CO-EXISTENCE OF ASIAN ELEPHANTS (*ELEPHAS MAXIMUS*) WITH HUMAN BEINGS - A DIFFICULT DREAM TO BE REALISED : A CASE STUDY FROM RAJAJI NATIONAL PARK IN NORTHERN INDIA

RITESH JOSHI* AND RAMBIR SINGH**

ABSTRACT

Elephants and human beings in Rajaji National Park in northern India are increasingly arriving into conflict because of the conversion of elephant's natural habitat into agricultural areas. Besides, railway track which passes through the park area, national highways, anthropogenic activities etc. are restricting frequent movement of elephants within their home range. In a few of the villages, farmers are not cultivating sugarcane mainly due to fear of damage by elephants. In order to identify the number of villages affected, crop raiding behaviour of elephants during period of seven years was assessed and the main reasons for crop raiding were identified. Data was collected using direct and indirect observation methods and through questionnaires and informal interviews of various farming communities and concerned local people. Trend of crop raiding by elephants was mainly undertaken by solo adult and sub-adult bulls (45%), bull groups (14%) and groups including males, females and juveniles (37%) whereas group sizes ranged from 1 - 14 individuals. Only recognized bull elephants and groups frequently strayed outside the park area. Elephants came out of the forest after sunset and return before dawn but had gradually begun moving towards outside areas after mid-day. These findings may have wider implications for developing predictive models of human-elephant interactions.

Key words : Asian elephants, crop raiding, conflict, conservation, Rajaji National Park.

Introduction

The Shivalik foothills are one of the world's most spectacular landscapes, encompassing the tall grasslands and the *Shorea robusta* (Sal) forests. This entire belt is a natural home of Asian elephants (*Elephas maximus*) besides many other wild animals like tiger, leopard, spotted deer, sloth bear etc. The Ministry of Environment and Forests, Government of India (MoEF, GoI) has declared this area as an Elephant Reserve (Rajaji National Park) with the sole aim of conservation of Asian elephants in their natural habitat. The Shivalik landscape is one of the last places in the world where elephants exist and offers urgent need for conservation. This Protected Area (PA) in India's lesser Himalayan region falls under sub-tropical moist deciduous forest type with extensive stands of *Shorea robusta* (Sal), *Mallotus phillipinensis* (Rohini), *Acacia catechu* (Khair), *Adina cordifolia* (Haldu),

* G.B. Pant Institute of Himalayan Environment and Development, Garhwal Unit, Srinagar, Garhwal - 246 174 (Uttarakhand), India. Email : ritesh_joshi2325@yahoo.com

** ESS Division, Department of Science and Technology, Govt. of India,Technology Bhavan, New Mehrauli Road, New Delhi – 110 016, India.

Terminalia bellirica (Bahera), *Ficus bengalensis* (Bar), *Dalbergia sissoo* (Shisham) etc., besides many other important fodder plant species. From the conservation point of view, it appears to be one of India's most successful national parks and its development has helped to boost the population of Asian elephants in their natural habitat. However, many nearby farming communities are hostile towards the park and towards the concept of elephant conservation because of the crop damage by elephants. The present study is a part of a long-term study on the behavioural biology of Asian elephant in and around the Rajaji National Park.

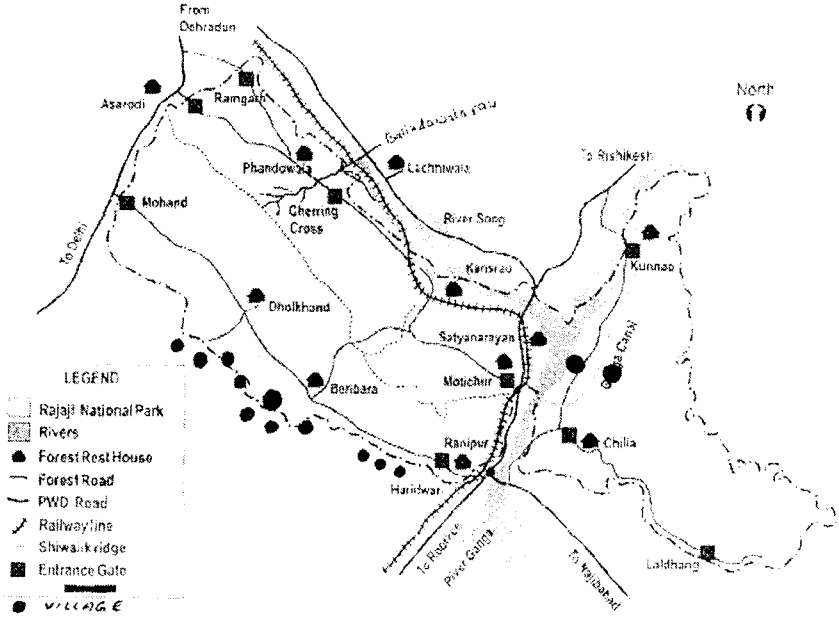
During the observations and surveys, it was felt that the people of the area were puzzled due to movement of this Proboscidian. Besides crop damage, man slaughter and elephant casualties especially around the park area are very high. Almost every few days we read in the newspapers and see on television about casualties on both sides, i.e. among the residents of the peripheral area and this giant animal. The park authorities also face several questions related to safety of this endangered animal from animal lovers. This has emerged as a very serious problem lately. During the recent past, the park management along with a few institutions has organised several meetings related to crop raiding around the conservation area but no solution to this problem has emerged. Presently, a big communication gap has arisen among park managers and local cultivators. Besides railway track, national highways, anthropogenic activities, hydro-electric power plants etc. are also responsible for restricting the frequent movement of elephants within their home range. The present study is an effort to document the impact of various developmental activities, which are presently hindering the frequent movement of elephants.

Methods

Study area : The study area comprises of a major portion of the Hardwar Forest Division area and the Rajaji National Park area. The area falls between the lesser Himalayas and the upper Gangetic plains, which are a major natural habitat for the world famous Asian elephants and also the terminal point of the North-western elephant population range. The PA lies between 29° 52' to 30° 16' N lat. and 77° 52' to 78° 22' E long. in the state of Uttarakhand, India. The study area is largely covered with moist deciduous forest type with the sub-types of moist Shivalik Sal (*Shorea robusta*) and the remaining area is mostly under mixed forest vegetation type. All the villages where the study has been conducted are situated peripheral to the PA. The study area is enriched with a few annual and perennial water streams in its premise.

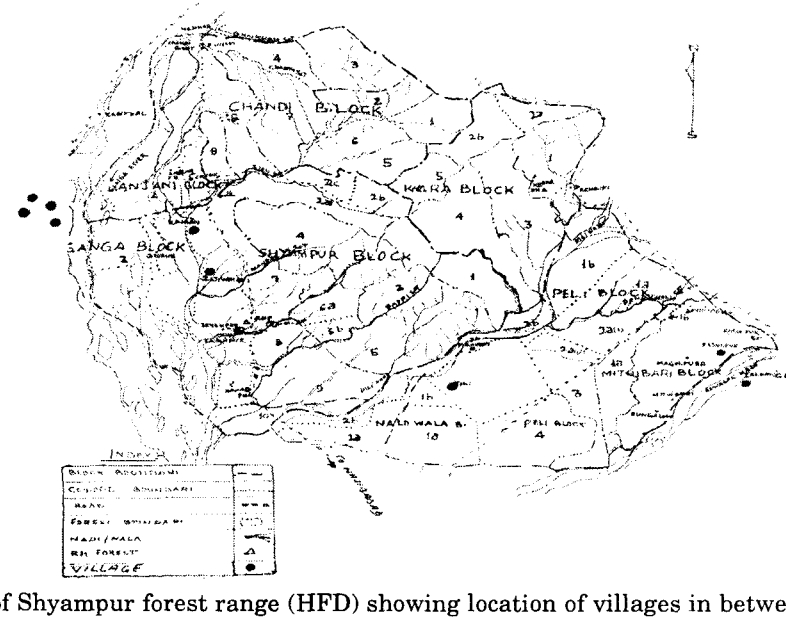
The Hardwar forest range is a part of Rajaji National Park (Fig. 1) and the Shyampur (Fig. 2) and Chiriapur (Fig. 3) forest ranges are part of Hardwar Forest Division, which is attached with the park area and proposed to be included in the national park area as Rajaji-Corbett corridor. The forest of Hardwar area falls under Rajaji National Park having an area of 8,526.10 ha. Major portion of Hardwar city is attached with this area whereas Shyampur (11,622.7 ha) and Chiriapur (10,289.5 ha) forests have a total area of 21,912.2 ha. This is an isolated belt, which covers the South-eastern part of Hardwar city.

Fig. 1



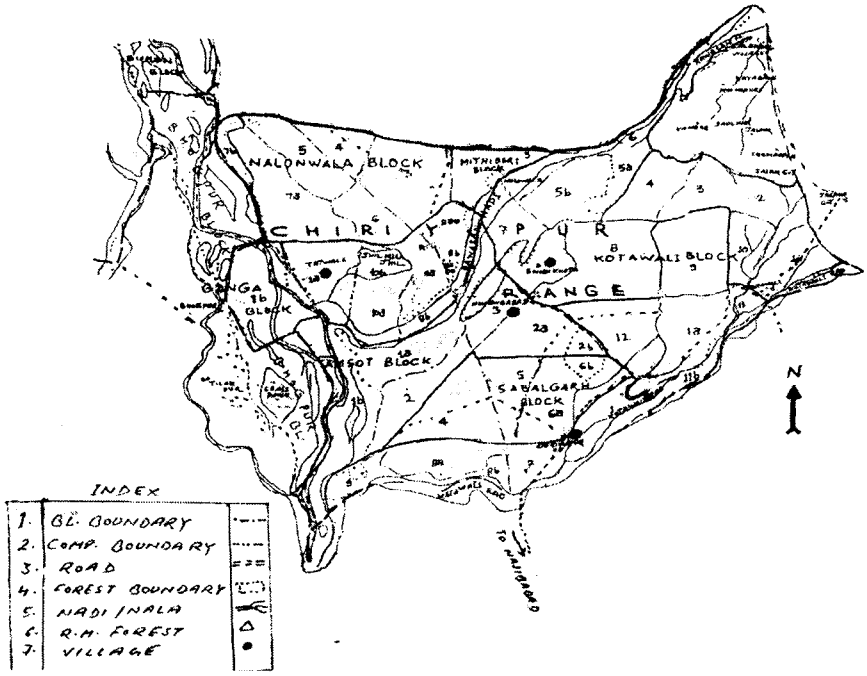
Map of the Rajaji National Park showing the location of villages attached peripheral to South-western boundary.

Fig. 2



Map of Shyampur forest range (HFD) showing location of villages in between the PA.

Fig. 3



Map of Chiriapur forest range (HFD) showing location of villages within the PA.

For studying the conflicts between agricultural communities and elephants and to assess the impact of various developmental activities on elephant's movement, the entire area of the Rajaji National Park (RNP) and Hardwar Forest Division (HFD) in Uttarakhand was surveyed in depth for about seven years. The causes of conflicts and the villages which are suffering from raids, were thoroughly investigated from both the environmental conservation and the socio-economic upliftment of rural communities' points of view. The natural behaviour of elephants was observed both during day and night, with due precautions. Different forest blocks of concerned forest ranges were chosen sequentially and searched for elephants for 10-12 hrs approximately (depending upon weather conditions) in a single day's search. The observations wee begun in the early hours as this is the best time to search and observe the elephant in open areas followed by four hours in the afternoon i.e. before sunset. Field binoculars werre also used for observing their feeding behaviour without disturbing the animal, from a safe distance.

The data collected is a part of the animal monitoring activities. The daily record is based on direct sighting of animals, indirect evidence like feeding signs, footprints, etc. Direct sightings were noted in duly prepared proformas, recording the herd composition, age and sex, if observed in groups and also the place of sighting, time and vegetation type.

Besides, villagers of adjoining areas, Gujjars (where available), staff of forest department, the researchers from various scientific institutions and non government organizations and other individuals working on this problem, were interviewed.

Results and Discussion

Crop raiding problem and its causes : There have been many studies documenting the behavioural patterns of elephant crop raiding in Asia (Joshi *et al.*, 2001; Sukumar, 1989; Santiapillai and Suprahman, 1986). Some of these studies have explored viable options to deter crop raiding elephants. During the recent past elephants were observed moving through many intensively cultivated and populated areas, including National Highways, railway track, villages and colonies. Rapid urbanization and industrialization (as a result of creation of Uttarakhand state from Uttar Pradesh) around RNP area have been major factors causing disturbance in elephant movement. A number of villages growing many cash crops are situated around both PAs. The major cash crops are *Saccharum officinarum* (Sugarcane), *Oryza sativa* (Paddy), *Triticum* spp. (Wheat), *Zea mays* (Maize) etc. and a few farmers also grow fruit yielding species in their fields like *Musa paradisiaca* (Banana), *Mangifera indica* (Mango) etc. Elephants leave the forest to feed in nearby villages, usually at night. Even before 1998, elephants were reported to be raiding fields but their outside movement became more common from 2001 (Joshi *et al.*, 2001). Currently the raids have become more frequent and the number of complaints by cultivators has increased.

Historical records and available literature indicate that elephants have been ranging over large areas and their habitats are also dynamic in food resources. Since the decade, many scientific studies have thrown light on this in different parts of the world. The question arises that why do elephants go into cultivated lands by crossing a large stretch with populated area and with imminent risk to their lives? Generally, it is said that the elephant's habitat becomes exhausted sooner as their large home ranges have generally been converted into smaller ones. But in RNP and HFD, the situation is totally different as the said area has those fodder species which the elephants like and it can be said that seasonal food resources are available round the year.

Many farmers believe that the increasing frequency of raids is evidence of increase in elephant population in the area but this is not confirmed data as elephants movement in nearby villages is quite dependent on the availability of cultivated crops. Some farmers also believe that there is scarcity of fodder and water resources inside the park area and to fulfill their routine requirements, elephants move into the village areas. An interesting point is that from RNP, elephants have been traditionally migrating towards Corbett National Park, therefore, the elephant population is not isolated. Most villagers seem to grasp the situation inadequately. When a villager was asked the reason for crop raiding by elephants and what the forest department has done for controlling this problem, replied "I am not sure but 10-12 years back, perhaps elephant population was not as much as it is today. At that time the tree cover was more, but it is said that elephants were dropped by Helicopter to the park area and forest officials allowed them to raid

our fields". This type of answer was heard from a number of villagers.

Credibility of forest officials/staff has sunk very low in these areas. The poor image of forest department among the villagers is on account of various reasons. This type of hostility between forest officials and villagers is one of the most important factors leading to serious man-elephant conflict in this region. The villagers feel that in case of injury to any person or damage to their crops they should be duly compensated by the Forest Department. It is apparent that there is a communication gap or some sort of fear psychology among the villagers towards the forest staff.

Our assessment of the situation is that that the increasing rate of crop raiding is a symptom of traditional utilization of home range by elephants. Another reason is utilization of their traditional feeding grounds, which are peripheral to the villages. Besides, drastic changes in the landscape around the Hardwar, Shyampur and Chiriapur PAs over last 5-6 years has also affected the frequent movement of elephants. Hardwar city alone has gone through a drastic change since the last decade. In the year 1995, many areas adjoining Kharkhari and Dudhia (island) forest beats were covered by lowland forests but since then road networks, human habitation, agricultural practices, construction of religious places, hotels etc. has extended into the forest zone. In addition to this, the railway track, which passes through the RNP area has caused the disturbance in the movement and natural activities of elephants. A few families of the oustees of Tehri dam were also settled near Motichur forest range of the RNP, which was once the elephants' home range and is presently denied to them.

Accidental deaths of elephants due to trains and impact of railway track on elephants' traditional seasonal movement

The Hardwar-Dehra Dun railway track, which passes through the Rajaji National Park area acts as an unnatural death trap for several wild animals and the major species, the elephant. During the last decade, so many accidents of this sort resulting in deaths of elephants have taken place in this part of the track. The most hazardous part of the railway track for elephants is between Motichur and Kansrao. This section has seen accidental deaths of 19 elephants since 1987 besides many other wildlife. Table 1 gives details of accidental deaths of elephants due to trains after declaration of the Rajaji National Park.

Both sides of the railway track fall under park area and comprise of vegetation cover, which elephants prefer to use. Also, during summer when natural waterholes shrink, they move towards the East of the park to go to the river Ganges. In order to fulfill their fodder, water and other routine requirements, elephants move towards eastern side of the RNP and before crossing the railway track, walk alongside for a short while to reach the rough route (bridle path) which goes downwards after these foothills. It is on such places along the track that accidents are frequent. This is also on account of the fact that the elephants, by habit follow this track route after sunset as human interference in these forest routes is much more during the day. Unfortunately this coincides with the train times as well.

Table 1

Details of accidental deaths of elephants due to trains in Rajaji National Park area since 1987

Sl. No.	Date	Place / Forest Range where death occurred	Animal detail	Approx. time/train	Remarks
1.	April 28, 1987	Motichur/Motichur Range	Female / 13 yrs.	10.00 p.m. / Mussoorie Express	Crushed by train
2.	Mar. 16, 1988	Motichur/Motichur Range	Female 30 yrs.	02.18 a.m. / Goods Train	Crushed by train
3.	Feb. 24, 1989	Kansrao/Kansrao Range	Male / 04 yrs.	08.45 p.m. / Doon Express	Crushed by train
4.	Jan. 01, 1992	Johra/Motichur Range	Female / 80 yrs.	05.30 p.m. / Hardwar - Rishikesh Passenger	Crushed by train
5.	May 02, 1992	Kharkhari/Hardwar Range	Female / 45 yrs.	02.10 a.m. / Goods Train	Crushed by train
6.	May 02, 1992	Kharkhari/Hardwar Range	Male / 04 yrs.	02.10 a.m. / Goods Train	Crushed by train
7.	May 02, 1992	Kharkhari/Hardwar Range	Female / 45 yrs.	02.10 a.m. / Goods Train	Crushed by train
8.	May 02, 1992	Kharkhari/Hardwar Range	Female / 40 yrs.	02.10 a.m. / Goods Train	Crushed by train
9.	Nov. 22, 1992	Motichur/Motichur Range	Female / 35 yrs.	10.00 p.m. / Goods Train	Crushed by train
10.	May 10, 1994	Motichur/Kansrao Range	Male / 08 yrs.	08.40 p.m. / Doon Express	Crushed by train
11.	May 17, 1994	Motichur/Motichur Range	Male / 55 yrs.	07.50 p.m. / Ujjain Express	Crushed by train
12.	Sep. 28, 1998	Suswa/Kansrao Range	Female / 35 yrs.	07.50 p.m. / Janta Express	Crushed by train
13.	Sep. 28, 1998	Suswa/Kansrao Range	Female / 06 yrs.	07.50 p.m. / Janta Express	Crushed by train
14.	Sep. 28, 1998	Suswa/Kansrao Range	Female / 01 yrs.	10.30 p.m. / Mussoorie Express	Crushed by train
15.	Apr. 03, 1999	- / -	- / -	- / Mussoorie Express	Crushed by train
16.	May 02, 2000	Kharkhari/Hardwar Range	Female / 35 yrs.	09.40 p.m. / Doon Express	Crushed by train
17.	June 04, 2000	Gular Parao/Motichur Range	Male / 08 yrs.	10.10 p.m. / Mussoorie Express	Struck by train
18.	May 29, 2001	Kharkhari/Hardwar Range	Female / 35 yrs.	10.30 p.m. / Mussoorie Express	Struck by train
19.	Jan. 25, 2002	Kharkhari/Hardwar Range	Calf / 02 yrs.	05.15 a.m. / Goods Train	Struck by train
20.	April, 2007	Kharkhari/Hardwar Range	Sub-adult/ -	09.45 p.m. / Doon Express	Hit by train (survived)

This is one of the elephants' traditional routes for moving from North-East side (Chilla forest) to South-West direction (Hardwar and Motichur forest) and from South-West to North-East direction by crossing the river Ganges and the island present in the river. This track is commonly known as the Chilla-Motichur corridor. But a few of the ongoing developmental activities of anthropogenic kind like construction related activities adjoining the forest area, presence of local people inside the forest etc. are hindering the frequent movement of elephants within these forests.

Impact of Urbanization/Human activities

The Motichur area of the Rajaji lies West of Ganga whereas the Chilla area lies to its East. There are four islands within the river in this region, which form part of the park. However, in the 1950s and 1960s, a number of developments, having drastic effect on land use came up on the western bank. BHEL set up a major plant to the West of Ganges in the southern park of this trans-Ganga corridor for wildlife, especially for elephants. Later, IDPL set up a large factory in the northern part of the corridor, also to the West of Ganga. The area in between has been utilised by the Army for an ammunition dump. Later, some remaining land was given for the rehabilitation of Tehri Dam oustees. Thus, most of the corridor on the west bank stands diverted and rendered unusable by elephants.

On the East bank, yet another major development activity has all but destroyed the ecological corridor. A hydel power project was set up in the 1970s. A barrage was constructed across the Ganga at Kunnao just outside the park in the middle of the northern boundary. From here, a deep power channel runs parallel to the East of the Ganga for about 14 km up to Chilla where the powerhouse is located. Although there are a couple of narrow bridges over the channel, these are not generally used by the animals. There have been cases of deer and even elephant mortalities, in attempts to cross these bridges.

Rarely, bull elephants and herds are known to cross, but otherwise there is complete isolation between western and eastern components of an eternal ecological unit now managed as RNP. The presence of an army camp in the elephant corridor has also adversely affected the movement of wild animals. Almost at the same place, one relocated village has 29 families, originally from Khand village of the submergence zone of the Tehri dam. The village occupies an area of 48.56 ha and has 18 houses constructed by the oustees themselves. Out of 29 families at present there are 18 families located inside the park area and 11 families are yet to construct their houses in Johra block, but they have occupied the land. The village is located in the elephant migration corridor and is an obstacle to their movement.

Impact of Gujjars and pastoralist activity within RNP

Background : The Gujjars came to the Shivaliks from Jammu nearly 200 years ago as part of the dowry of a princess of Nahan in present-day Himachal Pradesh. Here they raised buffaloes and practiced transhumance pastoralism, spending autumn (approximately October to April) in the Shivaliks and the summer and the rainy season (May to September) in the

alpine pastures of Himalayas. Migration between these grazing zones took up to 3 months. Their population increased rapidly throughout their new habitation. In year 2000, nearly 6,000 Gujjars with about 13,000 livestock lived in 'deras' (shelters) along the water courses in the park. In addition to Gujjar-owned livestock, 3,000 odd head of cattle graze in the park. Over the years, over-grazing by livestock and lopping of fodder trees has allowed the under growth of many weeds. One of the major problems is that the pastoralists always constructed their deras near the natural water holes and the dung deposited by the livestock pollutes these water sources, rendering the water unfit for elephants.

Relocation and resettlement efforts : The first attempt to resettle the Gujjars from the park area was made in year 1984 by the Uttar Pradesh government did not meet with much success due to drawbacks in the project. After the establishment of Uttarakhand, the rehabilitation programme has progressed rapidly and over the past six years five forest ranges of the park have been freed from the Gujjars. The settlers have been relocated to two rehabilitation sites namely Gaindikhata and Pathri. Keeping in view the welfare of the Gujjar community, the Uttarakhand Government has provided them necessary facilities like water, medicare, roads, agriculture land, schools, etc. This has resulted in increase in movement related activities of wild animals on the one hand and general improvement in the living environment of the Gujjars on the other. Each family was given a little over two acres (0.8 ha) of arable land, in which currently they are cultivating many vegetable and cereal crops. Each family was also provided a homestead site and Rs. 2000 to shift their belongings to the new area. Besides, they are also permitted to collect timber from nearby forests to build their deras. As per talks the present authors had with the Gujjars, they are fully satisfied with this government decision and are hoping that through this approach they can improve their livelihood.

Impact of resettlement schemes on wildlife : Another important impact on movement of wild animals that has been seen is that in many places insidence of wild animals straying into cultivated area have come down. This may also be due to rapid expansion of industries around the protected area. An encouraging aspect is that the locations of erstwhile Gujjar deras are getting re-greened by vegetation cover and water holes are getting fully recharged with natural water and are being used by wildlife. Presently the park authority is also making efforts to eradicate the Lantana inside the park area as a result of which many species like *Syzygium cumini, Holarrhena antidysenterica* etc. are growing rapidly.

The situation is just the opposite in the adjoining forest of HFD. Gujjars are currently utilizing the fodder resources frequently as the result of which a few forest patches are being rapidly replaced by toxic weeds like *Parthenium histerophorous* (Gajar grass) and *Lantana camara* (Lantana/Kuri jhari). Elephants must scarify the ground in order to feed on the short grasses due to domestic buffaloes being grazed. In this type of situation, elephants are diverting themselves to the peripheral forests or frequently moving outside the protected area, which generally leads to crop depredation. This has led to increasing man-elephant conflict.

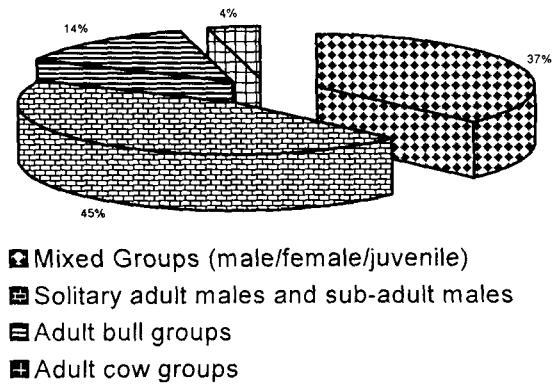
During the last two years, the State Government has constructed four flyovers on the Hardwar-Bijnor National Highway. As a result of this, about 18 km forest stretch along both the sides of highway has got disturbed mainly due to anthropogenic activities. Besides, agricultural expansion near the river Ganges has lead to the loss of forest wealth, which is also hindering the traditional movement of elephants. It was observed during the present study that mostly adult bull elephants are utilizing this route. Sometimes a few male elephants associate together, following this route to enter the forest near the Ganges. They cross the National Highway and the Ganges in the evening hours on a 3 km trek and re-enter to the forest area in the early morning hours. Besides, elephants also utilize the Gaziwali, Shyampurwali and Pili bridges which are situated peripheral to the Ganga canal for their movement outside and to feed on the cultivated crops in nearby villages. It was also observed during the study period that elephants use the Ganga canal for fulfilling their water requirements.

Of the 51 observations made during the study period, 23 (45%) represent those of solitary bulls, adult males and sub-adult males, 7 (14%) represent those of bull groups, 2 (4%) represent those of cow groups and 19 (37%) represent those animals which constitute groups including male, female and juvenile (Fig. 4). The highest number is observed for adult and sub-adult males. In a study of 113 elephants, the proportions of adults, sub-adults and juveniles as determined from direct and indirect observations around the PAs were 89 (79%), 10 (9%) and 14 (12%), respectively (Fig. 5). Calves were not observed during this period, therefore, these are not represented in the proportions of these age-groups. Adults were observed in maximum proportions as compared to other age groups.

After the establishment of the industrial area (2002) and flyovers on Hardwar-Bijnor national highway peripheral to RNP area and in between the HFD area, most of the straying routes of elephants are denied to them as all of these are replaced with factories and road network. Before year 2002, elephant groups were observed to frequently stray in the village areas but presently group movements are quite rare. Currently only bull elephants are crossing this track to visit the Ganga and village area; no groups were reported during last one year. Maximum numbers of bulls are fully adult but a few of the sub-adult bulls along with juvenile male elephant are also reported within this study period whereas adult, sub-adult and juvenile cows are observed within a group, when they are moving outside the PA.

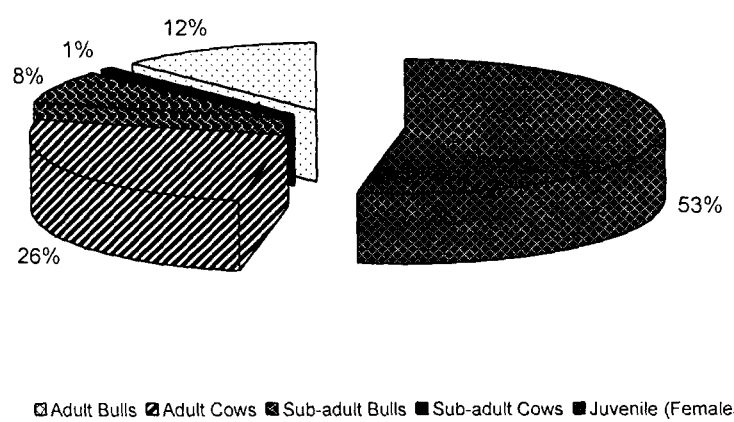
During moonless/dark fortnight periods, it becomes difficult to locate the wandering or grazing elephants anywhere. However, the silence of night helps villagers of peripheral villages to detect if these proboscides have strayed into their fields by their occasional munching sound. On such occasions, the villagers beat drums, or other noise creating instruments, to drive away elephants from their crop fields or orchards. At that time if elephants feel any disturbance they divert themselves inside the nearby covered areas and during such instances it is quite difficult to observe them due to lack of sufficient light and risk of casualty. The cultivators sometimes even allow them to raid crops as they could not drive off them due to

Fig. 4



Composition of elephants outside the park area (51 observations).

Fig. 5



Composition of elephants outside the park area during night / day period (n = 113).

unavailability of proper light sources and drive off devices.

The present study reveals that only identified solo bull elephants and groups were frequently straying outside the PAs. The study further reveals that elephants come out from the forest area boundary after sunset and return before dawn. But it was also observed from the present investigation that solo adult bulls are slowly showing a tendency to move outside from the protected forest after mid-day i.e. around 3 p.m. In a few of the places, their departure was delayed by 2-3 hrs after dawn. From the present study it

seems clearly that they follow the fixed routes while coming outside the PAs. Night straying generally occurred between 8.00 p.m. to 3.00 a.m.

Man-Elephant conflict in villages adjoining the PAs – Causes and concerns

All the villages facing the severe crop depredation problem have been investigated during the course of the present study. The affected villages are Jagjeetpur, Mishrpur, Panjneri, Ajeetpur and Jaipota in the western side of the PAs; all these villages are situated peripheral to the Ganges. Villages Kangri, Ghaziwali, Shyampur, Sajanpura, Pili, Laldhang, Rasulpur and Rasiabad are located peripheral to forest area and national highway whereas villages Gaindikhata, Lahadpur, Chiriapur, Vasuchandpur, Tatwala and Naurangabad are also situated adjoining to the forest area and national highway on the South-western direction of the forest area. Villages Roshnabad, Aanneki, Aurangabad, Meerpur, Teera Tongiya, Hazara, Daluwala, Rasulpur, Bandarjurdh, Haripur, Badiwala, Saheedwala Grant, Banjarawala and Ganeshpur are located in on the South-western side of the RNP area whereas villages Ravli-Mehdood, Aehtempur and Subhash Nagar are adjoining the industrial area of Hardwar city. During year 2000, elephants raided crops in these three villages but during the last four years, all these populated areas have been occupied by industries and developmental activities have led to drastic changes. This study has seen all the changes that have occurred during the last seven years (2000 - 2007).

The villages situated along the river Ganges are on land that was once part of the elephants' home range, therefore, the present escalation of the elephant-man conflict is unfortunate but inevitable. In few of the villages, concerned departments also fenced the sensitive area with electric fencing for restricting the elephants' movement but due to lack of maintenance and unawareness of local people, the fencing presently is damaged and has failed to control the movement of elephants. It was observed and inferred from the present investigation that elephants are utilizing their traditional feeding grounds in a few of the areas, which are presently denied to them and are replaced by human settlements. Villages nearer the PAs have expanded rapidly, thus accelerating the conversion of forest land during the last few years. The study has also revealed that elephants were attracted to farms with a variety of crops. As a consequence of the increase in food crop cultivation closer to the PAs, the areas peripheral to the forest have become increasingly attractive to elephants and their crop raiding behaviour is therefore a symptom of these drastic changes.

The RNP and HFD serve as good natural homes for Asian elephants, but increasing crop depredation and straying tendencies reveal their increasing uneasiness within their habitat, which is forcing them to move out of their traditional habitat, the PAs. The situation in this area conforms to the last category in that it involves elephants inhabiting an area that is capable of maintaining them, yet they raid crops along the boundary where small scale plantations, small holdings and human settlements abound. With the increase in the population, the demand for cultivable land is ever increasing. To meet the demand, more and

more forest is being converted into agricultural land, which results in disturbance in the ecological balance. All of the villages are peripheral to the reserve forest and elephants a decade ago used the said area as part of their home range. Most of these areas are presently denied to them as are replaced by human settlements and agricultural fields. Therefore, only a few of the recognized bull elephants and groups use the said area as part of their traditional habit. This diversion of the elephant inhabitants from traditional natural sources to new ones is also due to the shortage of food and water resources in the forest, that forces them to divert their search for the food towards the villages and settlements, which sometimes gives rise to various accidents leading to death of the animal.

In many places a few of the same groups were reported continuously for about 14-15 days. As already stated, only identified bull elephants and groups were reported outside the PAs. Most of the incidents of raiding were found to be in the late evening or at night and in elephant habitats fringed with agricultural fields which increased the chances of crop raiding (Nair, 1990). A preliminary study suggested that raids by elephants were the results of either solitary individual (adult males) or small groups (Santiapillai and Suprahman, 1986).

In addition to monitoring the general behaviour of the elephants causing damage, careful documentation of the economic losses is essential to assess the extent of damage. This involves monitoring the crops and their values at each season. Unfortunately no accurate data exists on the financial loss caused by these raids. The authors have made extensive queries with villagers regarding the said losses and it was revealed that during winter season from the month of October to January, crop raiding phenomenon is at its peak and elephants move extensively in search of cultivated crops in the surrounding areas. According to a survey made by the authors, Rs. 40,000 /- (on an average) of sugarcane land of a single cultivator (one third of his total land) was either disturbed or rendered by elephants, which is usually unproductive. This has happened to many other cultivators.

During the recent past, most of the parts of this forest stretch has been grazed by cattle of local villagers; besides cattle pressure of Gujjars was also very high in a few of the forest ranges as lopping was also done by Gujjars inside the forest area. In HFD, Gujjars are currently utilizing all the fodder resources frequently, as a result a few forest patches have been rapidly replaced by toxic weeds like *Parthenium histerophorous* (Gajar grass) and *Lantana camara* (Lantana/Kuri jhari). Elephants must scarify the ground in order to feed on the short grasses due to domestic buffaloes being grazed (McKay, 1990).

Crop raiding by elephants is a major problem for concerned authorities in this part of country. There are about 14 villages on the South-western direction of the Hardwar forest area whereas about 19 villages are situated on the South-western side of Shyampur and Chiriapur forest ranges, which grow sugarcane, paddy and wheat as major crops. The area under cultivation of crops varies in different places. Village Aurangabad on the boundary of Hardwar forest range has the largest area under sugarcane cultivation followed by paddy and wheat whereas village Mishrpur together with Jagjeetpur

has the largest area under cultivation of sugarcane. As a consequence of increasing sugarcane-raiding by elephants, a few cultivators have totally stopped the cultivation of sugarcane due to fear of loss by elephants. This fear is seen in those villages which are situated peripheral to the boundary of PAs.

Sugarcane is planted during February and March and harvested in December to January. Sowing of wheat takes place in the month of late December and it is harvested in April and May whereas paddy is sown in the last of June and harvested in October and November. Elephant movement increases between November to February. During monsoon period, only a few elephants, mainly loners, are found in these areas. Depredation of sugarcane took place throughout the year but was observed highest between November to February. Elephants show a great preference to a variety of crop yield but their preffered food item is sugarcane (Ali *et al.*, 1986). The raiding group size also differs in different seasons. During November to February group size is larger, between 1 - 14 elephants, than in the other seasons. In village areas, damage to banana plantations, jackfruit, mango etc. has also been noticed. Crop depredation pattern and season coincide with the high intensity of manslaughter in the area. The peak depredation period is between the months of October to March during which time incidents of manslaughter by elephants and elephant rampage cases are also very high.

Elephants are rapidly losing their habitat in India as their movement has become more restricted due to human activities (Dorji, 1997). Instances of wild animals straying into villages have also increased; wild animals also raid the crop and occasionally attack human beings (Khanna, 1995). During the last three years, the south-western part of these PAs has gone a drastic change. Besides, about a 5 km stretch (barren land) along the Hardwar forest range of the RNP boundary has been converted into industrial area. Rapid industrialization in this area has restricted elephant movement in surrounding areas. Presently the said area consists of numerous road networks along with human settlements and many headquarters of State Government departments. Construction of projects of public utility, for hydel, irrigation, roads etc. has entailed deforestation of large tracts and colonization brought in its wake has resulted in a significant shrinkage in the habitat of wild animals (Singh, 1969).

Loss of elephant habitat through spread of agriculture, and developmental activities such as hydroelectric and irrigation projects, roads, railway lines and mining, have been the most significant threats to elephant habitats (Venkataraman *et al.*, 2002). The status of the elephant in the adjoining countries is equally poor. Nepal, which has a very low population density, has lost over 80% of its elephant habitat on account of human settlement. Bangladesh, Myanmar, Cambodia, Vietnam, Laos and Sri Lanka etc. are also rapidly losing natural forest cover, specially the elephant habitats. In Thailand, in spite of the elephant having been a protected species since the 18th century, over-exploitation of the habitat and the pressure of human population has made the species highly vulnerable (Daniel, 1996).

This has also happened with Shyampur and Chiriapur PAs. Before the

construction of the Hardwar-Bijnor National Highway and settlement of various villages, the forest from the East of the Ganges to the West was a single forest stretch and elephants utilized this entire belt as their home range. But construction of the national highway within the forest and establishment of villages along the national highway and on the western side of the Ganges has restricted the elephants in use their natural habitat and traditional feeding grounds. Another major reason for crop raiding by elephants in this area is that a few of the villages, which are located in the eastern part of the Ganges and along the river are still exist within protected forests.

Fodder species like *Mallotus phillipinensis* (Rohini), *Acacia catechu* (Khair), *Dalbergia sissoo* (Shisham), *Tectona grandis* (Teak), *Zizyphus mauritiana* (Ber), *Aegle marmelos* (Bel), *Ficus bengalensis* (Bar), *Ficus glomerata* (Gular), *Grewia oppositifolia* (Bhimal), *Bombax ceiba* (Semal), *Lannea grandis* (Jhingan), *Bauhinia variegata* (Kachnar), *Lagerstroemia parviflora* (Dhauri), *Kydia calycina* (Pula), *Syzygium cumini* (Jamun), *Flacourtia indica* (Kandai) and *Ehretia laevis* (Chamror) are present in huge amount within these forests and elephants have to use these forest pockets as part of their habitat by crossing the national highway. Besides, elephants also use various grasses and shrubs as their food resources, which include *Dendrocalamus strictus* (Bamboo), *Helicteres isora* (Kapasi), *Saccharum munja* (Pula), *Saccharum spontaneum* (Kans), *Cynodon dactylon* (Doob Grass), *Eulaliopsis binata* (Bhabhar Grass), *Tinospora malabarica* (Giloe) and *Neyraudia arundinacea* (Bichhoo Grass) (Joshi, 2007).

Another reason is the presence of a few annual water streams nearer to the villages, which have traditionally acted as an elephant corridor. Flyovers are another major problem as due to these, elephant activity in some areas has got disturbed. The Government has constructed four flyovers during the last two years and work for establishing these flyovers took about two more years. During this period of construction-related activities, there was great hindrance in the frequent movement of elephants from one forest to another. Under such conditions strong and well-planned conservation strategies are needed to be implement by applying various scientific techniques for conserving the highly endangered Asian elephant, otherwise it is bound to face extinction in the near future.

Acknowledgements

The authors are thankful to the Science and Engineering Research Council (SERC) Division, Department of Science and Technology (DST), Government of India for providing financial support. Thanks are due to Dr. R.C. Srivastava, Scientist 'G' and Dr. Jagdish Chander, Scientist 'F' of the DST, New Delhi for their kind cooperation, support and advice. Grateful thanks are due to Dr. U. Dhar, Director, G.B. Pant Institute of Himalayan Environment and Development, Kosi – Katarmal, Almora and Dr. R.K. Maikhuri, Scientist Incharge of the Garhwal Unit of G.B. Pant Institute of Himalayan Environment and Development for their cooperation, support and kind advice during the study period. Thanks are also due to Shri Srikant Chandola, Additional Principal Chief Conservator of

Forests (Wildlife), Government of Uttarakhand and Shri G.S. Pande, Director Rajaji National Park for according permission to carry out the research work in the said area. Thanks are to various concerned forest officials and staff for providing help during the field investigations.

References

Ali, S., Daniel, J.C., Sivaganeshan, N. and Bhushan, B. 1986. Study of the ecology of some endangered species of wildlife and their habitats: elephants in Andhra Pradesh. *Technical Report 10*, Bombay Natural History Society, Mumbai.

Daniel, J.C. 1996. Conservation of Asian elephant. *Gajah*, **16** : 9-16.

Dorji, P.J. 1997. Status, distribution and conservation of Asian elephants in Bhutan. *Tiger Paper*, **24** (1): 1-3.

Joshi, R. 2007. Behavioural biology of Asian elephants (*Elephas maximus*) in and around the Rajaji National Park, India with special reference to the impact of railway track on their seasonal traditional migration. *Technical Report, GBPIHED*, Garhwal Unit, Srinagar-Garhwal.

Joshi, R., Joshi, H. and Verma, J.K. 2001. Crop depredation around Hardwar range by elephants (*Elephas maximus*) in the Rajaji National Park, India. *Nature and Biosphere*, **6** (1&2): 45-49.

Khanna, S. 1995. Man, wildlife and forest wealth. *Yojana*, **39** (13): 28-30, 33.

McKay, G.M. 1990. *Behaviour and ecology of the Asiatic elephant in South-eastern Ceylon.* Smithsonian Institution Press, Washington, DC.

Nair, P.P. 1990. Problem of crop raiding by elephants in Kerela. In: *Ecology, behaviour and management of elephants* (Karunakaran, C.K., ed.). Kerala Forest Department, Thiruvananthapuram, Kerala. pp. 208-212.

Santiapillai, C. and Suprahman, H. 1986. The ecology of the elephants (*Elephas maximus* Linn.) in the Way Kambas Game Reserve, Sumatra. *WWF/IUCN Report*, Bogor.

Singh, V.B. 1969. The elephants (*Elephas maximus* Linn.) in Uttar Pradesh. *J. Bom. Nat. Hist. Soc.*, **66** (2): 239-250.

Sukumar, R. 1989. *The Asian elephant: ecology and management.* Cambridge University press, Cambridge.

Venkataraman, A.B., Kumar, N.V., Varma, S. and Sukumar, R. 2002. Conservation of a flagship species: prioritizing Asian elephant (*Elephas maximus*) conservation units in southern India. *Curr. Sci.*, **82**: 1022-1032.