. *Afr. J. Ecol.* 33: 321-334.

Thouless, C.R. 1995b. Shocking elephants in Kenya. In: A week with Elephants: Proceedings of the International Seminar on Asian elephants. (Eds.) J.C. Daniel and S.H. Datye. Oxford University Press, New Delhi.

Thouless, C.R. and J. Sakwa. 1995. Shocking elephants: Fences and crop raiders in Laikipia District Kenya. *Biol. Conserv.* 72: 99-107.

Thurston, E. and K. Rangachari. 1909. Castes and tribes of South India. Cosmo Publications, Delhi.

Vairavel, S.M. 1998. Ecology of Gaur (*Bos Gaurus* H. Smith) with special reference to habitat utilization in Parambikulam Wildlife Sanctuary, Kerala, India. Ph D.Thesis submitted to FRI (Deemed University), Dehra Dun.

Varghese, T.C. 1970. Agrarian changes and economic consequences of land tenures in Kerala, 1850-1969. Allied publishers, New Delhi, 123-124.

Varman K.S., U. Ramakrishnan and R. Sukumar. 1995. Direct and indirect methods of counting elephant: a comparison of results from Mudumalai Sanctuary. In A week with Elephants: Proceedings of the International Seminar on Asian elephants. (Eds.) J.C. Daniel and S.H. Datye. Oxford University Press, New Delhi.

Vassant, J. and Boisaubert, B. 1984. Evaluation of experiments made in Haute-Marne to reduce wild boar damages. [Bilan Des exprimentations enterprises En Haute-Marne Pour Rduire Les Dgats De Sangliers (*Sus scrofa*) A L'ontre Des Cultures Agricoles.]. *Colloq. Inst. Natl. Recherche Agron.* 22: 187-199.

Vassant, J. And Breton, D. 1986. Reduction of damage to wheat fields (*Triticum sativum*) at the milk stage by wild boar (*Sus scrofa*): A preliminary study of the effects of the distribution of maize (*Zea mays*) in adjoining forests. *Gibier Fauna Sauvage*. 3: 83-95.

Vassant, J.; Jullien, J.M. and Brandt, S. 1987. Reduction of damage to wheat fields at the milk stage by wild boar - Effects of the distribution of maize in adjoining forests. *Trans. Congr. Int. Union Game Biol.* 18: 209.

Vassant, J.; Jullien, J.M. and Brandt, S. 1992. Reducing wild boar damage to Wheat and Oats in summer study of the effectiveness of the maize distribution in the forest. *Trans. Congr. Int. Union Game Biol.* 18(2): 79-88.

Vecellio, G.M., Yahner, R.H. and Storm, G.L. 1994. Crop damage by Deer at Gettysburg Park. *Wildl. Soc. Bull.* 22(1): 89-93.

Veeramani, A. and E.A. Jayson. 1995. A survey of crop damage by wild animals in Kerala. *Indian Forester* 22: 949-953.

Veeramani, A., E.A. Jayson and P.S. Easa. 1996. Man-Wildlife Conflict: Cattle lifting and Human Casualties in Kerala. *Indian Forester*, 122: 897-902.

Venevongphet. 1995. The status of elephant in Laos. In **A week with Elephants**: Proceedings of the International Seminar on Asian elephants. (Eds.) J.C. Daniel and S.H. Datye. Oxford University Press, New Delhi.

Watson, A. and R. Moss. 1970. Dominance, spacing behaviour and aggression in relation to population limitation in vertebrates. In: Animal population in relation to their food resources. (Ed.) A. Watson. Blackwell Scientific Publications, Oxford.

Watson, R.M. and R.H.V. Bell. 1969. The distribution, abundance and status of elephant in the Serengeti region of Northern Tanzania. *J. Appl. Ecol.* 6: 115-132.

Watve, M. 1992. Ecology of host-parasite interactions in a wild mammalian host community in Mudumalai, Southern India. Ph.D. thesis. Indian Institute of Science, Bangalore.

Weigum, L.E. 1972. The problems in the preservation of the Seladang in the Malaysian National Park. M.S. Thesis, Michigan State University, East Lansing.

Western, D. And W.K. Lindsay. 1984. Seasonal hard dynamics of a savannah elephant population. *Afr. J. Ecol.* 22: 229-244.

Wiegert, R.G. 1962. The selection of an optimum quadrat size for sampling the standard biomass of grass and forbs. *Ecology* 43: 125-129.

Williamson, B.R. 1975. The condition and nutrition of elephant in Wnakie National Park. *Arnoldia* 7: 1-20.

Wu, L.S.-Y. and D.B. Botkin. 1980. Of elephants and men: A discrete, stochastic model for long-lived species with complex life histories. *Am. Natur.* 116: 831-849.

Xiang, Z. and C. Santipillai. 1995. Conservation of elephants in Xishuangbanna, China. In A week with Elephants: Proceedings of the International Seminar on Asian elephants. (Eds.) J.C. Daniel and S.H. Datye. Oxford University Press, New Delhi.

Yadav, V.K. 1994. Man-elephant conflict in north Bengal, India. Abstract of paper presented in the workshop on wildlife damage problem and control. Wildlife Institute of India, Dehra Dun, India.