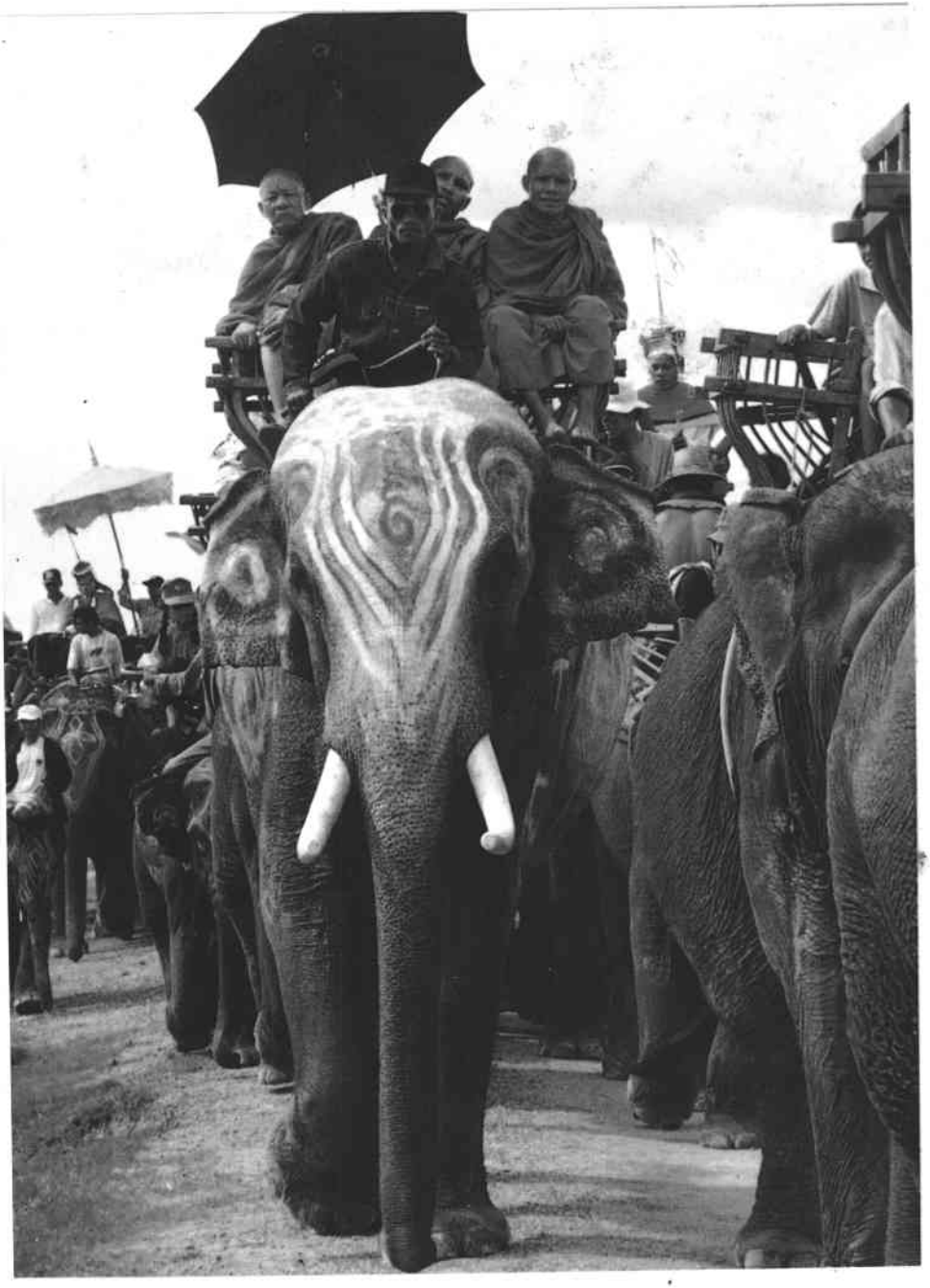
GAJAH

JOURNAL OF THE ASIAN ELEPHANT SPECIALIST GROUP



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Editor
Dr CHARLES SANTIAPILLAI
Executive Officer
IUCN/SSC Asian Elephant Specialist Group
Department of Zoology
University of Peradeniya,
Peradeniya, Sri Lanka.

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Dr. Charles Santiapillai
Department of Zoology
University of Peradeniya,
Peradeniya, SRI LANKA.

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Editor

CHARLES SANTIAPILLAI

Associate Editor

LYN DE ALWIS

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MITIGATION OF HUMAN - ELEPHANT CONFLICTS IN SRI LANKA

Charles Santiapillai
Department of Zoology, University of Peradeniya
Peradeniya, Sri Lanka.

INTRODUCTION

The basic inability of human beings and wild elephants to co- exist without some conflict was recognized in the ancient Indian treatise called "*Arthashastra*" written by Kautilia between 300 BC and AD 300 (Lahiri - Choudhury, 1991). Today, throughout Asia, elephant depreation has become a way of life. Increasing human population and incresing agricultural land use have considerably reduced the area available to wildlife in general and the elephants in particular in Sri Lanka since the turn of century. In addition, the activities of the ivory poachers and guerrillas have also tended to concentrate elephants into smaller ranges of relatively greater safety such as national parks. The obvious corollary to a decrease in a species' range is a decrease in its resource base (Croze *et al.*, 1981). The continuous contraction of the habitat available to elephants serves also to cut off certain channels of their response such as emigration and dispersion (Wastson & Bell, 1969). For a wide - ranging species like the elephant, this means that the animal's flexibility to buffer the effects of local resource depletion by moving elseshere is lost. Such a situation has led to an escalation of conflicts between man and elephant in Sri Lanka.

Ratnam (1984) in discussing the problem of crop depredation by elephants in peninsular Malaysia considers the phenomenon into three categories :-

1. where a group of elephants has been marooned by development into tiny pocket of forest which, being unable to meet the food requirements of the group, forces the animals to raid the surrounding agricultural crops.

2. where a group of elephants with sufficient useable habitat. for various reasons, still raids large adjacent development areas with a broad but unified boundary with the forest.

3. where a group of elephants with sufficient useable habitat raids a patchwork of villages, farms, orchards or smallholdings with no clearcut or unified boundary between the forest and the developed areas.

To this in Sri Lanka must be added the fourth category of crop depredations and human fatalities caused by the solitary bulls during their wanderings in search of oestrous females. The long-tern servival of the elephant in the wild in Sri Lanka will depend on how effectively the human - elephant conflicts are mitigated. The problem of elephant depredation is a complex one and there is so easy solution to resolve the problem. In Sri Lanka, man and elephant have to live together with mutual adjustment.

METHODS TO KEEP WILD ELEPHANTS AT BAY

Although it may be impossible to eliminate the human-elephants conflict totally, except by exterminating the offending animals, there is no doubt that this problem must be minimised if conservation efforts are to succed in developing countries facing harsh socio - economic realities (Sukumar, 1991). There are several methods to keep the wild elephants away from cultivated areas and according to Lahiri -Choudhury (1991), they can be divided into two catergories :-

1. Methods of combat which deal with elephants actually raiding crops, and
2. Preventive measures, which are designed to prevent elephants from such raiding.

Combative Methods :

Use of Spotlights :

Powerful car battery-operated spotlights have been found to be very effective in India (Lahiri - Choudhury, 1991) to deal with most crop raiders since elephants with a few exceptions, move away from powerful beams of light. The light must be strog and powerful to be effective. The use of torch light in fact attracts curious elephants to move towards the source (as happened in Xishuangbanna in Southern China). In the cultivated areas, a tractor or a jeep fitted with spotlights can be fairly effective in dislodging wild elephant provided the vehicle can be taken close enough to the animal . But once the vehicle is withdrawn, the elephant may come back (Sukumar, 1986).

Use of Domesticated elephants :

In India, domesticated elephants (called *koonkies*) are often used to drive back wild elephants into the forest, usually during the daytime (Lahiri -Choudhury, 1991). By using *koonkies*, a herd of about 60 wild elephants was chased away in 1980 successfully in West Bengal in NE India.

Use of fire crackers :

This is one of the most commonly used methods to chase wild elephants off cultivated areas by farmers. But elephants soon learn to recognize such psychological bluffs. Rockets that end with a bang appear to be more effective, particularly with family groups. Bamboo gun rockets have been successfully used to chase wild elephant out of cultivation in India (Morris, 1958). In the past, Wildlife Department officials in the field used to provide farmers with thunder flashes. Although these devices could not eradicate the elephant raids, they were able to mitigate the problem (Punchihewa, 1989).

Use of Loudspeakers:

In souhern India, the play back of a tape containing a jumble of noises, through loudspeakers was efective in keeping away a raiding bull elephant from a coconut farm (Sukumar, 1986). On the other hand, results of controlled experiments with tape recorded tiger calls have not been conclusive (Lahiri - Choudhury, 1991). The use ofhigh frequency sound "beepers" along with an electric fence may have potential in repelling elephants (Piesse, 1982).

Use of infrasound:

Asian elephants are known to communicate with one another using calls that range in frequency from 14 to 24 Hz (Payne *et al.*, 1985). Given that the Asian elephants can perceive calls at such low frequency better than calls at higher frequency in grassy savannahs or woodlands, over large distances (1.5 km or more), the play back of recorded distress calls of elephants could be used to drive back the wild elephants along cultivated areas. But this needs further research in identifying a frequency that is intolerable to elephants in the wild.

Use of fire arms:

Shooting with fire arms and guns over elephants may be effective in driving the animals back into th e forest. But some belligerent bulls may ignore such noises and move into cultivated areas.

Preventive Measures:

Common sense:

Gamini Punchihewa (1989) asked some Veddas in the Gal Oya Scheme the most important question as to how they managed to save their crops despite their small number vis-a-vis the density of wild animals in the area. To this question, one villager replied,

"Those days a few people existed and in stretch of land, we cleared the jungle, and prepared the land for *chenas* (shifting agriculture), we put our stockade fence, and we always avoided elephant paths. If we did come across them, we fortified these vulnerable points with giant jungle logs. We kept watch from the heights of trees..... Today most of these so called farmers come from towns, they do not keep watch but sleep and only when they awake do they know what had happened to their crops" (Punchihewa, 1989). It was also observed that most of the reported incidents of elephant damage came from colonists who were settled from towns or urban areas.

Use of Repellants :

Chemical repellants have been used as barriers, but without much effect so far (Lahiri - Choudhury, 1991). The problem is that chemicals may not persist for a long time under wet conditions. However in Sumatra, the Dutch planters even tried to hang rags soaked in human urine as a repellant against wild elephants raiding the oil palm plantations. More recently, in Zimbabwe a series of tests was conducted on free-ranging elephants to evaluate the effectiveness of a Capsicum-based aerosol as an elephant repellant, and the results indicate that it is an effective short-term repellant, up to 100m (Osborn & Rasmussen, 1995).

Changes in land -use pattern :

The most sensible option is not to plant palatable crops along the periphery of elephant reserves. Suger cane, oil palm, rubber and pineapple plantations in the vicinity of reserves having wild elephants will inevitably act as supermakets for elephants. Having established such plantations in or along elephant habitats, it would be naive to believe that they would escape the notice of the elephants.

Use of Buffer-zones :

Seidensticker (1984) recommended the establishment of "wide buffer zones" which lack any cover between the cultivated area and the natural forest. These zones, to be effective as barriers to elephant movement, should have zero appeal to the elephants. Although the idea is good, certain bulls can cross these areas into the cultivated fields.

Trenches :

To be effective, the trench has to be at least 2 m deep, 2 m across at the top and 1.8 m across at the base. However, under wet conditions, some "EAE" (Elephant Arse Erosion) can occur, often resulting in a reduction of the effective depth of the trench (Blair & Noor, 1981). The effectiveness of the trench can be improved by either strengthening the walls with concrete (expensive) or by growing

thorny vegetation along the inner-trench edge. A further improvement in the effectiveness of the trench can be made by erecting an electic fence along the inner-trench edge. But these efforts will be expensive. Alternately, s hallow trenches 1.2 m deep and 1.2 m wide can be used provided they are covered with a layer of bamboo matting which presents a psychological rather than a physical barrier. The elephants in India, feeling the bamboo mat with their trunks find it unstable and avoid treading on it. They havean instinctive sense about what surface will bear their weight (Lahiri - Choudhury 1991). The traditional elephant - proof trench, if well constructed and maintained, can be useful in minimising elephant depredations. But its usefulness must be weighed against the cost of its construction and maintenance. In Malaysia, trenches did reduce the extent of elephant damage to oil palm plantations, but usually not significantly enough to warrant their high cost (Blair & Noor, 1981).

Log fence :

In especially vulnerable areas, log fences (15 to 25 cm diameter) wrapped in barbed wire have been used in Malaysia along trenches. But these operations are very expensive and involve the extraction of suitable timber from the forest.

Electric fence :

In Peninsular Malaysia, the use of non-fatal electric fence has been found to be most effective in containing elephant depredations in oil palm plantations (Blair & Noor, 1981). The fence essentially consists of 2 strands of high tensile high carbon galvanised steel wires through which an energizer (operated either by a battery or solar panel) passes every second an electric pulse of 5,000 volts, which is non-lethal because of its very short duration (3/10,000 th of a second). It appears to be the cheapest and most effective from of all physical barriers (Lahiri-Choudhury, 1991). In one instance in Peninsular Malaysia, the fence was paralleled by elephants' footprints and dung that the electric shock had on occasions literally "knocked the shit" out of the elephants (Blair & Noor, 1981). But it is difficult to fool elephants. The tuskers have an advantage in that the ivory does not conduct electricity and so the tusks can be used to dislodge the fence or insulators. Constant maintenance is the key to the success of electric fences.

Translocation :

Pocketed elephants responsible for crop depredations can be rounded up *en masse* and either captured and moved to another safe area or driven to a new area (elephant drive). But in most cases, such translocated animals are known to have returned to their former habitat. One of the successful translocations was that in

Sumatra where a herd of 70 elephants was driven from sugar cane plantation to the way Kambas Game Reserve in 1984/85 (Santiapillai & Suprahman, 1985).

Selective removal of male elephants:

Given the fact that much of the crop depredations is caused by lone bull elephants, Sukumar (1989, 1991) argues that their removal will reduce depredation and save human lives to a far greater degree than the elimination of elephants from family herds. If only a few (less than 10 animals) bulls are causing crop depredations, then it is indeed sensible to remove them from the area of conflict. However, in Sri Lanka, the elephant is discontinuously distributed in small, local populations (or demes) and if all the crop rading bulls were to be captured and domesticated, then it would lead to a significant reduction in the genetic variation in the population and will also help accelerate the demise of several small, local populations of elephants. Removal of elephants should be the last resort of the management authority after all other options have failed. The policy of capturing a few chronic crop raiding elephants may be justified in the short-term, and undeniably has beneficial secondary consequences in providing a few animals to improve the genepool of elephants in captivity but such a policy should not become an institutionalised practice accepted as routine, in the present state of ignorance concerning the validity of assumptions on which it is based.

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ROLE OF ELEPHANTS IN SUJALKUTTAI -BANNARI CORRIDOR IN SATHYAMANGALAM FOREST DIVISION,TAMIL NADU, SOUTHERN INDIA

G. Sivasubramaniyan and N. Sivaganesan
Salim Ali Centre for Ornithology and Natural History
Kalampalayam, Coimbatore 641 010, India.

INTRODUCTION

In forests ecosystem, elephants could play a major role in shaping habitats while eating the canopy vegetation, stripping off bark and uprooting of trees both in Africa (Croze, 1974; Caughley, 1976; Leuthold, 1977; Pellew, 1983; Barnes, 1985) and in Asia (Ishwaran, 1983; Sivaganesan, 1993). Another notion about the elephant is its significance for other faunal communities through its role in the forests ecosystem, especially its ability to disperse seeds (Williamson , 1975).

Although studies (Vancuylenberg, 1977; Olivier, 1978; Choudhury, 1980; Nair *et al.*; 1980; Singh, 1978; Daniel *et al.*, 1987, Easa, 1988; Sukumar, 1989 a & 1989 b; 1990, Desai, 1991; Sivaganesan, 1991) have been carried out on ecology of Asian elephant *(Elephas maximus)* its role in forest ecosystem with regard to its interactions with other herbivores and dispersal of seeds has not been studied much in Peninsular India. Therefore, a study was attempted to :-

a) determine vegetation composition to assess abundance of browse plants available to elephants.
b) assess extent of height alteration on various plant species induced by elephants.
c) determine its impact on various size classes of food trees.
d) identify the plant species dispersed through dung and
e) find out the usage pattern of other fauna in elephant foraging niches.

STUDY AREA

The Sujalkuttai - Bannari corridor is located in the Sathyamangalam Forest Division of Tamil Nadu, Southern India. It is approximately 25 km² in length beginning at the tail end of Moyar Valley (Map 1) linking Bannari Forest Division on the eastern portion of Eastern Ghats and Kallar reserve forest of the Coimbatore Central Forest Division on the West. In many areas this corridor width is narrow(< 1 km) and it forms a bottle neck between

the Nilgiri Eastern slope which is steep and the water logged areas of the Bhavanisagar reservoir. The terrain is undulating. The study site is dominated by thorn forest (6 A/ C 1) apart from southern dry mixed deciduous forests (5 A / C 3) in the hill slopes (Champion & Seth, 1968). Common trees are; *Albizia amara, Acacia sundra, A. latronum, A. leucophloea, A. planifrons, Bauhinia recemosa, Commiphora berryi, Erythroxylum monogynum, Randia dumetorum and Ziziphus mauritiana.* Dominant shrubs are; *Cassia auriculata, Capparis spp., Grewia villosa, Grewia hirsuta,* and *Solanum spp*. Unpalatable and exotic plant species such as *Eupphorbia antiquarum, Opuntia dillenii* and *Prosopis juliflora* are colonizing in many areas which is a major threat to this corridor.

Perennial rivers such as Moyar and Bhavani are of great attraction to elephants during the dry season. The average annual rainfall is 824 mm. This area receives rainfall from both north -east and south - west monsoon but bulk of the rainfall comes from the former, from September to November.

The corridor has sizeable populations of blackbuck (*Antelope cervicopra*), fourhorned antelope *(Tetracerus quadricornis)*, striped hyena (*Hyaena hyaena*), gaur (*Bos gaurus*), sambar (*Cervus unicolor*), chital (*Axis axis*), leopard *(Panthera pardus)* and dhole (*Cuon alpinus).*

MATERIAL AND METHODS

Density of various plant species was estimated from 170 strip transects of 25x10 m which are laid randomly in the corridor. Number of individuals of each species, their girth at the breast height (gbh cm) and height (m) were recorded from each transect (Dittus, 1979). Observations on the vegetation modification induced by elephants particularly on mature trees (>10cm gbh) was collected from all the 170 transects. Data on species and parts consumed, total tree height and feeding height from the ground were collected along the feeding trails as followed by White *et.al.*, (1993). Occurrence of feeding signs on mature trees (>10 cm gbh), recruitment (>2m height saplings) and regenetation (<2m height sapling) of various species were also recorded to assess the impact of elephants' feeding. To determine the role of elephants in dispersing seeds of various plant species, 300 fresh (< 1 week old) and 743 old (< 1 month old) dung piles were visually examined in the field itself for occurrence of seeds. Abundance of various seeds in each dung pile was quantified on a four point scale: 1 (< 25 seeds per dung), 2 (< 25-50 seeds per dung), 3 (50-75 seeds per dung) and 4 (> 75 seeds per dung). Other materials like fungi were also noted whenever seen in dung piles to assess significance of elephants in providing various micro-habitats for other animals. Tracks and signs such as scats, pellet groups, kills and spurs of various animals were noted to determine their usage pattern along elephant foot paths and its foraging sites.

RESULTS

Species compostion

A total of 4394 individuals belonging to 47 species were recorded from 3.77 ha area, of which 28 were thorny species accounting for 41.2% of the total trees. These comprised mostly of *Acacia latronum* (230/ha), *Acacia planifrons* (62/ha), *Albizia amara* (46/ha) and *Commiphora berryi* (41/ha) (Table 1). These species constitute major food plants to elephants as evident from their browsing incidence. Among 16 shrub species *Fluggea leucopyrus*, *Grewia villosa*, G. *hirsuta* and *Solanum torvum* were commonly distributed. Shrub species formed up to 57.9% of the total individuals. Creepers/stragglers formed just 0.86% of the total trees enumerated. Unpalatable species such as *Dodonaea viscosa*, *Lantana camara* and *Calotropis gigantea* were observed invading the forested areas.

Feeding height

Elephants have suppressed crown height of *Acacia latronum*, *Albizia amara* and *Commiphora berryi* while feeding on the crown (Table 2). The mean feeding height on the crown portion of various tress by elephants ranged from 2.7 m to 5 m. It is of significance that more feeding signs were observed on noncoppiced individuals of *Acacia latronum* (76.7%) and *Albizia amara* (77%) and thus altering tree heights and in many cases the ultimate fate is total crown distortion.

Species eaten

Forage signs along fresh feeding trails were recorded mostly on *Acacia latronum*, *Commiphora berryi*, *Albizia amara* and *Grewia villosa* while 11 other food species were used less extensively (Table 3). Occurrence of feeding signs on various size classes varied in relation to availability. For example, feeding signs were poor on regenerating saplings. On the other hard, elephants fed predominantly on recruitment individuals of *Acacia latronum* (69%), *Albizia amara* (72%) and *Grewia villosa* (71.0%) (Table 3). Mature tree cover of *Commiphora berryi* was the most favoured species with 96% of the total feeding signs. Mature stands of *Acacia latronum* and *Albizia amara* also showed preference by elephants.

Dung contents

Seeds belonging to grasses, shrubs and trees were observed from 1043 dung piles examined during the study period. Seeds of 10 species of trees, 5 woody shrubs, 3 grasses, 1 creeper and 1 crop were observed in the dung piles and assumed to be dispersed by elephants (Table 4). Among various seed remains, *Grewia villosa* was abundant followed by *Bauhinia racemosa* and *Grewia hirsuta*. Seed remains of other species were low in

Table 1. Density and relative density of various plant species in Sujalkuttai - Bannari Corridor of Sathyamangalam Forest Division (Area sampled 3.77 ha.)

Species	Status	# individuals	Density (per ha)	Relative density
Acacia latronum	T/+	870	230.77	19.80
Acacia leucophloea	T/+	7	1.86	0.16
Acacia mellifera	T/+	9	2.39	0.21
Acacia planiferons	T/+	237	62.86	5.39
Albizia amara	T/+	176	46.68	4.01
Atalantia monophylla	T	2	0.53	0.05
Azadirachta indica	T	13	3.48	0.30
Bauhinia racemosa	T/+	10	2.65	0.23
Calotrophis gigantea	S	3	0.8	0.07
Cardiospermum halicacabum	C/+	5	1.32	0.11
Carssia auriculata	S	83	22.02	1.89
Carissa carandas	T	19	5.04	0.43
Capparis sp.	S/+	54	14.32	1.23
Cissus quadrangularis	C	3	0.8	0.07
Chloroxylon swietenia	T	61	16.18	1.39
Commiphora berryi	T/+	157	41.64	3.52
Dichrostachys cinerea	T/+	50	13.26	1.14
Dodonaea viscosa	S	70	18.56	1.59
Erythroxylum monogynum	S	136	36.07	3.09
Euphorbia antiquarum	T	21	5.70	0.49
Fluggia leucopyrus	S	736	195. 22	16.56
Grewia tiliaefolia	S/+	78	20.68	1.77
Grewia villosa	S/+	730	193. 63	16.56
Grewia hirsuta	S/+	35	9.28	0.80
Gmelina arborea	T	13	3.45	0.30
Gyrocarpus americanus	T	4	1.06	0.09
Jasminum auriculatum	C	13	3.45	0.30
Jasminum sp.	C	17	4.50	0.38
Limonia alata	T	27	7.16	0.61
Lantana camara	S	7	1.86	0.16

Table 1. continued.

Species	Status	# individuals	Density (per ha)	Relative density
Morinda tinctoria	T	1	0.27	0.02
Mundulea sericea	T	13	3.44	0.30
Opuntia dillenii	S	4	1.06	0.09
Prosopis juliflora	T/+	32	8.48	0.83
Premna sp.	T/+	52	13.79	1.18
Pithecellobium dulce	T/+	4	1.06	0.09
Pongamia pinnata	T	2	0.53	0.05
Pteralobium hexapetalum	S/+	4	1.06	0.09
Randia dumetorum	S/+	147	38.99	3.34
Randia malabarica	S/+	8	2.12	0.18
Solanum torvum	S/+	450	119.36	10.24
Sapindus emarginatus	T	2	0.53	0.05
Strychnos potatorum	T	2	0.53	0.05
Tamarindus indica	T/+	3	0.8	0.07
Terminalia tomentosa	T	2	0.53	0.05
Ziziphus mauritiana	T/+	19	5.03	0.43
Ziziphus xylopyrus	T/+	3	0.8	0.07

Total number of plant species recorded = 47
Total number of enumerated individuals = 4394
Total number of elephant food species = 23
Total number of non-food trees = 24
Diversity (H') index of food species = 3.10
Diversity (H') index of non-food tree species = 2.38

+= Food species
T= Tree; S= Shrub; C = Creeper.

number with less than 25 seeds per dung pile. It is of importance to note that *Acacia sundra* and *Hardwickia binata* which were not recorded from the transect but were observed in dung piles. Insect fauna belonging to five families were also noted from the dung piles.

Usage pattern of elephant's foot paths and foraging areas by other species

Large to medium size herbivores used elephant's foraging grounds for foraging and movement (Table 5). Local people also use the elephant trails for collecting fuel wood and lopping of trees. Cattle, sheep and goat have also shared elephant's foraging areas for feeding. However, cattle dung piles were low around the foraging sites of elephants. Pellets of chital, sambar and blacknaped hare were commonly seen around the fresh foraging areas of elephants. The branches broken by elephants may be big attraction to herbivores. However, pellet groups of blackbuck were low in the elephant's foraging areas.

Fauna associated with elephants

Dung piles of elephants provided substrate for a variety of insect fauna. Examination of dung piles revealed that insect groups belonging to 5 families, Anthopidae, Carabidae, Cholorphidae, Mosquidae and Termitidae were found (*Appendix* 1). One species of fungi belonging to *Agaricus* was noticed in old dung piles. Seeds, beetles and other insects found in the dung piles served as source of food for some bird species such as black drongo (*Dicrurus adsimilis*), common myna (*Acridotheres tristis*), forest wagtail (*Motacilla indica*), grey wagtail (*Motacilla cinerea*), grey jungle fowl (*Gallus sonnesalii*), house crow (*Corvus splendens*), Indian roller (*Coracias benghalensis*), Indian peafowl (*Pavo cristatus*), jungle crow (*Corvus macrorhynchos*), jungle myna (*Acridotheres fuscus*) and white bellied drongo (*Dicrurus caerulescens*). Dung bolus in the water bodies provided food for tadpoles and fingerlings of fishes.

Trees uprooted by elephants form foraging grounds for many herbivores; chital, sambar, blackbuck, cattle, sheep and goat (*Appendix 1*). Elephants create small sized water holes along sandy streams of Bolipallam areas in Karachikorai during peak dry season to drink the subsoil water. Water holes created by elephants are later used by other species such as chital and smaller mammals. Similarly, natural salt areas were dug out by elephants which were later used by sambar, chital, cattle and common mangoose. These salt licks dug out by elephants served as source of salt for other herbivores and livestock.

DISCUSSION

Species composition

The Sujalkuttai- Bannari corridor is dominated by open scrub vegetation with many species of thorny unpalatable species. This is a vital corridor for elephants to move from Moyar Valley to Eastern Ghats. The plant species which are not eaten by elephants, *Fluggea leucopyrus, Opuntia dillennii, Randia malabarica, Dodonaea viscosa, Lantana camara, Calotropis gigantea* and *Euphorbia antiquarum,* are proliferating due to serve biotic pressure from at least nine villages situated closer to the corridor.

Feeding height

The height reduction due to the feeding of elephants on secondary and lateral branches of trees have modified the overall vegetation physiognomy. Obviously the height ranges are easily accesible to elephants for feeding. This shows that elephants effectively control growth of the trees in order to maintain browse line for them. Since pushed over trees commonly coppice from the base, this selective damage could lead to increased availability of food at an accessible feeding level (Croze, 1974; Jachmann & Bell, 1985). In the study area trees appear to develop coppice shoots after being subjected to crown distortion by elephants' feeding activity. However, the distorted crown is available to elephants and other small sized herbivores for foraging. Occurrence of more feeding signs on non-coppice is related to feeding strategy of elephants. This feeding process has led to the formation of browsing line on trees which benefits elephants for feeding in the long run. Many vertebrate herbivores often produce browse lines on trees. In Africa elephants exerted a secondary effect by browsing the *Acacia* regrowth in Masai Mara Park, Kenya (Owen- Smith, 1988).

It is also possible that elephants avoided coppice trees due to non availability of green leafy portions and bark during the dry season. With the heavy grazing intensity of coppice trees by local livestock, the entire canopy layer tends to be degraded much and converted to open thickets of unsuitable habit for various animals.

Feeding

Out of 21 browse species, *Albizia amara, Acacia latronum* and *Commiphora berryi* were extensively used. Generally selection of browse species by elephants was in proportion to their abundance (Kalemara, 1989). Similar trend was also observed in this study. Elephants fed extensively on mature trees of *Commiphora berryi* in proportion to the availability. Preference for browsing on regrowth from previously damaged trees was observed. Similar observation was found by Owen-Smith (1988) for *Colophospermum mopane* in Africa. The present investigation revealed the depletion of *Commiphora berryi* due to heavy crown

Table 2. Extent of height alteration on trees by elephants' feeding activity in Sujalkuttai -Bannari corridor.

Food species	No. of feeding signs	Mean tree height (m)		Mean feeding height (m)		No. of feeding signs on coppice growth trees		No. of feeding signs on non-coppice growth trees	
		SD	Mean	SD	Mean	No	%	No	%
Acacia latronum	270	0.80	3.80	0.64	2.99	63	23.33	207	76.66
Acacia leucophloea	2	1.41	5.00	0.35	3.00	0	00.00	2	100.00
Acacia mellifera	5	0.44	3.80	0.41	3.10	0	00.00	5	100.00
Acacia planifrons	2	0.70	3.50	0.00	3.00	0	00.00	2	100.00
Albizia amara	100	0.82	3.38	0.48	3.07	23	23.00	77	77.00
Bauhinia racemosa	6	0.57	5.83	0.42	3.67	2	33.33	4	66.66
Commiphora berryi	102	0.19	5.08	0.13	3.99	0	00.00	102	100.00
Dichrostachys cinerea	10	0.48	3.70	0.43	3.05	3	30.00	7	70.00
Pteralobium hexapetalam	2	0.07	6.00	0.35	4.50	0	00.00	2	100.00
Pithecellobium dulce	1	0.00	6.00	0.00	5.00	0	00.00	1	100.00
Premna sp.	8	0.33	4.12	0.32	3.06	3	37.50	5	62.50
Randia dumetorum	1	0.00	3.00	0.00	0.00	0	00.00	1	100.00
Ziziphus mauritiana	2	0.35	5.50	0.18	2.75	1	50.00	1	50.00

distortion by elephants. Mature stands of several species have vanished due to uprooting and debarking by elephants in Africa (Croze, 1974; Vesey-Fitzgerald,1974; Field & Ross, 1976 ; Leuthold, 1977 ; Pellew, 1983; Barnes, 1985; Weyerhaeuser, 1985; Swanepoel & Swanepoel, 1986). In few places entire tree cover was converted to open thickets in Africa (Anderson & Walker, 1974; Thompson, 1975; Caughley, 1976; Bell , 1981). Occurrence of more feeding signs on mature trees of *Commiphora berryi* and *Dichrostachys cinerea* perhaps could lead to their disappearance from the corridor site. Sivaganesan (1993) reported possible extinction of *Ziziphus xylopyrus* from dry deciduous forests in Mudumalai Wildlife Sanctuary, as a result of elephants. Loss of plant species due to elephants feeding pressure would be higher in small- sized corridors.

Seed dispersal

Fruits of 16 plants species were dispersed by elephants through their dung. The dispersal of seeds by elephants through dung piles was reported by many authors both in Africa and Asia (Buss, 1961; Wing & Buss, 1970; Field, 1971; Williamson, 1975; Khan 1977; Alexandre, 1978; Short, 1981 & 1983; Barnes, 1982; Sivaganesan, 1992 and White *et. al.*, 1993). Although seed remains of 17 plant species were recorded from the dung piles, only *Grewia villosa* was found to be 34.1% of 1043 dung piles examined over the study period. Elephants utilized a wide variety of *Acacia* species in thorn forests and their seeds were predominantly observed in dung piles during the dry season in Mudumalai Wildlife Sanctuary, Tamil Nadu (Sivaganesan, 1991). Khan (1977) reported that fruits of 13 genera were used by elephants in Malaysia and 5 of them represented in the diet of elephants at Lope Reserve, Gabou . Olivier (1978) found that Asian elephants in rain forest in Malaysia ate fruits rarely.

It is of significance to note that elephants effectively dispersed seeds of many plants species and restored the degraded corridor forests. A few cultivated crops such as *Oryza sativa, Eleucine indica* and *Vigna guiculata* were also dispersed in the forest areas which might have come from cultivated crop fields and thus enhance the genetic diversity of the area. However, the successful establishment of seedlings dispersed through dung appears to be minimum in the study area due to the unsuitable micro habitats, coupled with heavy grazing intensity. Crawley (1983) suggested that availability of micro sites, grazing intensity and herbivore feeding are likely factors governing the seedling establishment. The other negative aspects of elephant's dispersal of seeds is the spread of exotic plants. In the study area, rapid invasion of *Prosopis juliflora* is attributed to more use of its fruits by elephants.

Fauna associated with elephants

Elephants feeding sites in degraded open thickets are heavily utilized by other species. Evidence of cattle using elephant foraging sites is scanty. Grazers move with cattle in rugged terrain which elephants tend to avoid. However, it is not applicable to goats and sheep. These animals are commonly found feeding in foraging areas of elephants. People hesitate to move in elephant's foraging areas such as gallery forests and low lying foot hill forests

Table 3. Percentage feeding signs on various size classes of food species of trees in Sujalkuttai- Bannari corridor.

Food species	Total # of feeding signs	% feeding signs					
		Mature >10cm GBH		Recruitment >2m		Regeneration <2m	
		#	%	#	%	#	%
Acacia latronum	270	72	26.66	186	68.88	12	4.45
Acacia leucophloea	2	2	100.00	0	0.00	0	0.00
Acacia mellifera	5	1	20.00	4	80.00	0	0.00
Acacia planifrons	2	0	0.00	2	100.00	0	0.00
Albizia amara	100	20	20.00	72	72.00	8	8.00
Bauhinia racemosa	6	6	100.00	0	0.00	0	0.00
Commiphora berryi	102	98	96.07	4	3.92	0	0.00
Dichrostachys cinerea	10	8	80.00	2	20.00	0	0.00
Grewia hirsuta	14	0	0.00	11	78.57	3	21.43
Grewia villosa	76	0	0.00	54	71.05	22	28.94
Pithecellobium dulce	1	1	100.00	0	0.00	0	0.00
Pteralobium hexapetalum	2	0	0.00	2	100.00	0	0.00
Premna sp.	8	7	87.50	1	12.50	0	0.00
Randia dumetorum	1	1	100.00	0	0.00	0	0.00
Ziziphus mauritiana	2	2	100.00	0	0.00	0	0.00

Table 4. Occurrence of various plant seeds and insect fauna in elephant dung piles (N = 1043) in Sujalkuttai - Bannari Corridor in Sathyamangalam Forest Division.

Food items in dung piles	Occurrence	% frequency	Ranking			
			1	2	3	4
Acacia lantronum	12	4.05	B			
Acacia chundra	7	2.36	B			
Acacia mellifera	1	0.34	B			
Albizia amara	10	3.38	B			
Albizia lebbeck	3	1.01	B			
Bauhinia racemosa	38	12.84		B		
Capparis sp.	3	1.01	B			
Cardispermum halicacabum	14	4.73	B			
Eleucine indica	2	0.68	B			
Grewia villosa	101	34.12				B
Grewia hirsuta	37	12.50		B		
Hardwickia binata	1	0.34	B			
Jasminum auriculatum	1	0.34	B			
Oryza sativa	15	5.07	B			
Prosopis juliflora	17	5.74	B			
Pteralobium hexapetalum	18	6.08	B			
Tamarindus indica	9	3.04	B			
Vigna unguiculata	3	1.01	B			
Ziziphus mauritiana	1	0.34	B			
Unknown grass spp.	3	1.01	B			
Total	296					
Insect Families						
Anthopidae	5	7.81	B			
Carapidae	8	12.50	B			
Chlorophidae	7	10.94	B			
Mosquidae	12	18.75	B			
Termitidae	32	50.00		B		
Total	64					

Ranking (# of seeds / insects per dung pile):
1= < 25, 2= <50, 3= <75, 4= >100.

Table 5. Tracks and signs of other herbivores and evidences of wood cutting in Sujalkuttai - Bannari Corridor in Sathyamangalam Forest Division (area sampled 3.77 ha)

Tracks & signs	Frequency	Density (per ha)
Sambar pellets	127	33.7
Chital pellets	252	66.8
Blackbuck pellets	12	3.2
Blacknaped hare pellets	123	32.6
Cattle dung piles	62	16.4
Pellets of goat	200	53.0
Wood cutting	69	18.3
Lopping evidence	28	7.4

APPENDIX - 1 Life forms benefited by elephants in Sujalkuttai - Bannari Corridor

Life forms	Purpose
FUNGI	
Agaricus Host	
PLANT SPECIES	
Acacia latronum	
Acacia mellifera	
Acacia sundra	
Albizia amara	(a) Dispersal of seeds through dung.
Albizia lebbeck	
Bauhinia racemosa	
Capparis sp.	
Cardiospermum halicacabum	
Eleucine indica	
Grass spp	(b) Restoration of habitats
Grewia villosa	
Grewia hirsuta	
Hardwickia binata	
Jasminium auriculatum	
Oryza sativa	
Prosopis juliflora	
Pteralobium hexapetalum	
Tamarindus indica	
Vigna unguiculata	
Ziziphus mauritiana	
INSECTS	
Antopidae	
Carabidae	
Chlorophidae	Host
Mosquidae	
Termitidae	
BIRDS	
Common Myna *(Acridotheres tristis)*	
Jungle Myna *(Acridotheres fuscus)*	
Forest Wagtail *(Motacilla indica)*	
Grey Wagtail *(Motacilla cinerea)*	
Large-pied Wagtail *(Motacilla maderaspatensis)*	
White-bellied Drongo *(Dicrurus caerulescens)*	Feeding
Black Drongo *(Dicrurus adsimilis)*	
House Crow *(Corvus splendens)*	
Jungle Crow *(Corvus macrorhynchos)*	
Indian Roller *(Coracias benghalensis)*	
Indian Peafowl *(Pavo cristatus)*	
Grey junglefowl *(Gallus sonnesalii)*	

Appendix 1. continued.

AMPHIBIANS / FISHES	
Tadpoles	Feeding on dissolved dung piles
Fish	and their contents such as parasites
AIDING IN AVAILABILITY OF FOOD	
Blackbuck *(Antelope cervicapra)*	
Cattle	Feeding on uprooted trees
Chital *(Axis axis)*	& ripe fruits
Goat	
Sambar *(Cervus unicolor)*	
Sheep	
SUBSOIL WATER CREATED BY ELEPHANTS	
Cattle	
Chital	Drinking
Goat	
Sheep	
SALTLICKS CREATED BY ELEPHANTS	
Cattle	
Chital	Feeding
Sambar	
Sheep	
Common mongoose *(Herpestes edwardsi)*	
ELEPHANT FOOT PATH	
Black buck	
Chital	
Cattle	
Goat	Moving
Hyena *(Hyaena hyaena)*	
Common mongoose *(Herpestes sp.)*	
Leopard *(Panthera pardus)*	
Sambar	
Sheep	
Sloth Bear *(Melursus ursinus)*	

for fuel wood collection in fear of elephants. Recently, Ramakrishnan (1995) reported that large number of people prefer to move 3 km from the village for fuel wood collection to avoid elephants. The more occurrence of pellet groups of chital in elephant foraging areas is perhaps due to its preference for open type of forest coupled with tolerance for human interference. By contrast, low number of pellet groups of sambar could be related to its avoidance of open forest with more biotic threats. The strong preference of blacknaped hare for elephant foraging areas may be associated with open thickets. According to Barnes (1985) elephants feeding pressure on plants affect the woody vegetation density over the whole park and this will have important implications for other ecosystem components such as soil and insect, bird and mammal populations. Elephants play a major role in this corridor. Dung piles of elephants provide host and food for many species. Fungi, insects, birds, tadpoles and fish fingerlings depend on dung piles for shelter and food. It shows co-existence of various species with elephants. Furthermore many browsed species by elephants develop coppice growth which is also used by other herbivores. For example, most of the broken branches and uprooted trees by elephants are used by other herbivores of smaller size than elephants. Similarly, elephants create subsoil water which is used by various species. It is of importance that salt licks used by elephants are easily accessible to other species as well.

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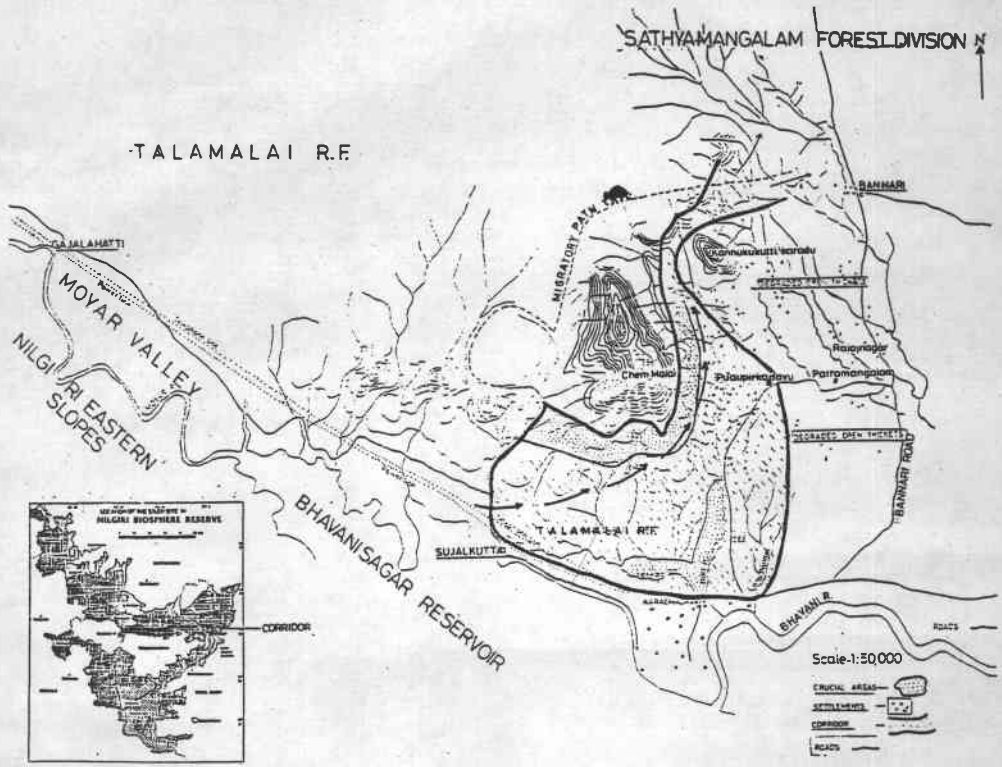
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Map 1. Map of the Sujalkuttai-Bannari Corridor in Sathyamangalam Forest Division, Tamil Nadu, Southern India.

DISTRIBUTION OF SELECTED HEAVY METALS IN BLOOD OF ASIAN ELEPHANT

S. Jayasekera and V. Y. Kuruwita
Faculty of Veterinary Medicine and Animal Science,
University of Peradeniya
Peradeniya, Sri Lanka

The biological impact of increases of heavy metals in the environment has become a major concern in recent years. The uptake, general distribution in tissues, metabolism and the effects of various heavy metals in many terrestrial species have been well studied (Sharma *et al.*, 1979 Jayasekera *et al.*, 1986, Jayasekera *et al.*, 1992). Although, they do occur in trace amounts, some metals (i.e. copper, zinc and magnesium) play important role as co-factors or components of enzyme systems involved in the metabolism in human and animal tissues, others (cadmium and lead) do not have any biogical role and are considered undesirable toxic elements (Lynch *et al.*, 1976, Sharma *et al.*, 1979). Trace metals that are essential can also exert toxic action if the physiologic threshold limits are imbalanced.

Apart from the published reports on plasma, serum norms and blood chemistry of Asian elephants (Niemuller *et al.*, 1990, Silva and Kuruwita, 1993a) there is little information available on the distribution of metals in the blood of Asian elephan (*Elephas maximus*). The study reported here investigated the occurrence and the distribution of cadmium, copper, lead, magnesium and zinc in whole blood of the Asian elephant to broaden the present knowledge of its blood chemistry. An attempt was made to compare the distribution of the selected metals between domesticated and free ranging elephants.

The test group consisted of 15 elephants from 4 to 20 years of age. Of this group, 8 were domesticated and 7 were free-ranging elephants. There were 6 male and 9 female elephants in the test group. The blood samples from the free-ranging animals were collected in duplicates when translocating them to national parks after chemical immobilization. Blood samples were collected into acid washed, heparnized test tubes from the ear vein of the animals. The samples were stored in the refrigerator and a 200 microlitre portion was digested in 2 millitres of concentrated nitric acid overnight at 70° C in a water bath. The preparation was then diluted with deionized water as appropriate prior to analysis. The metal content in the acid digested samples were analysed using an atomic absorption spectrophotomtre according to estabilished methods (Perkin-Elmer, 1976)

The mean concentration of cadmium, copper, lead, magnesium and zinc in whole blood of domesticated and wild elephants are presented in Table 1. Of the 5 metals tested, the cadmium content in blood was about 3.5 nm/1 and there was no significant difference between the values of domesticated and free-ranging elephants. While excess of cadmium is not compatible with normal physiological processes it has been observed in almost all living tissues. Statistically significant differences in copper and lead concentrations were noted in both domesticated and free- ranging elephants. It is apparent that, both copper and lead levels are significantly higher ($p \leq 0.05$) in domesticated elephants compared to those levels found in free-ranging animals. However, the concentration of copper noted in domesticated elephants in this study is about 34 percent of the value (165 micro moles/ 1) which has been reported by Debbie and Clausen (1975) for the African elephant *(Loxodonta africana)*. The reason for this discrepancy cannot percisely be explained at this point but may be related to the diet.

Elevated levels of lead in blood of cattle have been reported following outbreaks of acute poisoning and are usually associated with discrete sources of lead or contaminated feed (McEvoy and McCoy 1993) or it may be from an unlikely source. While the exact source and the form of elevated levels of lead in domesticated elephants have not been estabilished in the present study, it was noted that, the higher levels were found in elephants living in the urban environment. Nonetheless, the animals did not show any lead associated clinical manisfestations. Although an outbreak of flaccid trunk paralysis, suspected to be associated with lead has recently been reported (Oryx, 1993) the said report did not indicate the levels of lead in blood of affected elephants and suggested that, the sources of lead as water contaminated with petrol, batteries, discarded oil filters and most importantly automobile exhausts. The higher levels of lead in domesticated elephants reported in the present study may be related to the similar sources, which are usually the results of increased human activities in the urban environment. The whole blood magnesium concentration reported in this study is slightly higher than the levels which have been observed in serum (1.13 mmol/1) of the Asian elephants by Niemuller *et al*., (1990). There was no significant difference in the magnesium content between the two groups of elephants. The zinc content was slightly higher in domesticated elephants, but the mean values were not statistically different.

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Table 1. Metal concentration in blood of domesticated and free ranging elephants *

Group	Number of animals	Cadmium μ mol/l	Copper μ mol/l	Magnesium milli mol/l	Lead μ mol/l	Zinc μ mol/l
Domesticated	08	3.55 ± 1.10	55.20 ± 9.90	1.82 ± 0.28	24.13 ± 13.3	87.20 ± 12.54
Free ranging	07	3.50 ± 1.0	24.86 ± 12 90	1.80 ± 0.12	7.20 ± 2.80	72.50 ± 16.82

* Mean Concentration ± S.D.

† Significantly different from the values within the column ($P < 0.05$)

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THE ASIAN ELEPHANT IN AUSTRALIA

Jayantha Jayewardene
615 /32, Rajagiriya Gardens, Nawala Road,
Rajagiriya. Sri Lanka.

On a recent visit to Australia, I visited a number of Zoos and looked at the Asian elephants *(Elephas maximus)* there. I made further investigations regarding the Asian elephant and its history in the Zoos and Circuses in Australia. The first record of an Asian elephant in Australia is from the Taronga Zoo in Sydney. The record states that the elephant, named *Jumbo*, arrived from the Calcutta Zoo/King of Siam and died in 1896. There is no record of its sex, date of birth or when it arrived in Sydney. The record which gives both the Calcutta Zoo and the King of Siam as the origin, is confusing. Calcutta and Siam (the present Thailand) are far apart. However nothing is impossible. It is likely that the King of Siam presented this elephant to the Calcutta Zoo or some Potentate in India. The Potentate or the Zoo itself may have in turn gifted or sold the elephant to the Sydney Zoo. Interestingly *Jessie*, a female which was born in 1862, arrived in the Taronga Zoo in Sydney in 1882 and her origin too is again the Calcutta Zoo /King of Siam. Were both elephants sent to the Taronga Zoo at the same time? This is most likely. The Taronga Zoo may have had an idea of breeding these two elephants.

The record shows that the cause of *Jessie's* death was euthanasia on 26 September 1939. *Jessie* would have been 77 years old at the time of her death. Euthanasia may mean that *Jessie* was dying of old age and the authorities decided to put her to sleep. The records of the Adelaide Zoo show that a female named *Miss Siam*, of unknown age, was gifted to it by Mr. T. Elder. It was recieved at the Zoo on the 2nd of January 1884 and lived in the Zoo for 20 years till it died on 7 May 1904. On 27 November that same year the Adelaide Zoo purchased another female named *Mary Anne* from a person whose name was not recorded. This elephant lived for thirty years at the Zoo until its death on 20 January, 1934.

The Taronga Zoo seems to have been, till recently, the entry point for most of the elephants coming into Australia and may have also been the quarantine station. However the first elephant to come to the Adelaide Zoo is not on the Taronga records nor is the second elephant at Adelaide. The records at Taronga show that they have had 22 elephants in their Zoo at sometime or the other. Some of these animals had died and others had been sold mainly to circuses and one to the Ridgeway Zoo in New Zealand. Of the 22 elephants recorded at Taronga, nine have died, five have euthanasia as the cause of death and five have been sold, whilst three are exibited at present.

The Taronga records show that sixteen elephants had been kept there on their way to other Zoos and circuses. The first such elephant at Taronga was in 1930. Its stay at Taronga was only four days. Strangely the elephant had come from Hobart in Tasmania and was sent to the Auckland Zoo in New Zealand. On perusing the records at Taronga the transit elephants had been there for generally a month or so. There are others that had been there up to six months, one elephant up to nine months. It is possible that the Zoos and circuses that these elephants were bound for, were not ready for them. One of the elephants that had come to the Taronga Zoo arrived from the Durban Council in South Africa. What was an Asian elephant doing in South Africa? This may have been an elephant that the Taronga Zoo bought from a circus in South Africa. Most of the elephants in Australia seem to have come through animal suppliers and circuses. Mayfield Kennels, later known as Eurasia Exporters, have supplied the most number of elephants for the Taronga Zoo and the other destinations via Taronga.

The Perth Zoo has four Asian elephants at present. The first, *Tricia* was born in 1957 and obtained by the Zoo from Mayfield Kennels on 23 January 1963. On 15 December 1963 another three were imported from Malaysia. All three named *Silup, Siput* and *Chepam*, were born in 1989. The Auckland Zoo in New Zealand had two Asian cow elephants in 1992. *Kashin* was twenty three years old and has now been at Auckland for nearly twenty five years. She had come from a Zoo in the USA but had been caught in the jungles of Thailand. The other female was named *Burma* and was brought there in January 1990. The Zoos that have had Asian elephants are Taronga Zoo in Sydney, Royal Melbourne Zoo, Perth Zoological Gardens and Auckland Zoo in New Zealand, The Western Plains Zoo in Dubbo, New South Wales has three African Elephants (*Loxodonta africana*). The Asian elephant at the Monarto Zoo, in South Australia, died in October 1994. The Australian Species Management Programme (ASMP) has decided to concentrate on the mainland Asian sub species *(Elephas maximus indicus).*

At the Melbourne Zoo the elephants are not worked at all. They are primarily for display and are housed in an enclosure with a dry moat. There is a similar arrangement at the Taronga Zoo. At Melbourne the elephants are not chained at night or at any other time. They spend the nights in a large barn. The female is handled freely and under protection whilst the male is handled always under protection. An elephant restraint chute, which is a corral that restricts the free movement of the animal, is used. This helps in veterinary attention, blood sampling and foot care.

It does not look as if any of the Zoos have a serious breeding programme for their elephants. The animals have been mainly for exibition. There is no record of any elephant breeding in Australia, either the Asian species or the African. However with the ASMP it seems that some Zoos intend going in for a serious breeding programme. The Perth Zoo has obtained young elephants from Malaysia, and the Melbourne Zoo which has an Asian male and female at present, is also on the lookout for young females.

Table 1. Number of elephants in Australian Zoos

Name of Zoo	*Males*	*Females*	*Total*	*Remarks*
Taronga	1	2	3	*seking three elephants from Malaysia*
Dubbo	1(Af)	2(Af)	3	*has only African species. Plans to breed them*
Melbourne	1	1	2	*seeking females Asian elephants*
Adelaide	0	0	0	*no plans for elephants at the moment*
Monarto	0	0	0	*plans to get a young group of Asian elephants*
Perth	1	3	4	*plans to breed elephants*
Auckland (New Zealand)	0	2	2	*needs a male elephant*

Af = African elephant
Source: (Chandima de Alwis, Curator of Mammals, Royal Melbourne Zoo)

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STATUS OF TEMPLE ELEPHANT MANAGEMENT IN TAMIL NADU, SOUTHERN INDIA.

V.Gokula
Salim Ali Centre for Ornithology and Natural History,
Kalampalayam, Coimbatore 641 010, India.

M. Varadharajan
A. V. C. College, Manampandal, Mayiladuthurai 609 305, India.

INTRODUCTION

The Asian Elephant *(Elephas maximus)* an endangered species is declining in numbers due to habitat loss and poaching. Less than 50,000 elephants are believed to survive in the wild and an additional 15,000 in captivity, a total population size which is only 10% of the current estimate for the African elephant (Sukumar, 1986). Many who study and care for elephants believe that the future for elephant's survival rests with captive breeding programmes and it can be claimed to be a very useful and indispensible tool in conservation work. In India, zoos, circuses, working elephant camps (Forest Department) and temples are the four places where elephants are being kept in captivity but due to advances and changes in the recreation and entertainment field during the past decades the number of circus companies in India has gone down. Among the rest, zoo and working elephant camps are functioning as significant breeding centres which could reduce pressure on wild elephant population by meeting the requirements of demand through captive breeding. Since breeding is not at all an objective of elephant management in temples it does receive less attention and apparently no information is available regarding the management.

Keeping elephants in the temples has been a religous practice in India and elsewhere in Asia. In South India, 150 to 200 elephants are being kept in Hindu temples (Sukumar, 1989). Since a sizable population is preserved by these practices, knowledge about the current practices would be helpful to improve its condition through effective management with the help of zoo and working elephant camp management techniques. A survey showed that 36 -40 elephants were found to be kept in temples of Tamil Nadu, Southern India. Since most of the elephants are kept without the permission from the Forest Department, getting the exact figure is difficult. As elephants have been treated in more or less the same way in all the temples, only a representative of 12 elephants was selected for this study (for details, see Gokula, 1994).

HISTORY

Most of the elephants were purchased either through Forest Department auction or from the circus by devotees and given to the temples (mostly at the age of 3 - 5 years old) as a donation. Only the temple authorities are taking all the responsibilities for elephants from the date of acquisition untill their death. One or two mahouts (mostly non tribes) are given the charge of handling the animal. Due to the problem in maintaining and controlling bull elephants, cows are mostly preferred by the temples.

ELEPHANT ENCLOSURE

No house or shelter was specially designed and built for elephants. Some of them are given a room without enough space and some are tethered to any available pillar in the temple or outside. Most of the shelters did not match with the standards stipulated by Government of India for elephants (8.0 x 6.0 x 5.5m, Central Zoo Authorities Act, 1992) and evidently the space is not enough for free movement of the animal. Further- more in majority of elephant shelters in temples, ventilation and the drainage systems are not up to standard. Spraying of disinfectants is not regularly done. Only a few have water troughs and electricity.

DIET AND FEEDING

Elepthant like any other animal needs a balanced diet and for captive elphant this can be achieved by including grain rations in its diet in addition to the green fodder (Krishnamurthy, 1992). He further stated that the grain ration should be in the cooked form as it improves the digestion and palatability and should contain cereals like rice, wheat, finger millet and maize to meet the elephant's energy demands as they are rich in carbohydrates. Protein rich legumes such as green gram, horse gram etc, are also needed to meet the protein needs and addition of salts and minerals to meet their mineral needs. In the temple, rice alone as cooked food and 4 types of plant species (sugarcane leaves, *Zea mays* leaves, Coconut leaves and *Cyanodon* grass) as natural food are given to elephants. An average of 10.3 $\pm$ 5.87 kg of cooked food and 54.7 $\pm$ 39.87 kg of natural food (total 64.1 $\pm$ 31.6 kg day) is given to elephants. Apart from this, some of them are getting various types of food (green vegetables) through begging practices (discussed seperately). Moreover there is no difference in the quantity of food given, as the age of the elephant increases. Krishnamurthy (1992) stated that on a dry matter basis, the grain ration requirement is about 0.5% of the body weight and the daily ration of elephants should be according to the age groups. Hence the food given to temple elephants is in no way near to meet the demands of a balanced diet of the elephants.

EXERCISE

Apart from enteraining the devotees coming to the temple by offering blessings and walking either for begging practices or to the water source for bathing, literally the temple elephants do no exercise. Most of the time they were literally tethered to their house or to a pillar in the temple the whole day. This factor may phychologically or physiologically affect the animal as it spends less amount of time for resting in the wild.

MEDICAL CARE

All the elephants are provided with local medicene (herbal medicine) which is prepared by the concerned mahouts in their traditional way. No temple had a permanent veterinary doctor for elephants. The temple elephants lack adequate bath and neem oil treatment because of poor water facilities and lack of knowledge about the neem oil treatment. No adequate care was given to this job. Majority of the elephants were infested with namatode and trematode parasites. Santiapillai and Jackson (1990) stated that the elephants in captivity are prone to number of disease and therefore their care and treatment are important aspects of their management. Dhungal *et. al.*, (1990) reported worms to be one of the common health problems in captive elephants. Lack of modern medical facilities and absence of veterinarians to attend the elephants coupled with the practice of herbal medicines by majority of the mahouts and non practice of de-worming had resulted in such a poor health condition of the temple elephants.

BEGGING PRACTICES

An endangered animal begging in each and every shop and house can be seen in most of the templ cities of Tamil Nadu. Though, keeping elephants has also been a traditional religious practice since prehistoric periods, they were not trained to beg but food was given voluntarily by people. The elephants have been trained recently to beg and give "begging call" as well as "thank you call". It occurs any time of a day. It might have started because of the mahouts' interest in getting money out of it. Even though this practice seems to be bad, the elephant receives energy rich and diverse food from the people.

CONCLUSION

In all aspects, the current elephant management in temples seems to be poor because of lack of knowledge on the elephant behaviour and keeping the elephant in temples seems to be merely to adorn the temple rather than playing a role in endangered species conservation. This practice can also be effectively improved by enhancing conditions for keeping and maintaining elephants, encouraging studies on domestic elephants, and increasing the people's awareness.

RECOMMENDATIONS FOR EFFECTIVE MANAGEMENT :

1. *The current practices could be improved by encouraging research on various aspects of elephants in captivity.*

2. *Each temple or few temples (with elephants) should have a permanent veterinarian or the animals must be at least regularly taken to the local veterinary hospital.*

3. *The begging practice must be stopped.*

4. *Quality and quantity of food should be increased.*

5. *Massive funding from either government or private nature organizations for elephant care is needed.*

6. *All temple elephants should obtain the ownership certificate and licence from the Wildlife authorities. This would help in their ennumeration.*

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RANGING BEHAVIOUR OF THE ASIAN ELEPHANT *(Elephas maximus)* IN THE NILGIRI BIOSPHERE RESERVE, SOUTH INDIA

N. Baskaran and Ajay A. Desai
Bombay Natural History Society Elephant Project
Kargudi, Nilgiris 643 211, India

INTRODUCTION

The Asian elephant *(Elephas maximus)*, on account of its large size and intemperate appetite, needs large areas to forage. Bull elephants are known to take greater risks in moving out of their habitat in search of palatable, highly nutritious plants and also females in oestrus. An understanding of the home range of elephant in Asia is invaluable for its conservation and management. The home range of elephants has been extensively studied in Africa, covering habitats ranging from deserts to tropical forests. In Asia, home range has been studied in the Malaysian deciduous rain forest (Olivier, 1978). However, detailed studies on the ranging pattern of Asian elephant have been lacking. Home range sizes depend on the habitat types. This paper summarises the results of a long-term study that was carried out in the Nilgiri Biosphere Reserve in South India under the auspisces of the Bombay Natural History Society.

STUDY AREA

Much of the observations on the movement and ranging behaviour of the Asian elephant was made in the Mudmalai Wildlife Sanctuary located in the Nilgiris district of Tamil Nadu, South India. The Nilgiris Biosphere Reserve covers an area of 700 km². Mudumalai is a part of a complex of four sancuaries, the others being Bandipur Tiger Reserve (Karnataka), Nagarhole National Park (Karnataka), and Wynnad Wildlife Sanctuary (Kerala). The four areas and adjoining forest reserves cover over 3,300 km² of forest land and are known to support an estimated population of 1,800 to 2,300 elephants. Together, they form one of the largest single protected elephant populations and ranges in Asia. The terrain is undulating, with an average elevation of 1,000 m. The rainfall varies from 600 mm to 2,000 mm per annum.

MATERIALS AND METHODS

Ranging Behaviour

Data on ranging behaviour was collected from the three radio collared elephants (Priyanka, Harini and Wendy). The details of number of locations collected from these collared elephants are given in the Table 1.

Table 1. Data on radio-collared elephants

#	*Name of elephant*	*# of locations*
1.	PRIYANKA	23
2.	HARINI	30
3.	WENDY	6

The objective was to collect a minimum of four locations per month (i. e 24 locations in 6 months) for clans Priyanka and Harini and two locations per month for clan Wendy. A total of twenty three locations was collected from Priyanka and thirty locations from Harini. Though efforts were made to collect the required data every month, lack of funds made it impossible to locate the elephants when they were far away from the Mudumalai field station. Additionally, the strength of the signal from Priyanka's transmitter became very weak as the transmitter had been functioning for more than three and half years. Therefore the number of locations in different months was not even, especially in the case of Priyanka. The collared elephant Wendy was operating at Coimbatore division during the study period and therefore a total of six locations (one location per month) was collected on this animal. It was not possible to travel to this area and locate the elephant more than once given the financial and transport constraints. But efforts were made to collect information on its past movements from the local staff and people. This was possible as this clan raids crops frequently and the collared female is known in the area.

Feeding and habitat utilization

The collared elephants Priyanka and Harini were observed and data on feeding, major- habitat, micro-habitat dispersion, etc. were collected. A total of 100 hours of observations on the feeding of clans Priyanka and Harini were made. The data on habitat utilization was collected from all three collared elephants (Priyanka 23 records, Harini 30 records and Wendy 6 records) and non collared elephants (20 records).

Social organization

The data on the group size was recorded at every sighting of the collared and non collared elephants. Interaction between clans and between clans and bulls were also recorded to study spacing behaviour and reproductive behaviour. The dispersal of the identified sub adult males from the radio-collared clans was also recorded during the period.

Ranging behaviour

a. The collected data on ranging behaviour from the radio- collared elephants (from April to September 1994) were plotted on the map.

b. The plotted locations (from Septemer 1993 to September 1994) were digitized in the computer. These data were latter segregated into year and season and analyzed for annual, seasonal, daily and overall home range. The data was also analyzed to determine the spacing pattern of different clans.

c. The use of corridors by these collared elephants was also analyzed.

d. Analysis of ecological and administrative boundraies was also carried out.

Crop raiding

The crop raiding data collected from six villages during 1993 -1994 was analyzed and lodged in the computer. The combined data on crop raiding was entered and analysed.

Feeding data

A total of 115 hrs of feeding data was collected on the collared- elephants, Priyanka and Harini between October and December 1993, and from July to October 1992.

Habitat utilization

Data on habitat utilization and micro habitat use of the three radio collared elephants (Priyanka, n = 308; Harini, n = 335; and Wendy, n = 45) were entered. The non- collared elephant groups (n = 216) recorded in the study area and the radio- collared males data are yet to be entered.

Social organization

The group size of the three collared females (Priyanka, n = 236; Harini, n = 251; and Wendy, n = 45) and the males (Salim Ali and Admiral) and the non-collared elephant groups (n = 197) were entered in the computer and analysed.

RESULTS AND DISCUSSION

Home Range Size

The home range of all three clans reached an asymptotic value in the second year and there was only a marginal increase in the third year which can be expected due to minor changes in the ranging pattern due to vatiation between years in the habitat quality. In Fig. 1 the cuumulative home range size in relation to time has been plotted for clans Priyanka and Harini. Wendy shows a similar trend but has not been plotted as it has shifted its home range.

The two bulls provided data for 15 and 22 months. We have been unable to locate Salim Ali after the 15th month. The elephant itself has not been re-sighted by anyone in its former range, whereas earlier it was regularly sighted by others. It could be that its collar had. stopped functioning and it had moved to another area or that it had been poached. The male Admiral was shot dead in September 1993. Figure 2 shows the area-time curve for the two male elephants. Samil Ali was a young male in the process of establishing its own home range and there had been a gradual shift in its ranging pattern. It is certain that its home range size will increase further and the size defined in the present study is not the final size. In the case of Admiral, though the home range size shows an asymptotic value, the actual home range size has not been defined. This bull has not come into musth during the entire period due to gunshot injury resulting in the loss of body condition during the first year and it was killed in the second year. Home range sizes of males during their musth period are several times larger than the size of their non-musth period home ranges.

The overall home ranges defined for three years for the three clans Priyanka, Harini and Wendy was 670 km^2, 562 km^2 and 799 km^2 respectively. The basic information is given in Table 2. The home ranges for the three years are given in Fig. 3. The mean home range size or the range will have little or no significance for actual management (design) of elephant reserves as they represent the area used in any one year under certain climatic (therefore habitat) conditions. The clans in reality require the upper home range size defined by the cumulative figure for three years as this is the area that will support them under different climatic conditions.

Table 2. Basic data on home range of the three elephant clans.

clan	*sample size (locations)*	*home range cumulative km²*	*mean home range size km²*	*range km²*	*SD*
Priyanka	564	670	464.6	395 - 555	81.8
Harini	539	562	382.6	261 - 530	136.7
Wendy *	127	799**	288.8	19 - 799	442.7

** This lann had shifted its home range and its range should not be taken as respresentative of clan home range sizes in the study area.*

*** The actual size is 1665.3 km² but the area with actual forest cover and accessible to the clan is 799 km².*

It can be seen that home ranges are much larger than those defined in the earlier studies on Asian elephants (Desai, 1991; Easa, 1987; Olivier, 1978; Sukumar, 1985, 1989,) For elephant conservation, areas larger than 600 to 700 km² will be required in deciduous forest areas. This would be the minimum area for a single clan. The overlap between two clans can be between 0 and 80% and even assuming that two clans overlap to the extent of 50%, we would require at least 900 km² of area. In the absence of such large areas, it is likely that the clans that do not have adequate habitat will start moving into agricultural areas on the periphery for their resource (food) requirements and thus the level of human - elephant conflict will increase. Small areas of 300 km² or less are likely to be too small for long term conservation, as they are too small while the level of conflict being too high.

The home range size of males though not fully defined in this study is still larger than those defined as non-musth ranges in earlier studies. This means that the actual home range sizes are likely to be bigger or equal to those of the clans. The same problems of conflict with humans are likely in the male situation also. This too has to be taken into account when designing conservation areas for elephants. Areas of high males or bull areas as defined by Moss and Poole (1983) should get special attention when designing elephant reserves. In the low male areas (due to poaching) as in south India, new males (maturing) coming into the population will automatically adjust their new (establishing) home ranges to the available forest areas and do not pose a real problem.

Fidelity to Home Range

The annual home range for three years of clans Priyanka and Harini (Figs. 4 & 5) overlapped to a large extent with only minor shifts in the home range between years. This indicates a strong fidelity to the home range under natural conditions. Both clans tended to use the same areas consistently year after year. This is the only study other than that of Desai (1991) that has looked at home range fidelity.

The home range of Wendy shows a major shift (Fig. 6) from nothern part of Nilgiri Biosphere Reserve (NBR) to the southern part. This clan operates primarily in the thorn forests and most of its southern range has been degraded and also access to the river Bhavani has been cut off due to cultivation. As such we feel that this clan could have shifted its range due to the poor quality of its present range. This is the first recorded case of home range shift in a large forested tract. The present range it is operating in is of poor quality when compared to the areas in NBR north. This strongly suggests that clans within poor habitats or those whose home ranges are lost or degraded cannot simply move into better areas within the remaining elephant range. This could be due to competition between clans.

The above findings are vital for elephant management as thay show that elephants (clans) have specific home ranges and that they do not freely use all the available habitat (possibly due to competition) and as such when a part or whole of the home range is lost or degraded the affected clan cannot move into the remaining elephant habitat (if it isn't a part of its range) due to competition. It may have to move into agricultural areas (fewer elephants or lower competition) or into agricultural areas. Those that move into agricultural areas end up as wandering herds that cause enormous loss in crops and human lives. That habitat loss could be related to increased incidence of crop raiding.

The home range of Admiral did overlap almost tatally between the two years of study showing that males also show strong fidelity to their non-musth home range (Fig. 7). The reaction to loss of habitat of males with estabilished home ranges will be similar to that of females i.e. they will come into greater conflict with humans. Sub-adult males in the process of establishing new ranges are likely to be more flexible and therefore likely to shift into the forest (but we do not yet know anything about competition between males for resources). We can safely assume that loss or degraduation will lead to greater conflict with humans and also result in greater stress for the elephants. Both these situations are not good for the population and as such efforts should be made to reduce them.

Administrative Areas

Analysis on the legal status of home ranges of the collared animals showed that elephants move irrespective of administrative zones. Figs. 8 & 9 show the details of

percentage of home ranges that lie in different administrative zones. Though the clans Priyanka and Harini have very little part their home ranges (16.1% and 12.1% respectively outside the protected areas) they spent nearly 30% of their time in these areas. Since these two clans operates in the central areas of PAs TR, MWS and WWS) spending over 60% of their time there and together represent over 120 elephants (6% of the NBR population), the unprotected part of their home range should be included into protected areas (PAs). The home range of other male Admiral had an even larger part of its range (22,5%) out side the PAs than the other two clans Priyanka and Harini.

Clan Wendy has only 4.3% of its home with in the PAs while 92.1% of its home range lies within the Reserve Forest (Fig. 9). Trying to include all these areas into PA network will be very diiifcult as inclusion of all home ranges basically means that the entire population range will have to be converted to PAs. Socio-economic considerations generally do not permit such an action. In such cases, the Reserve Fortest area out side PAs which form a part the elephant range should be managed as elephant conservation areas. Management in these areas should take into account the requirement of elephants before embarking on any foresty operations.

Corridors

The clans and the adult bull (Figs. 10-13) all used corridors identified by earlier studies (Desai, 1991). The study shows that elephants show strong fidelity to the routes used during their seasonal movement. In species that show such fidelity to the home range and the routes for movement between seasonal ranges, creation of corridors in directions other than the established movement would be futile. Corridors between and within elephant habitat should be designed and created only after confiming that there is a movement in that direction otherwise the entire effort will be wasted.

Crop raiding

The findings clearly show that only specific clans and males raid crops Where management option also includes capture of elephants for reducing conflict it should be kept in mind that only identified raiders should, be caught. Random capture will result in some non-raiding elephants being caught and as such it will harm the population that is non-raiding and most suitable for long term conservation. The finding is that clans are also responsible for serious damage and their capture should also be considered where capture is an option. This will have a dual benefit, namely reducing the growth rate of elephant populations in already confined ranges and reducing crop damage. This may be the only option in areas like south India where male rremoval is not an option due to the skewed sex ratios. The data on elephant crop raiding was collected from six villages (Masinagudy, Moyar, Bokkapuram, Mavinhallah, Vazhithottam and Anaikatti) situated in and around of MWS between 1993 & 1994. Ten fields were selected from each village and monitored once in a month to record the elephant damage. The major crops damaged by elephants

were Green fodder (25. 80%), Ragi (3.53%) and Paddy (3.41%) (Tabele 3). Total area of crops damaged by elephants indicates that Ragi, Paddy and others together contribute 11.6% of damage while the green fodder alone contributes 88.4% of the total area damaged. The major crop raided was green fodder and the high damage inflicted could be due to poor maintinance of electric fencing. Both males and females raided the crops but the males raided more frequently (8 times) than the females (3 times). However the total area of crops damaged by females was greater (65.2%) than that by the males (34.8%). As the rain fall was low, a considerable number of fields were abandoned by the for formers during the study period.

Table 3. Details of crops damaged by elephants.

Crops	*Area cultivated (in sq.m)*	*% of damage*
Ragi	36100	3.53
Horse gram	6750	0.00
Paddy	2200	3.41
Maize	1500	0.00
Cotton	350	0.00
Others	64375	0.44
Green fodder *	48000	25.80

* *A hybrid species of Sorghum raised for cattle by the Dairy Department*

Social Organization

The data has to be analyzed but preliminary analysis shows that there are differences between dry season and the first. wet season group sizes (Fig. 14). For clan Priyanka, the mean group size during the dry season was signifiantly smaller than the 1st. wet season group size. This indicates that elephants within the clan are likely to aggregate more during the wet season than during the dry season. Group sizes in relation to seasons and habitat are to be analyzed and interactions betweeh clans and also between clans and males have been entered and preliminary analysis shows that clans avoid each other i. e. that there is competition between clans. The male Admiral did not associate with females on any appeciable level. This could be due to the fact that it was injured and did not come into musth

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Fig. 1 Cumulative monthly increase in home range size

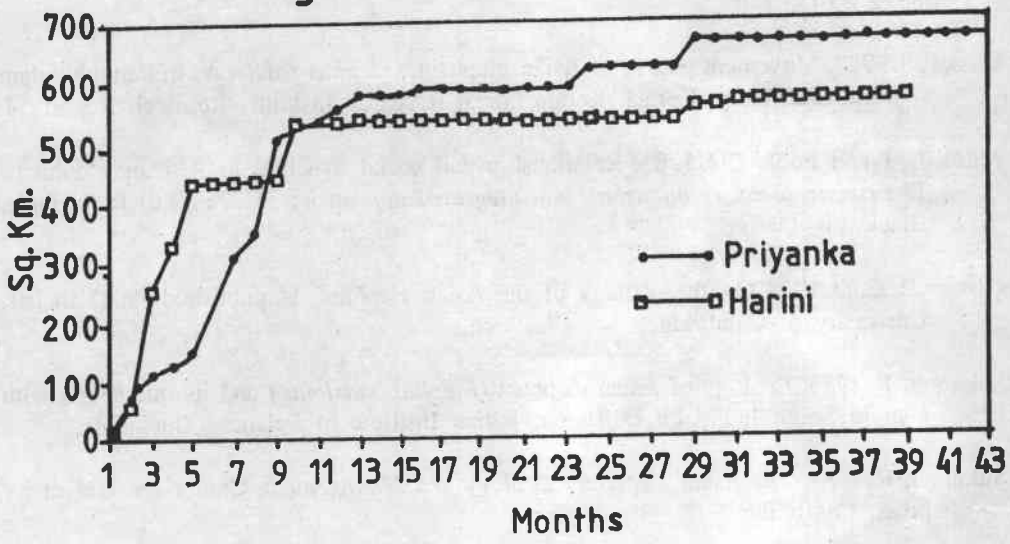
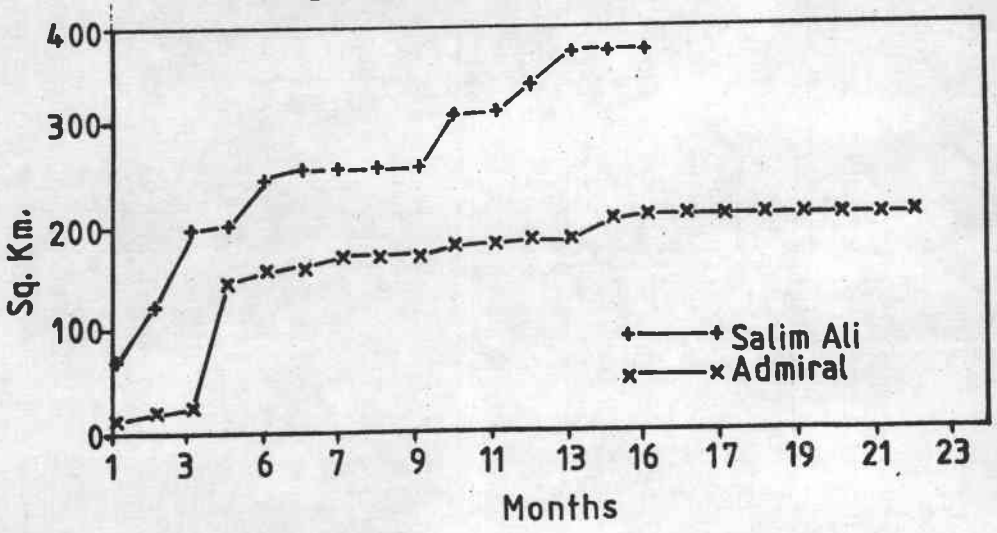
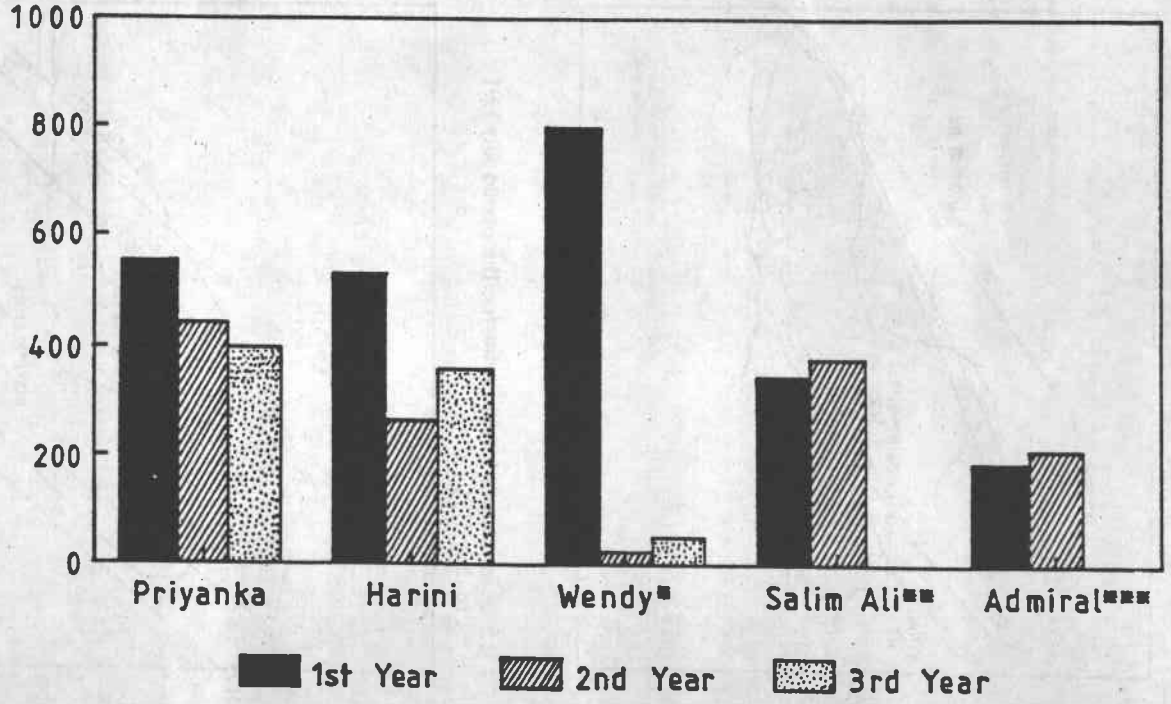


Fig. 2 Cumulative monthly increase in home range size



Inter-annual differences in home range size



* shifted its home range to new area
** 2nd year represents 22 months data
*** 2nd year represents 22 months data

Fig. 4 Home range of clan 'Priyanka' for the period March 1991 to March 1994

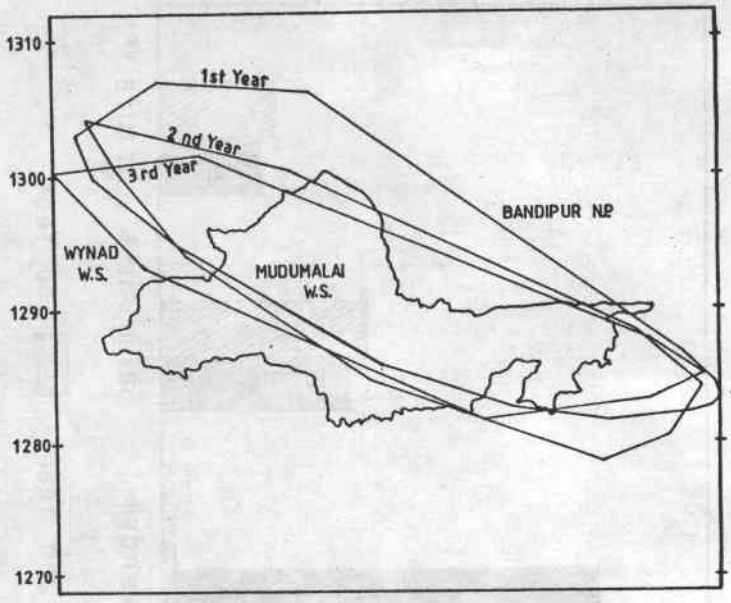


Fig. 5 Home range of clan Harini for the period July 1991 to July 1994

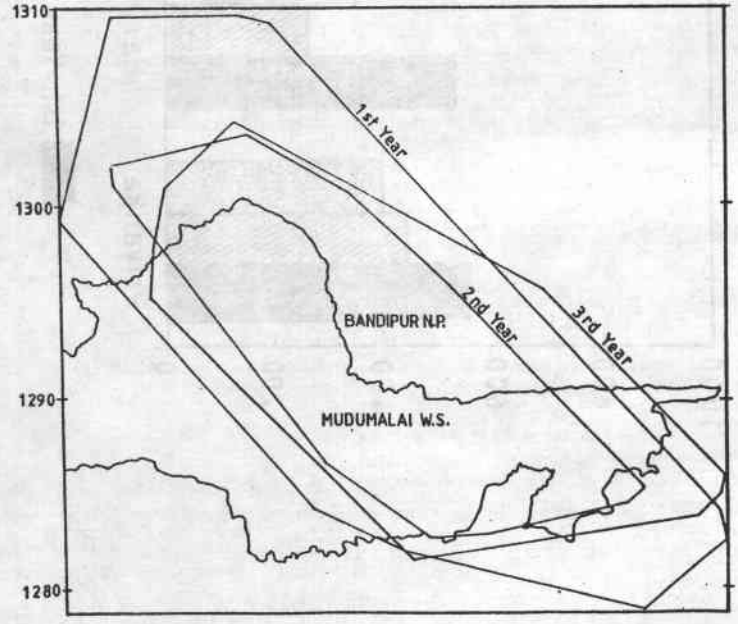


Fig. 6 Home range of clan Wendy for the period June 1991 to May 1994

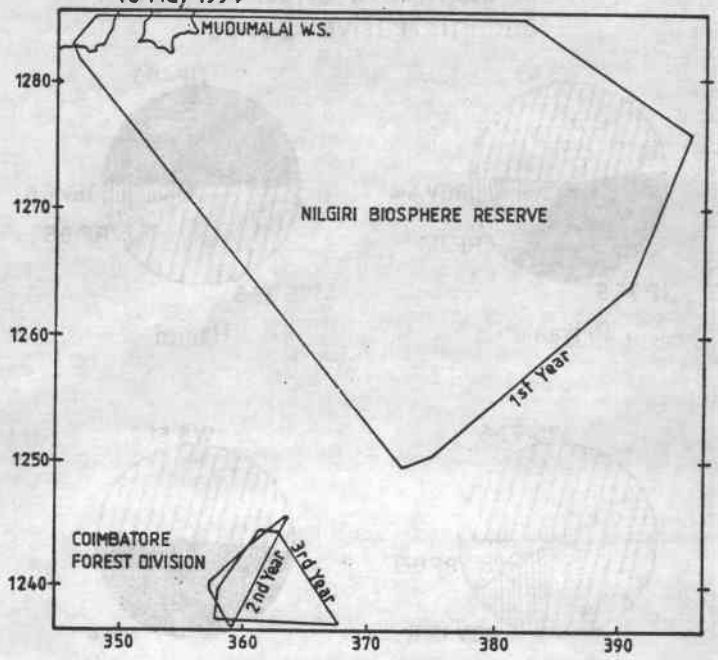
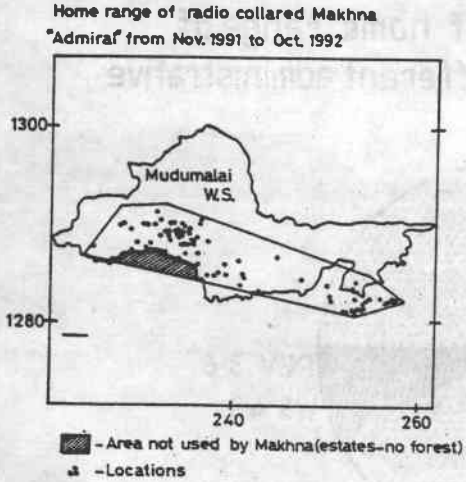


Fig. 7



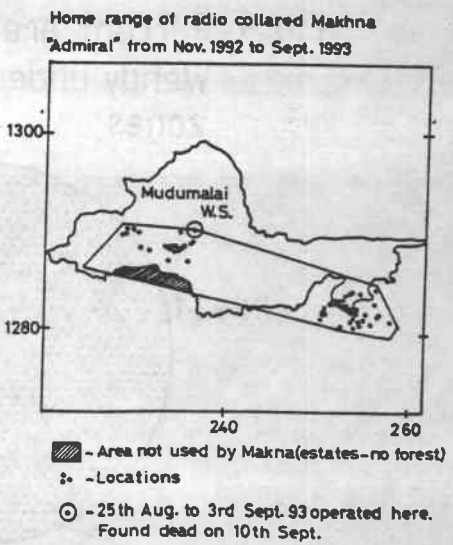


Fig. 8 Percent area of home ranges of elephants under different administrative zones

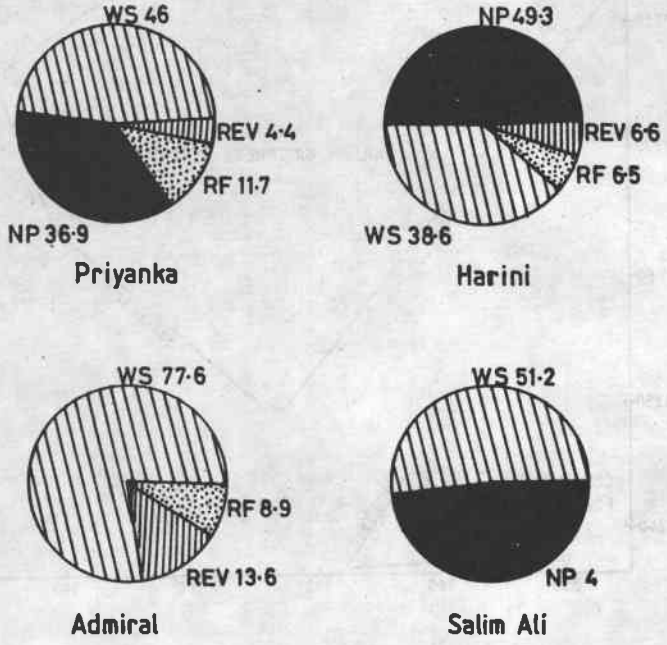
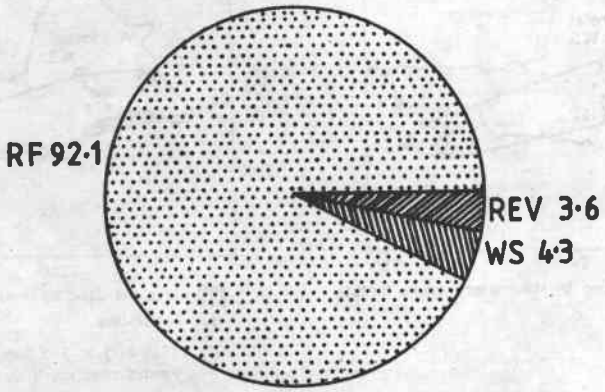


Fig. 9 Percent area of home range of Wendy under different administrative zones



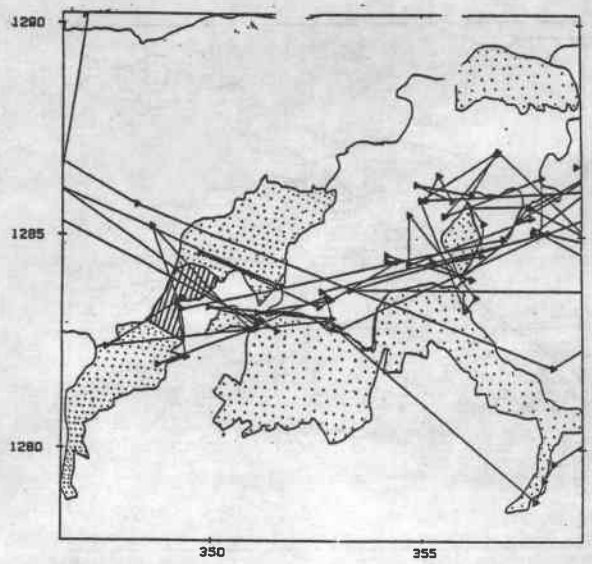


Fig 10. Corridors used by clan # 525

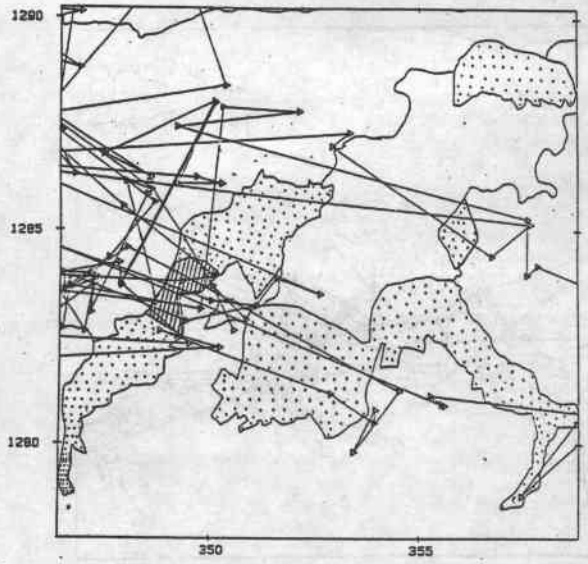


Fig 11. Corridors used by clan # 462

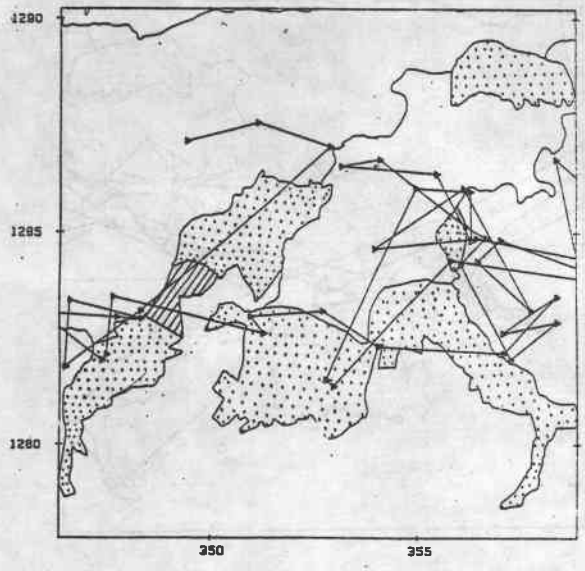


Fig 12. Corridors used by clan # 522

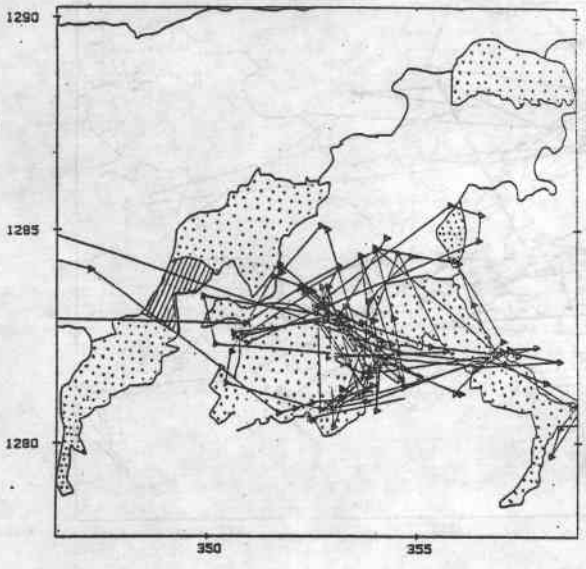


Fig 13. Corridors used by bull # 464

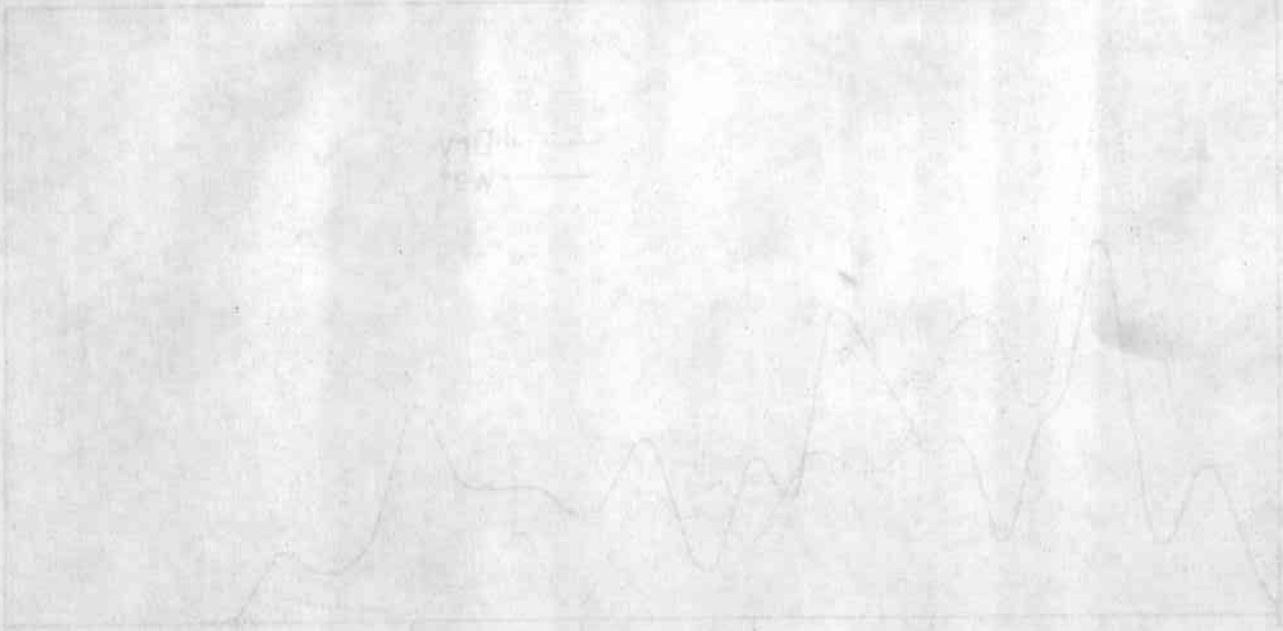
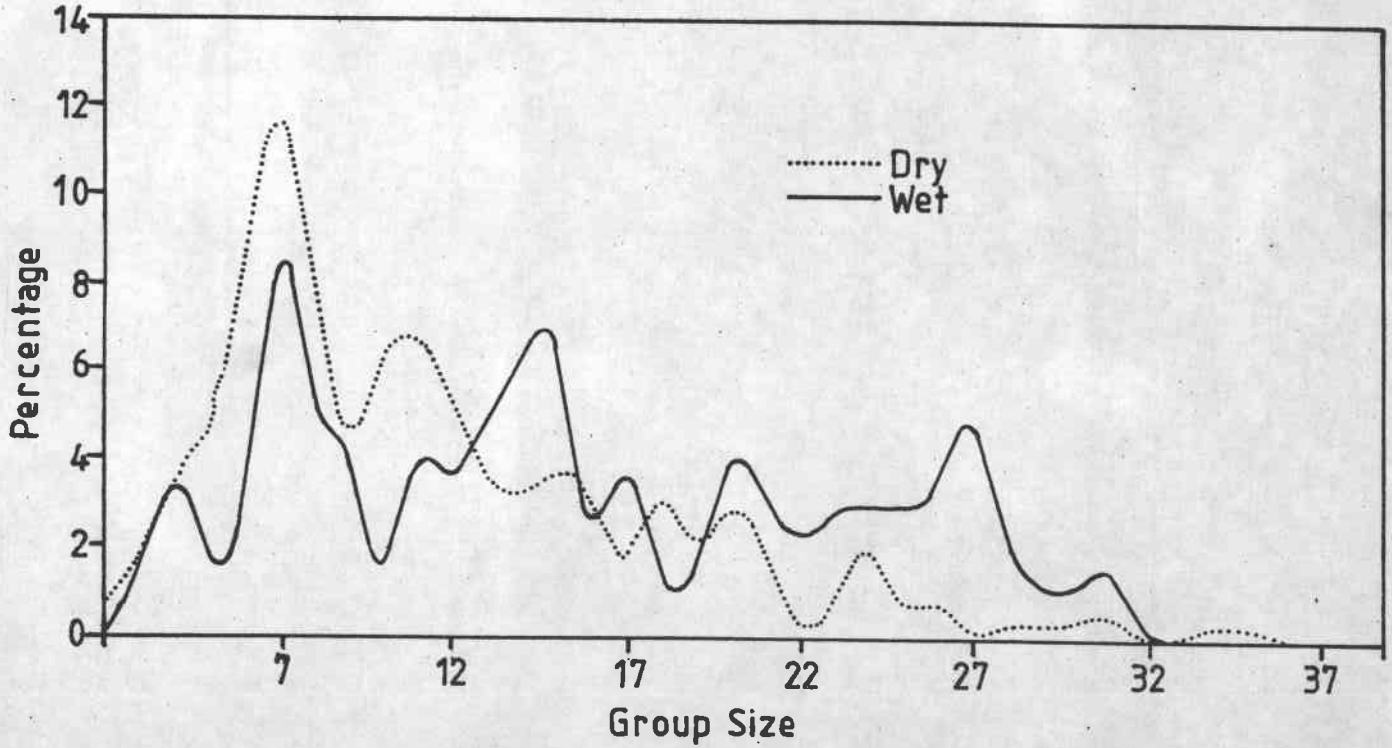


Fig. 14 Group size differences between dry and 1st wet season (Priyanka)



Front cover : Buddhist ordination parade, Surin, Thailand.
Photo : Richard Lair

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