Decline of the Asian Elephants (*Elephas maximus*) from Hardwar Forest Range of the Rajaji National Park, India: The First Documented Case of Free-Ranging Wildlife Species

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Abstract: Study on Asian elephant's population composition and impact of developmental activities on elephant's seasonal movement was made during 2000-2001 and 2006-2007 in Hardwar forest range of the Rajaji National Park, north-west India and is discussed. During 2000-2001, a total of 91 recognised elephants were sighted whereas only 31 elephants were observed during 2006-2007. Long-term field observations indicated that population composition of elephants was almost same during both the study periods but their number has decreased to three folds since last seven years. Developmental activities are increasingly recognized as the cause of mass mortality events, and population declines of wildlife species. In a number of cases, it has been hypothesized that huge amount of habitat deterioration have caused extinctions of wildlife species. However, few of the other natural reasons are also responsible for the decline in the population of wildlife. In this article, we review the potential involvement of developmental activities in the recent decline of the Asian elephant *Elephas maximus*. Our review of available evidence suggests that tremendous amount of developmental activities, shrinkage of water and fodder resources, running traffic and railway track, have caused a rapid catastrophic decline of this species from the Hardwar forest range of the Rajaji National Park area. We propose that this is the first case of decline of a free-ranging wildlife species where industrialization and urbanization acted as both the proximate and ultimate cause of species decline. This highlights probable anthropogenic activity as a cause of biodiversity loss. [New York Science Journal. 2009;2(1):1-12]. (ISSN: 1554-0200).

Keywords: Asian elephant, *Elephas maximus*, decline, Rajaji National Park, conservation, India

Introduction

India currently has the largest surviving population of the Asian elephant, approximately 50 % of the total world population of the species (Daniel, 1996). A number of wildlife habitats have undergone or are being threatened with fragmentation due to various anthropogenic factors and this has adversely affected the large mammal populations residing in them (Johnsingh et al., 1990). The status of the elephant in the adjoining countries is equally poor. Nepal, which has the lowest country population, has lost over 80% of its elephant habitat on account of human settlement. Bangladesh, Myanmar, Cambodia, Vietnam, Laos and Sri Lanka are also losing rapidly the 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).

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 natural home of Asian elephants (*Elephas maximus*) besides many other wild animals like *Panthera tigris* (tiger), *Panthera pardus* (leopard), *Melursus ursinus* (Sloth bear), *Hyaena hyaena* (Hyaena), *Muntiacus muntjak* (Barking deer), *Axis axis* (Spotted deer), *Cervous unicolor* (Sambhar), *Sus scrofa* (Wild boar) and *Ophiophagus hannah* (King cobra). The Rajaji National Park was established to enhance the long-term survival of the Asian elephant in a sub tropical moist deciduous forest in India. Recently, human exploitation and habitat destruction have caused major decline in the abundance of the terrestrial megafauna. As most of the wild animals are presently categorized under threatened category therefore, there is increasing concern that the area-wise decline of the elephant will have unexpected and grave consequences for the long-term viability of the terrestrial ecosystems.

The Rajaji National Park was established to enhance the long-term survival of the Asian elephant in a sub tropical moist deciduous forest in India. But during the recent past natural continuous forest ranges of India has been broken up into many parts due to agriculture, urbanization, increasing road traffic and development related activities as well

as other anthropogenic activities. This situation creates many problems for various organisms living in forests especially for large size mammals like elephant. Genetic isolation, limitation of dispersal, migration and the decline of populations of animals requiring large territories are the most common problems connected with fragmentation of forests and other components of the environment. From conservation point of view Rajaji National Park appears to be India's one of the most successful national park and its development has helped to boost the population of Asian elephant in their natural habitat.

But during the recent past natural continuous forest ranges of India has been broken up into many parts due to agriculture, urbanization, increasing road traffic and development related activities as well as other anthropogenic activities. Human settlements in and around the park area have created the shrinking of elephant's natural paths. The human population around the Raja National Park alone has doubled during past one decade and rapid urbanisation and industrialisation has resulting in the loss of many forestlands to townships and to various development related activities (Joshi and Singh, 2008). A serious threat was also recorded to European wildlife resulting from the dynamic development of a transportation infrastructure network within the Trans-European Transportation Network (TEN-T) programme. This transportation network disrupts migration corridors of large terrestrial mammals and causes a fragmentation of their environment on a scale not previously recorded (Nowak and Myslajek, 2005).The present study was a part of our long term study on the behavioural biology of Asian elephant in north-west India.

Methods

Study Area

Rajaji National Park [29^0 15' to 30^0 31' North Latitude, 77^0 52' to 78^0 22' East Longitude] is spread over an area of 820.42 Km^2 in and around the Shivalik foothills, which lies in the lesser Himalayas and the upper Gangetic plains (Figure 1). Spread across Hardwar, Dehradun and Pauri districts of Uttarakhand state, Rajaji National Park (RNP) has been designated as a reserved area for the "Project Elephant" by the Ministry of Environment and Forests, Government of India with the sole aim of maintaining the viable population of Asian elephants in their natural habitat. The Shivalik foothills offer the most prominent geomorphic features of this tract. The river Ganges has cut across these hills at Hardwar. The Chilla forest area of the RNP lies in the east of the river Ganges and is attached by the Garhwal Forest Division. The study is ongoing in Hardwar (District-Hardwar), Chilla (District-Pauri) and Motichur (District-Dehradun) forest ranges of the RNP. Besides, few of the adjoining forest areas (Shyampur forest range of the Hardwar forest division) were also incorporated in this study. The altitude lies between 302-1000 m asl. This protected area 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), *Terminalia bellirica* (Bahera), *Ficus bengalensis* (Bar) and *Dalbergia sissoo* (Shisham) in its premise besides many other important fodder plant species.

Data Collection

All the field observations were made from March to June and October to January during 2000 to 2001 and 2006 to 2007. It is not possible to observe the elephants during monsoon as the areas are dominated with tall grasses and dry period is the best time to observe the elephants near to water source. For conducting the study on elephant's presence we made all the observations from a vehicle and we adopted the road-strip count method (Hirst, 1969; Santiapillai et al., 2003) to monitor the fluctuations in elephant numbers. The study area was visited at weekly intervals during which observations on elephants were made along a 6 kilometer stretch of motorable forest track, adjoining to forest habitat. Few other connected rough routes, which link the grassland habitat with motorable road were also used during the course of study. As few forest beats of the Hardwar forest does not comprises of any road, therefore, study was made on foot. Although some animals were observed upto a maximum distance of 100 meter, most of the observations fell within 50 meter. Besides, all the potential habitats (water dominant areas, cool shaded areas, fodder enriched areas and rough forest routes) were also investigated on foot during early morning, mid-day and evening hours. Cool shaded trees like *Ficus bengalensis*, *Adina cordifolia* and *Ficus glomerata* and dense forest of *Mallotus phillipinensis* were examined mostly during mid day (March-June) hours as elephants generally take rest under these cover. Whereas all the water sources (perennial/annual) were investigated alternatively during evening hours.

As the elephants in RNP have been known to emerge from the forest predominantly during evenings, all sightings of elephants were made between 1500 hours and 1900 hours. Different forest blocks of concerned forest ranges were selected one after another sequentially and searched for elephants for about 10 – 12 hours (depending upon weather conditions) in a single day search. The observations started at early hours in the morning being the best time to search and observe the elephant in open areas and four hours in the afternoon, before the sunset. The data collected was as part of the animal monitoring activities. The daily record was based on direct sighting of animals, indirect evidences like feeding sign, footprints impression time and fresh dung piles. The direct sighting were noted in duly prepared observation sheet, recording the group composition, age and sex, if observed in groups and also the place of sighting,

time and vegetation type. Field binocular was also used for observing their movement behaviour without disturbing the animal from an adequate and safe distance.

Besides, villagers of adjoining areas, Gujjars (where available), staff of forest department, the workers from various scientific institutions and non-government organizations and other individuals working on this problem, were also interviewed. Identification of the elephants is important to verify their movement as in the same area there is a possibility that the same group was observed in the different forest beats. Therefore, distinctive features, with certain identification marks of individual elephants were noted like; shape of the ears, tusk size and shape, scars and tubercles on the body, tail length, total number of individuals (all ages separately), body mass and nature of group or solitary bull. For census purpose, the four categories recognized by Eisenberg and Lockhart (1972) – namely adult, sub adult, juvenile and calf were adopted.

Results

During 2000 and 2001, a total of 91 recognised elephants were sighted whereas during 2006 and 2007 only 31 elephants were observed in the study area (Figure 2). Adult and sub-adult females were accounted for highest number 54 – 59.3% (2000-2001) and 18 – 58.06% (2006-2007) while, calves represented the lowest number (9 – 9.8%, 2000 and 2001 and 3 – 9.6%, 2006-2007). 12 – 13.1% (2000-2001) and 5 – 16.1% (2006-2007) represented solitary adult or sub-adult males and juveniles represented 16 – 17.5% and 5 – 16.1% during 2000-2001 and 2006-2007 respectively. And as per the field observations and available data it seems that population composition of the elephants was almost same during both the study periods but their number has decreased to three folds since last seven years. A study on 42 classified groups of elephants (n=378) gives the relative proportions of the adults, sub-adults, juveniles and calves to be 214 (56.6%), 87 (23%), 58 (15.3%) and 19 (5%) respectively (Joshi et al., 2007).

Elephants have suffered most grievously as compared to other wild herbivores on account of loss of their natural habitats and corridors as they require larger space. Increasing human pressure inside the deeper forest regime and developmental projects has given rise to management and conservation problems. These include crop raiding by elephants outside the protected area and even some human fatalities. The human population around the RNP alone has doubled during past one decade and rapid urbanization and industrialization has resulted in the loss of many forestlands to townships and thereby increasing the major problem during the recent past. Presently RNP is a natural home to about 418 elephants (Figure 3 & 4) and few of its forest ranges has helped to enhance the population of elephants but the population of elephants was continues to decline in Hardwar forest range of the RNP mainly due to biotic pressure, developmental activities, presence of railway track and national highways. Since 1987, 19 elephants were died in Hardwar forest range due to various reasons (Table 1) and it was observed that the status of elephants' movement in this forest was continuing to decline.

1. Utilization of Forest Products

Collection of fuel-wood by villagers was one of the major problem, as they sometimes fell down the juvenile trees or shrubs. During the recent past, grazing of the cattle's and lopping of fodder species by Gujjars (nomadic community) within the park area during the recent past has caused serious effects on the regeneration potential of many fodder species like *Shorea robusta* (Sal), *Ficus benghalensis* (Bar), *Emblica officinalis* (Amla), *Anogeisus latifolia* (Bakli), *Terminalia belerica* (Bahera), *Terminalia tomentosa* (Sain), *Oogeinia oogenensis* (Sandan), *Garuga pinnata* (Kharpat), *Bauhinia variegate* (Kachnar), *Schleichera oleosa* (Kusum) and *Lannea coromendelica* (Jhingan), which are crucial for frugivorous birds and mammals. Collection of non-timber valuable forest production like *Eulaliopsis binata* (Bhabar grass), *Kydia calycina* (Pula), *Neyraudia arundinacea* (Bichla grass), *Dendrocalamus strictus* (Bamboo) and *Aegle marmelos* (Bel) with leaves are also the causative agents for decline in the population of elephants. Presently Gujjars are relocated outside the park area as per the directions of Honorable Supreme Court of India and in few of the ranges settlement programme is still ongoing. In RNP Gujjar rehabilitation programme has provided the better opportunity for livelihood to pastoral Gujjars and on the other hand it has promoted the regeneration of forest wealth along with movement related activities of wildlife (Joshi and Pande, 2007).

2. Biotic Pressure

There have been cases of loitering in the park area without permission probably such people are of questionable identity and are responsible for acts of poaching. These types of anthropogenic activities are more commonly seen in those areas, which are attached to park boundary. Several times it was also observed that many people enter to the park area and indulged in nefarious activities. Sometimes they were observed to play cards, booze, roam here and there, burst crackers and throw stones to deter away the elephants. Religious places like Goddess Mansa devi temple, Sureshwari devi temple and Bilkeshwar temple are also situated inside the Hardwar forest range and the visiting devotees and workers of the temples sometimes hinder elephant's movement. There are many instances when religious banquets on large scale are organised and hoards of visitors disturb elephants that come to drink water in the

evening hours. More than 6-7 lacs people visit Mansa devi temple every year. During last decades the general economic condition of people has bettered, this has leaded to increase in the purchase power, social interactions, tourists and religious activities of the people at all levels (Joshi and Joshi, 2006).

In other temples more than 50,000 people visit annually and the crowd was seen especially during the Shivratri and Sawan Purnima fairs. In 2007 about 25 lacs people visited on the occasion of Sawan Purnima in July. It was observed during the study period that in few of the places elephant's activities has changed, which has caused irregularity in their natural activities. Dudhia forest beat due to its proximity to the Haripurkala village and river Ganges is one of the most sensitive area as far as elephant casualties are concerned. Occasionally, the movement of only solo bulls was observed in this part of the park but group movement was almost restricted in this forest pocket. Dudhia forest is having huge amount of *Dalbergia sissoo* (Shisham) and *Acacia catechu* (Khair) forest, the preferred food item of the elephants. Besides, few of the grass species like *Saccharum munja* and *Desmostachya bipinnata* were also grow in profusion in this area. Generally, the solo adult bulls follow the city route for visiting to Dudhia forest and river Ganges through crossing the railway track and Hardwar–Dehradun National Highway.

Elephants enter to the city from northern Kharkhari forest beat and moves towards Chilla forest after the sunset and re-enter to the northern Kharkhari forest before dawn. During this long journey of about 2 kilometer elephants have to cross many of the minor routes along with various human habitation areas. Sometimes solo bulls from Chilla forest also enter in this forest through crossing the island in between the river Ganges. This track falls under Chilla – Motichur corridor and is one of the important habitat as far the elephants' conservation is concerned. Before 1998 elephant groups were known to cross this track for performing their long-term migration towards Corbett National Park area. Similarly, other forest beats of Hardwar forest range were also attached with human settlements.

3. Hardwar – Dehradun Railway Track

Presence of railway track, which passes in between the RNP area (Hardwar – Dehradun railway section) is one of the major obstacle in elephants' long-term migration and frequent movement within their home range. A total of 19 elephants are killed due to train accidents since 1987 besides many other wild animals like leopard, spotted deer, sambhar, python, porcupine, peacock and jungle fowl (Table 2). This track is 16 kilometer long and comprises of sharp bends through which train drivers are unable to see the elephants from a safe distance and most of the accidents were occurred during night hours and in dry season (Joshi and Joshi, 2000). Train accidents mainly occurred during the dry season when the availability of natural water was scarce. This also coincides with a thick and rich harvest of the Rohini (*Mallotus philipinensis*) trees, available in rich amount adjoining to the railway track. This is favourite food item of the elephants in this part of the park. *Mallotus phillipinensis* was also present in the eastern side of the track, and for feeding on these the elephants cross the track mainly around the sunset and return back in the early morning hours. Most of the unnatural deaths of the elephant occurred during night, while these were moving in groups. During the night train drivers are unable to see the object from a safe distance as the head lights of the engine can penetrates only up to the distance of 100 meters (depends upon climatic conditions).

4. State Infrastructure and Industrial Development Corporation of Uttarakhand Limited

After separation of the Uttarakhand from the Uttar Pradesh state (2000), Hardwar city became the industrial area of the state, which was named as State Infrastructure and Industrial Development Corporation of Uttarakhand Limited (SIDCUL) and adjoining area (2034 Acres) of the Hardwar forest range was acquired for development of SIDCUL. Since 2002 rapid expansion of industrial area has caused obstruction in frequent movement of elephants besides many other wildlife in adjoining forest area. Before 2002 tiger movement was frequently observed in few of the forest pockets but presently has got restricted. As the result of establishment of more than a dozen of industries, demand for water has been increasing and to meet the demand ground water is being extracted by various stakeholder industries and that has caused the major impact on ground water of adjacent areas. Besides, industries are frequently discarding their effluent to the ground because of absence of any appropriate outlet for discharge of waste material.

5. Shrinking of Perennial Water Sources

Hardwar forest comprises of many wells those were constructed before the declaration of park area with the aim of maintaining the water availability especially during dry months. Historical evidences suggested that these wells are constructed before 1877 and adjoining to forest roads and raos (seasonal water streams). It was observed that the water level has decreased in all the wells. According to our measurements, about 1.5 meter of the water level has decreased during the last 4 years. This area is currently facing the scarcity of water and fodder species as far the elephant presence is concerned. Most of the perennial water sources (Ranipur water stream in Ranipur forest beat, Bagro, Sukro, bara pani and chota pani in Kharkhari forest beat and hathi kund in Bilkeshwar forest beat) have shrinked presently, whereas before 2002 all of these water sources were fulfilled with tremendous water (Table 3). Similarly, Nauranga water pond in Kharkhari forest beat, Dhak and Jhabri water sources in Mayapur forest beat and Harnol

water source in Harnol forest beat have shrinked completely whereas before 2001 elephants have utilized these sources throughout the year as this forest is an connecting corridor for elephant movement towards Motichur, Kansro and Dholkhand forest range.

6. Forest Fire

Forest fire was one of the most important factor, which has forced the elephants to move out of this forest range. As per available records about 15 hectares of Kharkhari forest was destroyed during 2007 mainly due to forest fire. Again in March and April 2008 about 7 hectare of Kharkhari and Ranipur forest was burned due to fires. It was observed after examining the situation that all of these fires were originated due to human beings. A total of 146 annual fires in RNP area in between 1996-2002 has affected 540.71 hectare of forest cover (Management plan of the Rajaji National Park). Study revealed that many of the important fodder species were affected along with grasses and animal leave the area for a long period of time.

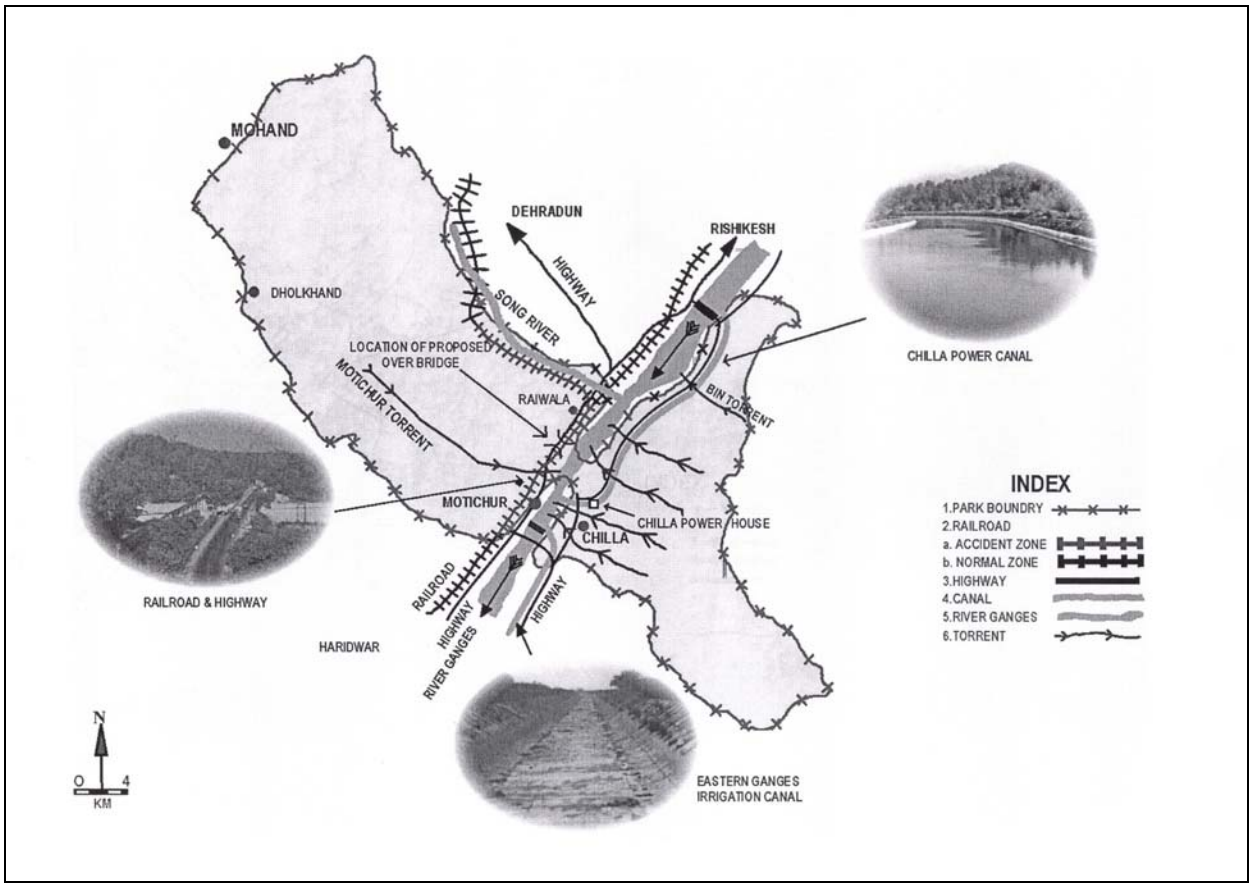

Figure 1. Map of the study area.

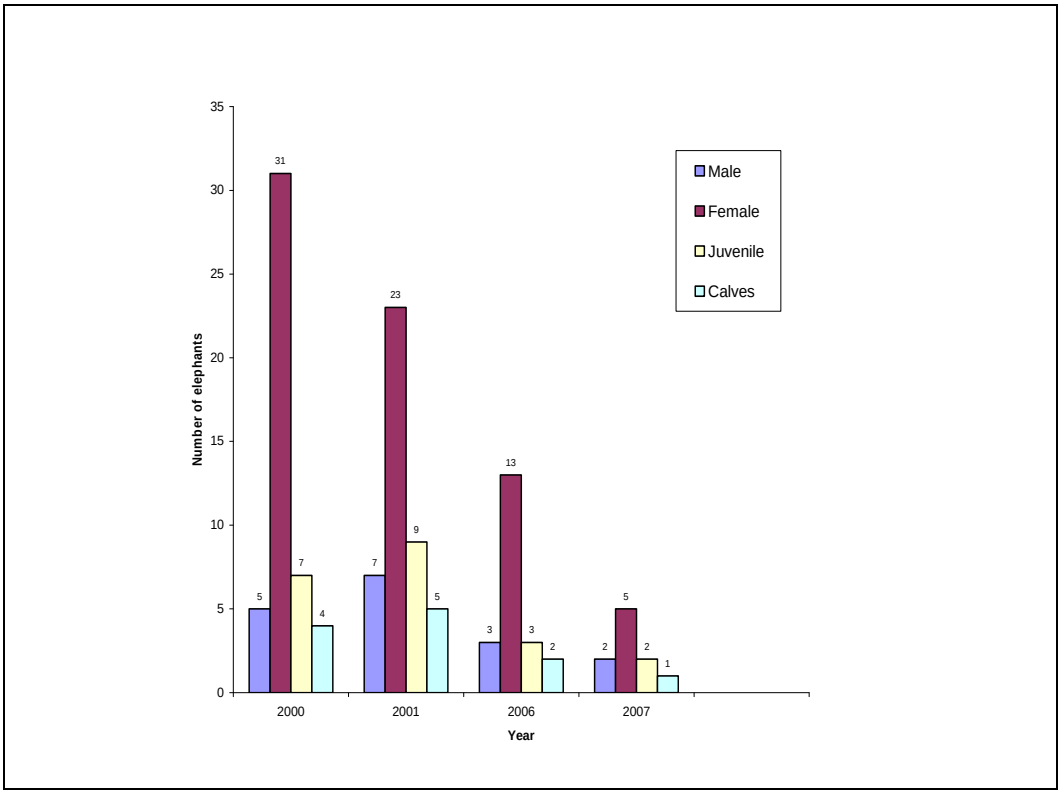

Figure 2. The composition of the elephants in Hardwar forest range of the Rajaji National Park during 2000, 2001, 2006 and 2007

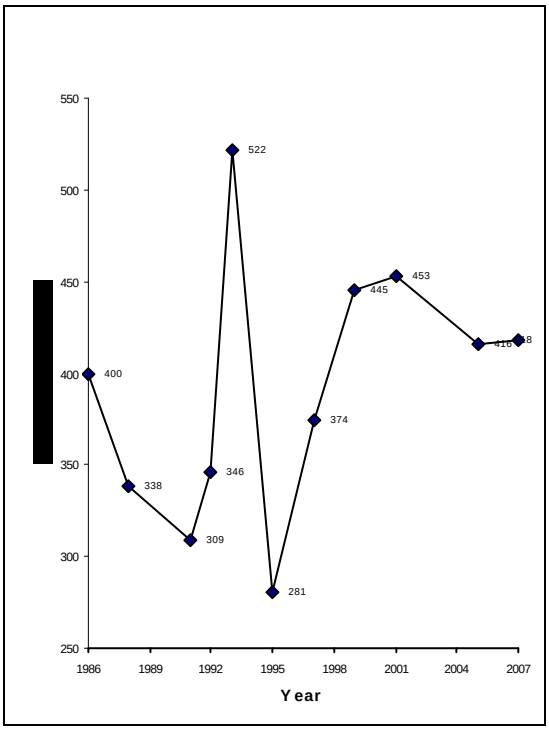

Figure 3. Showing Elephant Population in the Rajaji National Park since 1986.

Figure 4. Elephants at Hardwar forest of the Rajaji National Park.

Fig.3. The composition of the elephants in Hardwar forest range of the Rajaji National Park during 2000, 2001, 2006 and 2007

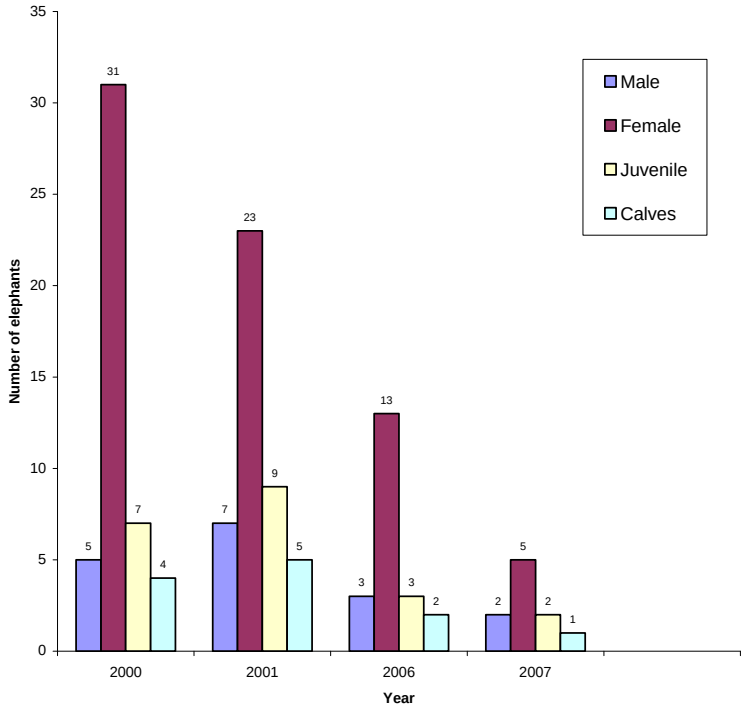

Figure 3. Showing elephant population in the Rajaji National Park since 1986.

Table 1. Elephant's deaths in Hardwar forest range of the Rajaji National Park since 1987.

S. No.	Date of death	Forest range / beat	Animal details	Reason
1.	16.01.88	Hardwar, Kharkhari	Female, 21 years	Electrocution
2.	15.02.87	Hardwar, Kharkhari	Male, 02 years	Falling through hillock
3.	05.10.90	Hardwar, Kharkhari	Female, 12 years	Electrocution
4.	07.11.90	Hardwar, Kharkhari	Female, 15 years	Electrocution
5.	04.12.90	Hardwar, Kharkhari	Female, 01 year	Falling through hillock
6.	02.05.92	Hardwar, Kharkhari	Female, 45 years	Train accident
7.	02.05.92	Hardwar, Kharkhari	Male, 04 years	Train accident
8.	02.05.92	Hardwar, Kharkhari	Female, 45 years	Train accident
9.	02.05.92	Hardwar, Kharkhari	Female, 40 years	Train accident
10.	14.11.93	Hardwar, Kharkhari	Male, 30 years	Bull fighting
11.	18.11.93	Hardwar, Kharkhari	Female, 32 years	Falling through hillock
12.	23.02.96	Hardwar, Harnaul	Male, 65 years	Natural
13.	01.01.98	Hardwar, Rawli	Male, 80 years	Natural
14.	13.03.99	Hardwar, Kharkhari	Male, 11 years	Falling through hillock
15.	02.05.00	Hardwar, Kharkhari	Female, 18 years	Train accident
16.	27.04.01	Hardwar, Kharkhari	Female, 35 years	Natural
17.	29.05.01	Hardwar, Kharkhari	Female, 18 years	Train accident
18.	25.01.02	Hardwar, Kharkhari	Female, 35 years	Train accident
19.	12.03.02	Hardwar, Kharkhari	Male, 03 years	Train accident

Source: Management plan of the Rajaji National Park (2000-01 to 2009-10).

Table 2. Train accidental deaths of elephants in the Rajaji National Park area since 1987.

S. No.	Date	Place / Range where death occur	Animal detail	Approximate time and 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	Crushed by train
5.	May 02, 1992	Kharkhari / Hardwar Range	Female / 45 yrs.	Passenger	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.	02.10 a.m. / Goods Train	Crushed by train
10.	May 10, 1994	- / Kansrao Range	Male / 08 yrs.	10.00 p.m. / Goods Train	Crushed by train
11.	May 17, 1994	- / Motichur Range	Male / 55 yrs.	08.40 p.m. / Doon Express	Crushed by train
12.	Sep. 28, 1998	Suswa / Kansrao Range	Female / 35 yrs.	07.50 p.m. / Ujjain 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.	07.50 p.m. / Janta Express	Crushed by train
15.	Apr. 03, 1999	- / -	- / -	10.30 p.m. / Mussoorie Express	Crushed by train
16.	May 02, 2000	Kharkhari / Hardwar Range	Female / 35 yrs.	- / Mussoorie Express	Crushed by train
17.	June 04, 2000	Gular Parao / Motichur Range	Male / 08 yrs.	09.40 p.m. / Doon Express	Struck with train
18.	May 29, 2001	Kharkhari / Hardwar Range	Female / 35 yrs.	10.10 p.m. / Mussoorie Express	Struck with train
19.	Jan. 25, 2002	Kharkhari / Hardwar Range	Calf / 02 yrs.	10.30 p.m. / Mussoorie Express	Struck with train
20.	April, 2007	Kharkhari / Hardwar Range	Sub-adult / -	05.15 a.m. / Goods Train 09.45 p.m./ Doon Express	Hit with train (status not known)

Source: Office, Director, Rajaji National Park.

Table 3. Natural water sources in Hardwar forest range with their status during 2000-2001 and 2006-2007.

S. No.	Name of water source	Forest area	Perennial/Annual	Status during 2000-2001	Status during 2006-2007	Current status
1.	Naraunga	Kharkhari	Perennial	Fulfilled with water	Dried	Dried
2.	talab	Kharkhari	Perennial	Running water	Less water as compared to 2000-2001	Only one water point was present
3.	Bada pani shroath	Kharkhari	Annual	Small water bodies at short distances	Water present only in internal zones	Dried
4.	Sukh rau shroath	Kharkhari	Annual	Water available because of	Water points has got decreased	Shrinking
5.	Bag rau	Mayapur	Perennial	ground water seepage Small water points available	Water is continues to shrink	Shrinking
6.	shroath	Mayapur	Perennial			Dried
7.	Gaurikund	Mayapur	Perennial	At 2 points water available At 4 point water available	Shrinked Only 1 water body present,	Shrinking
8.	mandir	Mayapur	Perennial		unpurified	Shrinking
9.	shroath Dhak shroath	Bilkeshwar	Perennial	Water in small quantity available	Shrinked Water sources shrinked,	Shrinking
10.	Jhabri shroath	Rawli	Perennial	Water available in between	water present only during	Water available
11.	Aam shroath	Chirak	Annual	hillock ridges Tremendous water was present	monsoon Water present but	Water available in less amount
12.	Hathikund jamun	Harnaul	Annual	Water present at short distances	fragmented Water present in very less	Water available in internal zones
13.	shroath	Ranipur	Perennial		quantity	Shrinking
14.	Rawli rau	Ranipur	Perennial	Sufficient water was present		Water available
	Aandheri shroath			Unpurified water was present	Less water was present	but in less amount
	Harnaul rau			Water was available through out the year	Shrinking Water shrinking and dried during hot periods	
	Mittha shroath Ranipur rau					

Discussion

A large mammal like the elephant could be expected to move more considerable distances even with a short period and families of a clan seemed broadly coordinated in their seasonal movements (Sukumar, 1989). In the dry months (January to June), when no rainfalls occur, the groups seek the neighbourhood of streams and shady forests. From the month of July, after the first shower, they start roaming and feed on the fresh grass and this grass in hill tracts become long and coarse by July and August, the elephants then show their upward movements. The reason for the elephants and other animal's migration is the high lands, continuous and uninterrupted hilly terrain for grazing, assured food and ideal breeding ground (Sinha, 1981).

Ranipur, Ravli and Chirak forest beats of the Hardwar forest range are historically famous for *Dendrocalamus strictus* (Bamboo) and due to the presence of huge amount of bamboo patches elephants utilized these forest pockets throughout the year before 2002. It was observed during the course of study that from last 3-4 years the regeneration potential of the bamboo was decreasing continuously. Besides, over feeding on bamboo bushes by elephants has led to destruction of this species. Elephants are a great menace to the bamboo crops and cause considerable damage. In 1950s the bamboo damage through elephants was not so serious in this area but reported to be gradually increasing, therefore, at that time, park managers recommended that the damage should be minimize elsewhere if necessary by effective artificial barriers (Singh and Sibtain, 1959). Forest fires during the last three years have also restricted the frequent regeneration of bamboo in this area. Sometimes villagers are also found responsible for damaging bamboo as they uproot whole of the plant body along with nodes/roots to fulfill their energy requirements.

Another major impact on the conservation of the elephant was forest fire. The periods from mid-March to June are the most fire prone season and this fire may be of natural or of anthropogenic origin. Sometimes, burning cigarettes, biddies, matchsticks and electric fence are the causative agents of forest fire but sometimes this fire also took place naturally. During very period when the upper surface of the land is too much hot the dry grasses like *Eulaliopsis binata* due to highly flammable nature sometimes catch fire on account of minor negligence of human beings around. Few of the villagers are also responsible for this fire because they think that after burning of old vegetation new seedling of the trees come up quickly. During March 2007 forest fire has destructed about 15 hectare forest of Kharkhari and our assessment just after the fire concluded that all the wild animals' even herbivores has leaved the forest for few months. About 7 hectare of Ranipur and Kharkhari forest was also damaged due to forest fire during

March and April 2008 and both of these areas are very crucial as far the movement of elephants during monsoon is concerned. These fires may cause irregularity in the movement pattern of elephants and their movement could be increased towards adjoining forests and human habitation areas. The reasons for migration of elephants can be annual fire, drought, non-availability of fodder, paucity of drinking water and absence of cool green shades in their respective areas (Ramachandran, 1990). Stray behaviour among elephants in adjoining areas of the RNP has been more common from last two years as compared to previous years (Joshi and Joshi, 2001).

Our earlier observations reviews that the declining rate of elephant's population in this area was mainly due to scarcity of natural water and declining rate of fodder species. A total of five villages named Ravli Mehdood, Roshnabad, Aaneki, Aurangabad and Subhash Nagar were attached to the boundary of this forest and over the last 6-7 years rapid expansion of agricultural land and construction activities has also hindered the movement of elephants in this area. The motor roads, which are adjacent to the forests like Hardwar-Dehradun National Highway and BHEL roads have heavy traffic pressure. As per a preliminary study, the average number of vehicles passing on Dehradun-Hardwar road per day is 7,929 and all the wild animals, including elephants, are not in a position to cross this track at any time due to the presence of heavy traffic (Singh and Sharma, 2001). Same situation is with other corridors present adjacent to the RNP area. Kotdwar – Lansdowne road runs parallel to the river Kho and crosses the Rajaji-Corbett corridor, the major movement track of northwestern elephant population between the Yamuna and river Sharda. This road serves as the major transport link between Pauri town and Kotdwar area. The presence of traffic on the road, construction of steep retaining walls by the side of road and the presence of human population along the entire corridor area have almost restricted the migration of elephants using this corridor (Johnsingh and Williams, 1999). Most of the seasonal migratory routes through which elephants performed their long-term migration have been shrinked presently as the result of which elephants of Rajaji are restricted to move only in internal ecological units, whereas bull elephants occasionally were observed to move within such long corridors like Chilla - Motichur and Khara – Anjani (Joshi and Singh, 2007).

In RNP the non-edible shrubs were found to form 57% of the total shrub cover. The main herbs and shrubs are – *Parthenium hysterophorous, Lantana camara, Cassia tora, Cannabis sativa, Pogostemon benghalensis, Sida rhombifolia* and *Ageratum conyzoides*. Most of the wild animals do not feed on these species and on the other hand fast growth of these species has been reducing the fodder composition within the protected area. Weeds like *Parthenium hysterophorous* were more dominant in Motichur forest beat and distributed all over the site. In the month of October and November it shows flowering as well as fruiting stage, while in the month of December and January, it was in seed dispersal stage (Joshi et al., 2000).

The factors that contribute to the killing of humans by elephants are the presence of people into elephant's habitat to collect firewood and fodder, conflict over water and cultivation of palatable crops near the forest boundary. In between years 1986 to 2004, elephants have killed 47 persons and injured 43 persons in and around the Rajaji National Park area. And in Hardwar forest range, elephants have killed 26 persons and injured 11 persons in between year 1985 to 2001.

Before 2002 groups of elephants have been observed frequently in different forest beats of the Hardwar forest range. Kharkhari forest is traditionally one of the important habitat of elephants as this area lies in Motichur-Chilla corridor – the major corridor for elephant movement from Rajaji to Corbett National Park area. Another important factor of elephant presence in this forest during hot period is the presence of tremendous amount of *Mallotus phillipinensis* (Rohini) trees, which is the favourite food item for elephants (Table 1). In few of the streams (Ravli and Ranipur) internal core zone parts were always fulfilled with natural water but due to lack of fodder species elephants are not utilizing these forests. Presently, elephant's movement is quite rare in all of the forest beats of the Hardwar forest range. Only solo bulls and sometimes small groups of 3-7 elephants were reported to move within this forest stretch. As per our review of the study, elephants start utilizing this forest area at the onset of monsoon (from the month of July), when due to extreme rains all the water bodies get filled with tremendous water leading to spontaneous regeneration of the fodder species along with natural vegetation of the area. Besides, bamboo seedlings also start growing considerably in this part of the park.

Recommendations

1) For controlling heavy traffic between Haridwar and Raiwala, there is a need of a fly-over, which will help in reducing the road accidental deaths of wild animals and which makes them to move freely within the Motichur – Chilla corridor. There is also need to convince the local people and tourists not to feed wild animals in the forest stretch, which also attracts elephants, to feed on the remains.
2) Strengthening of the Chilla –Motichur corridors.
3) Islands on the river Ganges (including Dudhia forest beat of Hardwar forest range) should be restored and freed from any anthropogenic disturbances.
4) Traffic should be stopped in the Hardwar – Jwalapur bypass road during evening hours.

5) Artificial water holes must be created, spread within the park area at short distance. For solving the problem water uplifting pumps can be used to uplift the well water during day hours, which will help during hot periods.
6) As the park area mainly comprises of Dehradun and Hardwar region, so it is proposed that the time of the night trains be shifted approximately half an hour earlier than the present schedule time. By employing this method the train could be made to move slowly and can be easily stopped in emergency, through the park area up to Hardwar.
7) Few of the sub-way (elephant under path way) may be constructed on the sharp places from where elephants cross the railway track and the national highway.
8) The foothills near the track must be widened and cleared for better and distant visibility of the train drivers as well as for the wild animals.
9) The people those are roaming here and there in the national park area especially in those forest beats, which are attached to human habitation should be stopped. Besides, construction work, which was ongoing in adjoining areas of the park boundary should be regulated to some day hours.
10) A better management strategy / action plan will be needed to control the unwanted activities from the industrial estate.

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