

Asian Elephant's *Elephas maximus* Behaviour in the Rajaji National Park, North-West India: Eight Years with Asian Elephant

Ritesh Joshi

G. B. Pant Institute of Himalayan Environment and Development, Garhwal Unit,
Srinagar-Garhwal, 246 174, Uttarakhand, India

E-mail: ritesh_joshi2325@yahoo.com

Abstract: In order to generate scientific knowledge on behaviour of wild Asian elephant *Elephas maximus*, field study was conducted from 1999 to 2007. The data were derived from a novel combination of self field observations (direct and indirect methods), traditional knowledge of various local communities, and available literature on elephant studies. During the course of study 19 different behaviours of elephant were documented from Rajaji National Park, north-west India. Despite, the status, movement pattern, habitat utilization, feeding behaviour and human-elephant conflict of Asian elephant, extremely rare research work has been carried out on its behaviour in the wild. My review of available evidences suggested that wild elephants also used to perform various usual and unusual behaviours, which are directly linked with their management and conservation. The elephants in Rajaji are emerge out in the open areas in evening hours. The movement of elephants was entirely seasonal and they also utilize the adjoining protected habitats. Fodder requirements are quite variable in groups and bulls and breeding season seems maximum to extent from May to November. Locomotion, social organization, drinking and bathing, resting and sleeping, defecation and urination, recognition, male-male aggression, sympathy and cooperation, play behaviour, association with other wild animals, parental care and elephant communication were another major behaviours observed in elephants. Besides, four unusual behaviours were also studied during this period. This is the first documented study, which could be helpful in generating more biological information about the activities of wild Asian elephants. All of these findings may have wider implications for developing predictive models of human – elephant interactions. [Nature and Science. 2009;7(1):49-77]. (ISSN: 1545-0740).

Keywords: Asian elephant; *Elephas maximus*; behaviour; Rajaji National Park; Conservation; India

Introduction

India has between 21,000 and 25,000 Asian elephants (*Elephas maximus*) in the wild and among them Uttarakhand state harbours 1346 elephants distributed within 14 protected areas. India currently has the largest surviving population of the Asian elephant, approximately 50 % of the total world population of the species (Daniel, 1996). Historically, elephants were known to raid crops but during the recent past because of increasing human population and decreasing forest cover, the conflicts between man and elephant have escalated. 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). Recently, developmental activities 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 (Figure 1). 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. Shivalik landscape (lesser Himalayan zone) is one of the last few places in the world where elephants exist and offers urgent need for conservation. 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.

Traditionally wild animals used to perform different unique behaviours to fulfill their life requirements like social calls, alarming calls, threat calls, greetings, matriarchy and hierarchy, pseudo fights, play, association with others and communication and at the same duration they perform different behaviours along with body contexts. This aspect has remained neglected during the past, which is highly required to be documented and will be helpful in management of any wild species. Knowing behaviour of wild animal is a valuable conservation tool, which can help in management and conservation of any threatened species.

Presently human beings have been fascinated towards different behaviour of animals particularly in wild form. The behaviour of wild animals is a subject matter of great interest leading to understanding about the nature of various wild animals, which may be helpful in their management and conservation. Behaviour of Asian elephants (*Elephas maximus*) particularly in circus and domesticated form provide lot of recreation to the human beings and easy to watch and enjoy. However, the behaviour of wild elephants is a tough task to be observed and studied in wild especially in foothills dominant areas. The elephant being a flagship species in this area plays an important role in the structuring of plant and animal communities. Several research studies on the behavioural biology of African elephant (*Loxodonta africana*) were conducted during the recent past but only few studies has been carried out on the behavioural biology of wild Asian elephants. In recent years, due to dwindling of forest areas only few protected areas are available for wild elephants where they can be observed in their natural habitat performing their usual activities and different behaviours.

Methods

Study Area

Rajaji National Park [29° 15' to 30° 31' North Latitude, 77° 52' to 78° 22' East Longitude] is spread over an area of 820.42 Km² in and around the Shivalik foothills, which lies in the lesser Himalayas and the upper Gangetic plains (Figure 2). Rajaji National Park (RNP) was notified in 1983 by amalgamating three erstwhile wildlife sanctuaries namely, Rajaji, Chilla and Motichur. Spread across Hardwar, Dehradun and Pauri districts of Uttarakhand state, Rajaji National Park 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 was conducted in Hardwar (District-Hardwar), Chilla (District-Pauri), Motichur (District-Dehradun) and Kansrao (District-Dehradun) forest ranges of the RNP. Besides, Laldhang forest range (Lansdowne forest division), Shyampur and Chiriapur forest ranges (Hardwar forest division) were also included 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 philippinensis* (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. 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), *Cervus unicolor* (Sambhar), *Sus scrofa* (Wild boar) and *Ophiophagus hannah* (King cobra).

Data Collection

All the field observations were made during 1999 to 2007. It is not easy to sight elephants in dense forest habitats due to thickness of the undergrowth and foggy climate especially during the monsoon and winter period. Also there are chances of any casualty. In few of the forest pockets it was difficult to observe directly the elephants in RNP because of dense sub-tropical vegetation and presence of undulating foothills with bushes taller than the animal. Thus the study incorporated both direct as well as indirect methods.

Direct Method

For studying the behavioural biology of elephant's four forest ranges (Chilla, Hardwar, Motichur and Kansrao) of the RNP and few adjoining forests (Shyampur forest range, Hardwar forest division and Laldhang forest range, Lansdowne forest division) were selected and in-depthly surveyed. It was not possible to observe the elephants during monsoon as the areas are dominated with tall grasses and dry

period was the best time to observe the elephants especially near to water sources. The study area was visited at weekly intervals during which observations on elephants were made along the motorable forest track, present in between different forest habitats. 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 study area does not comprises of any road, therefore, study was made on foot. Although some animals were observed up to 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 philippinensis* and other favourite fodder species 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. All the natural behaviours of the animal were observed and recorded directly. 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 i.e. before the sunset. The data collected was as part of the animal monitoring activities and 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 proforma, recording the group 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 also interviewed. Field binocular was also used for observing their movement behaviour without disturbing the animal from an adequate and safe distance.

Movement behaviour

Different groups and solitary adult male elephants were selected and followed in Chilla, Hardwar, Motichur and Kansrao forests of the RNP alternatively. Their activities along with movements were duly plotted on map. For census purpose, the four categories recognized by Eisenberg and Lockhart (1972) – namely adult, sub adult, juvenile and calf were adopted. Photographs of the groups and bulls were also taken for confirmation upon repeated sightings. Whenever any marked groups or solitary males were encountered during early morning circuit, their location was noted along with ongoing activity. An attempt was again made later in the evening hours to relocate the animal that had been observed in the morning. Video camera was also used to cover small footages of group composition along with different behaviours of recognized groups. Whenever herds were encountered, they were observed until they disappeared from sight or until darkness made further observations impossible. As elephant movement was restricted in between Chilla – Motichur and Rajaji – Corbett corridors, therefore, it has made us easy to follow and observe these recognized groups and bulls those were performed their movements in eastern part of river Ganges.

Feeding behaviour

For studying the feeding behaviour of elephants, all the plants species on which elephants were observed to feed in the study area were identified either through the flora dictionary or by the help of subject experts (herbarium identification). Some plant species were well-known to us. The majority of plants were collected after observing an elephant feeding on a plant then waiting until the animal had moved away. Besides, elephant's traditional movement tracks along with feeding grounds were searched and observed directly.

Identification of the elephants was important to verify their movement as in the same area there was 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.

Indirect Method

In few of the places the indirect count method was followed for checking their number in study area (Dawson and Dekker, 1992; Ramakrishnan et al., 1991 and Santiapillai and Suprahman, 1986). This involves path counts and frequency of elephant signs. For conducting the study on elephant's presence, all the observations were made from a vehicle and through adopting the road-strip count method (Hirst, 1969; Santiapillai et al., 2003) to monitor the fluctuations in elephant numbers.

Results

1) Movement and Migration Behaviour

Movement is one of the most important ecological factors that represent the home range as well as habitat utilization of an animal. Both movement and migration depends upon the availability of natural food and water (Figure 3). Changes in season and scarcity of water and natural fodder species force wild animals to leave a place for few months and reached to new feeding grounds for fulfilling their feeding, water and other routine requirements. There are seasonal variations in fodder species as RNP area falls under sub-tropical moist deciduous forest vegetation type. Elephants use whole of the park area as their natural habitat but mostly they leave some of the areas having less vegetation cover and water for few months and move towards other ranges richer in fodder species and natural water. Although at that time few of them (mostly solitary bulls) use the same feeding grounds or move frequently in all the forest beats of the park as a general rule of migration of any species. Selected range wise movement pattern of the Elephants is described below.

(i) Hardwar Forest Range

On the onset of winter from the month of mid-October, when there is slight scarcity of fodder species elephants move towards the Dholkhand forest range, which is situated towards north-west direction and towards Kansrao forest range, situated north through crossing Motichur forest range. Study revealed that elephant's move from Hardwar forest range to the adjoining ranges on the arrival of winter and also at the onset of summer period especially from the month of March to June, which were also known as the forest fire months. But the movement of few of the solitary bulls and occasionally group (very rare) have been observed in whole of the range. Most of these movements are obviously being restricted by various villages, temples, railway track and national highways those are present in the vicinity or in between the park area. Hardwar forest range is partially covered on one side by villages (Nai Basti-Bhimgoda, Lodha Mandi, Ravli-Mehdood, Roshnabad, Aehtampur Aanaeki and Aurangabad), therefore, instances of man-elephant conflicts are relatively more in this area, than in other ranges. These conflicts may be in any form viz. crop raiding and manslaughter. Dudhia forest beat due to its closeness to the Haripur Kala village and river Ganges is one of the most sensitive area as far as elephants' casualties are concerned.

During the study period occasionally, the movement of only solo bulls was observed in this part of the park. Despite the fact that Dudhia area is rich in *Dalbergia sissoo* (Shisham) and *Acacia catechu* (Khair) forest, being the preferred food item of the elephants. Group movement was almost restricted in this forest pocket due to most active nature of anthropogenic and developmental activities. Generally, the solo adult bulls follow the city route to reach the Dudhia forest and river Ganges by crossing the railway track and Hardwar-Dehradun National Highway. Elephants enter to the city from northern Kharkhari forest beat and moves towards Chilla area after the sunset and re-enter to the northern Kharkhari forest beat before dawn. During this long journey of about 2 kilometers elephants crossed many of the minor routes along with various colonies. Besides, solo bulls from Chilla forest also enter in this forest beat after passing through the islands situated in between river Ganges. This track falls under Chilla – Motichur corridor and is one of the important habitat as far the elephants' conservation is concerned.

During the field observations it was observed that this pocket of the area is very sensitive for the movement of the elephant mainly due to huge scale anthropogenic activities. During 1999 to 2002 few cottages have been constructed in this area inhabited by about two dozens of sadhus and likes; on the other hand this pocket has been part of the traditional route for the elephants to interchange the forest. Rapid developmental and construction activities in Haripur Kala village situated peripheral to the island and in adjoining areas; the elephant's movement has been disturbed. The residents of the area revealed that seven years ago an adult tusker was killed by electrocution by a villager, however no human casualty has been reported till now.

(ii) Chilla Forest Range

Elephant use this forest range round the year because of altitude wise variation of rich fodder species. On the arrival of winter elephant's movement is towards lower areas like Chilla, Mundal and Khara forest beats. At the same time elephants also utilize the adjoining forest of river Ganges, which is spread up to Rishikesh along the river. On the arrival of rainy season elephants migrate towards upper areas like in Luni, Pulani, Rawasan and Kasaan forest beats and that was the time when elephants start their long term migration towards Lansdowne forest division. Many of the groups and solitary bulls use all of the forest beats for their local movement. During the summer elephants also use the Gohri forest range, which is in the north of the Chilla forest range.

Elephants also use the Ghasiram water stream for visiting to river Ganges especially when their movement was frequent in and adjoining forest beats, which were attached to river Ganges along with few bridges, which are situated in Ganga canal of Chilla hydro electric power plant. Few of the groups were also observed to use the Shyampur and Chiriapur forest ranges of Hardwar forest division during rainy season because of availability of Ganga canal water. At the same place elephants perform their movements towards river Ganges through crossing the Hardwar-Bijnor National Highway. Currently only bull elephants are utilizing this track whereas no groups were reported during last three years. As per last 4-5 years data, groups of the elephants were observed in the same area but rapid developmental activities has restricted the frequent movement of elephant's group towards river Ganges.

Few of the main reasons affecting local movement of the Elephants in rainy season are:

- a) During rainy season the elephants were seen moving towards upper areas of the park. This is because the low lying areas become swampy and unfit for free movement of the Elephants.
- b) Another major factor contributing to their upward movement is the abundance of a blood sucking fly locally called as "daans" in low lying areas which irritates these elephants by hovering around their ears and trunk. This fly is commonly found affecting the cattle stock of Gujjars.
- c) Forest fire is also one a factor to force the Elephants movement to a separate area where fire had not been so extensive. This fire if spread extensively then the movement of such a large animal also restricts to the same area for some time.

(iii) Motichur Forest Range

Elephants in summer use this forest range extensively as compared to winter and on the arrival of winter their movement is towards Kansrao forest range (north-west) and towards Beribara and Dholkhand forest ranges. In summer, elephants were observed more around the natural water sources (Koyalpura west, Kalakund, Jamunkhatta and Danda) besides the fact that this forest comprises of dense vegetation cover. Few of the group and solitary bulls use whole of the range for their movement. Elephants frequently use the Motichur rau (seasonal water stream) as a corridor for going to river Ganges. Occasionally they also follow the forest route between Motichur Forest Range Office and Raiwala area for going to river Ganges by crossing the Hardwar – Dehradun National Highway and railway track situated in between the protected areas. Establishment of Satyanarayan area, Raiwala area and Khand village has created a permanent barrier to frequent movement of elephants to different forest ranges. In this way they are forced to restrict themselves in low land areas as all of these areas lie in between the park area.

This is again one of the important and long stretched crucial corridor for elephant movement from Rajaji to Corbett National Park. This corridor is known as Chilla – Motichur corridor. River Song and Suswa flow through this range and elephants from Motichur and Kansrao forest ranges utilize the thick vegetation cover near to river water especially during dry season. Elephants, which move from Kharkhari forest beat to Motichur and Kansrao forest represent their seasonal movement as they leave the Kharkhari forest for few months mainly due to scarcity of water sources. During the recent past rapid developmental activities has restricted the frequent movement of elephants in this forest stretch and therefore, caused irregularity in the confirmed movement pattern of elephants within their home range (Joshi and Singh, 2007).

(iv) Kansrao Forest Range

Kansrao forest represents one of the best habitat where elephants can be observed in large groups, while performing their seasonal movement. On the arrival of summer season elephants from Motichur and Dholkhand forest move towards Kansrao forest (north-west, north-axis) as this forest is blessed with several water sources and Song river. Besides, cool shaded forest canopy also promotes the large scale

movements of elephants. Jamunkhatta and Bahera forest blocks are again the best resources where elephants stay for longer duration. But at the onset of winter elephants migrate from Kansrao and at that time their movement is towards south-west axis. During hot periods elephants also use Beribara ghata forest as this forest stretch was quite cool and dense forested habitat. During dry periods elephants used to cross the railway track regularly to visit river Song, which flows on northern axis and on the edge of the park boundary.

2) Feeding Behaviour

Generally elephants fed in the early hours of the morning and most markedly in the evenings, just before dark. They were observed to feed in mid-day hours in winter but in summer, they rested during midday. Sometimes elephants were observed continuously feeding throughout the night. In summer, they spent their nights in open forest areas and when the day advanced they move towards the denser forest. In evening when the sun begins to set they again came out of the thick forest cover into the open forest areas.

In RNP elephants mostly fed on the tree species like *Mallotus philippinensis* (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). Besides, elephants also use various grasses and shrubs as their food, which included *Dendrocalamus strictus* (Bamboo), *Helicteres isora* (Kapas), *Saccharum munja* (Pula), *Saccharum spontaneum* (Kans), *Cynodon dactylon* (Doob Grass), *Eulaliopsis binata* (Bhabhar Grass), *Tinospora malabarica* (Giloe) and *Neyraudia arundinacea* (Bichla Grass). Though elephants consume a variety of plant species in the study area, but their diet mainly consisted of fifty (50) plant species, which are available to them alternately round the year. Alteration between a predominantly browse diet throughout the year with a grass diet during the early dry season was related to the seasonally changing mineral content of grasses.

In few of the plant species elephants utilized both leaves and twigs as their fodder for example when they were feeding on species like *Dalbergia sissoo*, *Acacia catechu*, *Bombax ceiba*, *Aegle marmelos*, *Ficus bengalensis* and *Ougeinia oojeinensis*, they ate different parts of the plant according to various seasons. It was observed from the present investigation that during January to March elephants mainly utilized the bark of different trees (*Shorea robusta*, *Bauhinia variegata*, *Mitragyna parvifolia*, *Schleichera oleosa*, *Lagerstroemia parviflora*, *Cordia obliqua*, *Tectona grandis*, *Holoptrophora* spp. and *Bombax ceiba*) as their food. Elephant prefer to feed extensively on the bark and twigs of *Tectona grandis* at the onset of summer whereas they were observed to eat bark of *Bombax ceiba* tree during very hot season. Barks of the trees were mostly removed with the help of trunk but sometimes were also scrapped by using the tusks in case of bull elephant. Bulls have more options for feeding purpose as compared to cow elephants as sometimes cows could not remove the young and compact bark of trees whereas bulls are very able to remove such barks easily with the help of their tusks.

Fruits of *Aegle marmelos*, *Flacourtia indica*, *Ehretia laevis* and *Zizyphus mauritiana* were consumed by elephants. They often uprooted the plant with the help of the trunk and sometimes with the help of forefoot. Succulent grass species such as *Saccharum munja* and *Saccharum spontaneum* were favoured, although these are not the perennial food resources in the park area. *Tectona grandis* and *Holoptrophora* spp. are also important fodder species, which were directly linked with elephant foraging as few of the area comprises of extensive stands of both of these species and currently elephants are utilizing these food resources in some particular months of the year (from December to June). Direct observations indicated that these species are preferable food item for elephants and it was noticeable that elephants are feeding extensively on these species since last 5-6 years whereas before 2002 elephants were not reported to feed on these species. Only bark of these trees is being utilized by elephants they spent even whole of their day to feed on these species (Figure 4). Elephant induced damages to these species is quite large. Both of these species were planted in few forest pockets sometimes 20 years back to get rid of open damaged forests besides the fact that the regeneration potential of these species is very fast. Extensive feeding was observed on these food resources by elephant in eastern part of river Ganges whereas currently south-western population of elephants were not utilizing these species as their food. Although these plants are not the natural food but now as per the results of our observations these fodder species can be categorized under primary food.

Cordia obliqua, *Holarrhena antidysenterica* and *Mitragyna parvifolia* were also eaten by elephants occasionally. Generally bark and soft twigs (without leaves) were consumed as food especially

during dry periods (April-June). This study described about these important fodder species, which are completely seasonal for the first time and all of these new findings have wider implications in conservation of Asian elephants through habitat improvement and management approaches. In Shyampur (Hardwar forest division) and Chilla forest range (RNP) elephants are currently utilizing *Eucalyptus* spp. (*Eucalyptus*) as their food especially during dry months. It was observed during the course of investigation that elephants start to feed on this resource after August 2007 whereas before 2007 elephants have not utilized the said species as their food. Observations indicated that only soft bark of this plant species is being utilized by elephants and only four identified adult bull elephants were observed to feed on, whereas till today no single group was utilizing *Eucalyptus* species as their food. This observation is a new record from north-west elephant range of India regarding to elephants' feeding behaviour.

Elephants sometimes spent long time to feed on some particular plant species like *Dendrocalamus strictus* (Bamboo), *Mallotus philippinensis* (Rohini), *Cynodon dactylon* (Doob grass), *Ficus religiosa* (Pipal), *Saccharum spontaneum* (Kans) and *Saccharum munja* (Sarkanda). The consumption of tree species was highest, followed by few important shrubs and grasses. Study revealed that the total amount of plant matter removed by the elephants was not fully consumed. In fact a relatively large part was dropped to the ground and left as such, which was sometimes utilized by other herbivores thus representing associational behaviour. The elephants in RNP fed extensively on the mixed vegetation including trees, grasses and shrubs. Although the study area has dominant plant species like *Shorea robusta*, *Mallotus philippinensis*, *Acacia catechu*, *Dalbergia sissoo*, *Terminalia tomentosa*, *Syzygium cumini*, *Ehretia laevis*, *Lagerstroemia parviflora*, *Holarrhena antidysenterica*, *Helicteres isora* and *Lannea coromandelica* besides, few species of *Ficus* and *Zizyphus* are available. The most preferred food item in this area was *Dendrocalamus strictus* (Bamboo) and *Mallotus philippinensis* (Rohini) but elephants used different food resources round the year as per their availability. The bulk of the diet in number of species and quantities eaten came from twigs, bark, fruits and leaves. Though study area comprises of 128 tree species, 63 shrub and herb species, 33 climber species, 1 bamboo species and 37 grass species but out of total recorded fodder plant species (50), trees represented 74% of the species that elephants fed followed by 14% (grass species), 8% (shrub species) and 4% (climber species).

3) Reproductive Behaviour

Elephant is a highly social animal with group instinct and generally one group consists of 5 to 15 individuals, which comprises of adult cows, sub adult cows, juveniles and calves (newly born). Adult bull elephants are rarely seen within any group, they were observed to join the groups for only breeding purposes. Adult bull elephants prefer solitary life and they utilize wide range of feeding grounds and move more as compared to groups. As RNP area falls under sub tropical moist deciduous forest type; therefore, feeding and breeding parameters are dependent on availability of natural food and water. Several studies have conducted on the breeding habits of elephants but still little is known about the actual breeding biology of Asian elephants in the wild.

Like many other animals elephants also show the phenomenon of love play, which includes mixing of bull elephants in the groups, selecting prospective partner to mate, smelling of genital organs, sniffing the urine and dung, touching the trunk especially temporal gland and discharge of urine. The whole process was observed to happen within 15-20 days but sometimes it also took one month if environmental conditions are unfavourable (scarcity of fodder and water and high rate of movements). Sometime it was also observed that the adult cow within a group does not accept the bulls in their groups, at that time groups produce loud noise and reflects their weirdness. Long duration of love play and secretion of urine are important factors, which promotes the successful mating. The males are capable of making a second crossing after about 45 minutes and may do the copulation act 4 to 5 times a day (Iyppu, 1990). The duration of coitus was observed to be 3-4 minutes depending upon presence of group members and cooperation of the cow elephant.

The contact promoting was important factor, which includes separation from groups and mounting of bull elephant but several times false mating were also occurred, which expands the conception duration. The total time required for love play and actual act may take one or two hours. In younger bulls, which are afraid of grown up leaders, the whole act may be brisk and is completed in a short period (Iyppu, 1990). When cow comes under heat, exhibits her approval for the conception and at the same time both of them respond equally towards each other and the process of smelling of genital organ by male was observed to be quite frequent. As per the observations of the study it was not compulsory that the bulls, which are in musth condition only exhibits healthy sexual contacts, mating bulls are often observed to have no signs of

musth phenomenon, besides the fact that the bulls those are in musth are quite aggressive then those who do not exhibit the phenomenon of musth and can dominate over other males.

Mating was observed mostly inside the dense forest zones especially in those areas, which are enriched with water. Whenever the mating process was completed (10 to 15 days) bull elephants leave the group and start to live solitary life. Longer stay of bull elephants with a group was also observed during the study period but at the same time they also leave the group for a short period of time to perform movement on a wide range as the group movement was always restricted to some extent (03 kilometers). Examinations of genital organ with trunk, hugging, touching of temporal region of males and sniffing the dung are important pre-contact promoting behaviours of male and female elephants (Nair, 1990).

Most of the newborn calves were observed during January to May, which corresponds to the wet as well as dry season. The gestation period in Asian elephants varies from 18 to 23 months and if an average value of twenty months is taken as the gestation period, then the breeding season seems to be maximum to extend from May to November, which through embraces the hot, rainy and beginning of cold seasons, but can be taken up by and large as - warm period. On the basis of these observations, it would appear that there are some particular months of breeding. The important ultimate factors that influence the animal's reproductive cycle are probably the seasonal availability of food and water (Laws et al., 1975). Since, there is never any extreme shortage of food in RNP area therefore; the breeding season of elephant's was never so pronounced and drastic. Numerous perennial and seasonal rivers and streams further ensure the yearlong availability of fresh water.

4) Locomotion

The elephants usually move at a slow pace, but are capable of moving very fast. Movements were quite dependent on the activity they perform. If the animal is feeding, the slow walk is generally used and if the animal is moving towards water sources and crossing the forest road their walk became fast. In both the slow and fast walk, the position of the trunk and tail are quite variable. The movements of calves and juveniles are fast mainly due to their playing nature, chasing each other and to catch their mothers while changing the track and at the same time they upraise their trunk and tail for a short period of time. Fast movement by adult animals was observed only in case of flight and attack.

During the course of study several times I encountered the charging behaviour of elephants either of group or solitary bulls (Figure 5). It was observed that solitary adult bull elephant can run fast than cow elephants. Although charging by group leader cow or by whole group is very rare phenomenon whereas charging by adult bulls was noted to be more common. Charging by group or cow was measured to approximately 18 kilometer per hour and by bull elephant was approximately 30 kilometer per hour. Besides, bull elephant can run fast for a longer period of time but cow was observed to run fast for a short distance mainly due to group constraints. During the charge tail is generally arched upward and trunk is curled in between the fore legs.

Faster walk was also observed during when the elephants perform their journey adjoining to human habitation areas mainly due to anthropogenic disturbances and threat. Group movement was always slow and restricted to a shorter distances whereas movement of solitary bull was quite vast and bulls make a large seasonal territory as compared to groups and herds. This also depends upon the musth phenomenon in males during which period, their movements became expand to join groups and in search of prospective females for mating needs. During the study period elephant movement was observed more during night and during the day they travel shorter distances and their walk was also observed to be slow.

Swimming

Elephants are well capable of swimming even under high flow of water. Several times I have observed the elephants during swimming in river Ganges. When swimming, their bodies remained submerged in river water, only the tops of the head and trunk tips being above the water. It was observed during the present investigation that elephants swim 100 meter wide river in 35 seconds (Figure 6). They sometimes also lie down in the water for few minutes to cool down their bodies especially during hot periods. When elephants are in groups, they swim serially and during the said period juvenile elephants are completely protected by their elder ones. The groups or herds with baby elephant (calves, smaller than 2 years) were only observed to drink and play in river bank area; they completely avoid swimming in the river water. As RNP and its adjoining protected habitats consist of several islands situated in between river Ganges, therefore, swimming in elephants is apparently common. Besides, several corridors are also

present in between different forest stretches and elephants traditionally use these corridors for interchanging the different forest zones.

5) Social Organisation

Social organisation is highly developed in elephants. A group of elephants is in general called herd, which is a large family unit. These herds move separately and maintain their kindship in terms of acoustic communications and through intra-mixing of various groups time to time. On several occasions (long-term migration and when elephants' movement was nearer to human habitation areas) several smaller groups may join to make a large herd, but this large group formation was restricted to the herds of same kindship. Social factors such as home range, average group size and seasonality of breeding have a profound influence on the population dynamics of many large mammals and are also important in their management.

During the study period inter-mixing of groups was mostly observed during their long-term migration. Besides, intra-mixing was also observed during their local movements especially when elephants inter change the forests through internal corridors. Whenever two elephants were in the same vicinity, the first indication that one has become aware of the presence of the other was generally the extension of the trunk by one or both in the direction of the other. When one elephant approaches another, the trunk was generally extended forward towards the animal being approached. Initial contact between two animals generally involves mutual examination by both animals; the trunk tip was extended towards the other individual, the most frequent areas of contact being the ear, mouth, eyes, temporal gland point, tail, anus, feet and genitalia (Mc Kay, 1973).

The oldest cow usually leads the herd however, this was a disputable point whether bull form the part of the herd or not. Bulls are observed to live in the groups for a short period of time and during the same period they randomly leave and join the groups. During the course of musth in males their movement was enhanced and they perform longer distances as group movement was restricted to shorter ranges. When a group was on move, the group forms a formation in such a way that young ones are protected in all manners. Usually, the oldest cow elephant [leader] heads the groups, the bull move on the periphery while the young ones are kept inside. Some bulls live a truly solitary life, sometimes accompanied by a companion who may be of around equal age. Generally solitary bulls branded as rouges though many of them may be inoffensive and peace loving. The extensive generation overlap leads to the establishment of linear dominance hierarchy among the females, and the leadership often falls on the oldest female in the group (Santiapillai and Suprahman, 1986). The mixing and separating of the different groups was another factor, which shows their social organisation.

The most cohesive social organisation in elephants was that of the adult female and her offspring, which constitutes a family unit. A number of family units join to form a clan and such clans consist of closely related animals of all classes excluding the adult males. Lactating cows with attendant young may aggregate together to form nursery units. Young pubertal males also mix with the herd to form loose associations for their reproductive activity. Since, the elephant calf is vulnerable to predation, therefore, the social organisation of the matriarchal groups serves as a protective device and at the same time, creates a social behave within which the young can mature and learn the template of their environment. It is therefore inevitable that an animal, which remains a member of a family unit for over 20 years should develop strong social ties with its mother and siblings (Eisenberg, 1981).

6) Drinking and Bathing

Water is the most important environmental factor that determines the elephant's distribution in any area. The elephant's home range must contain at least one river system in a general view. In the RNP, elephants were observed to drink between 15.00 and 19.00 hours. They were also observed to drink water during early morning hours (3 am to 7 am) and very occasionally during midday hours as this will quite dependent upon the presence of calves within any group. It was observed that drinking activity was quite frequent when the calves are in the group and at that time elephants allow themselves to drink water as per the requirements of their young ones. This factor was also dependent on the temperature, humidity, season and the amount of intake of food diet and water. Elephants are quite selective for certain specific locations along the river, this indicates that the drinking or bathing sites could be traditional and perhaps memory or habit based. These fixed points facilitate regrouping by members of a herd who have been foraging alone or as small units. Water holes appear to be especially important in this regard.

Elephants appeared to have traditional drinking spots, both water holes and sandy stream beds. While drinking the water they also spray the water on to the body. Besides, bathing with water, elephants also frequently cover the body with mud or dry soil (Figure 10). This helps them to cool their body for long period of time and get rid of the tiny flies, which irritates the elephants during their movements especially during monsoon period. After bathing with water or mud elephants rub their body against trees and rocks.

Presently, within few of the areas (where Gujjars still exist) their natural time for the same activity appears to be changing mainly due to anthropogenic pressure. In such conditions, when their movement was towards water source during day hours or in early evening hours, they swallow the water immediately and return back to forest area. On the other hand when they reached the water source after sunset or late evening hours they spent more time in the same activity. Sometimes it was also observed that an adult bull (occasionally groups also) spent whole of the day near to water source and feed on vegetation of adjoining areas. 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).

In Chilla the elephants after rains when move towards lower areas get their water supply from river Ganges by crossing the Hardwar-Chilla-Rishikesh road, which passes through the park area. They spent whole of the night in the adjoining forest of river Ganges and return back towards eastern direction in early morning hours. When any herd starts bathing, firstly the leader adult cow enters in the water, after that sub adults with calves enter the water body. During the said period adult elephants continuously sense the area and if they don't recognised any threat, only then other fellows of the herd enter to the water and at that time adult cow always remains alert towards her young ones. Sometimes it was also observed that elephants do not drink water if sense human presence and in such situations they returned back to adjoining forest upto the sunset.

Sometimes it was also observed that when elephants were drinking water and any incident of human presence will occurred, the adult bull (if present within group) or cow might suddenly charge the object. The most interesting thing was that they do not make any sound when they are entering the water and after entering, they cautiously try to listen to any disturbing or threat sound. When they observe that no interruption signal was around, they start bathing and sprinkle water over their body. During summer, they sometimes also observed to stand or laid down for few hours in the water. Sometimes elephants rub their bodies with trees just after taking swampy bath and these rubbing scratches were usually observed nearer to water points especially in areas those are continuously utilized by elephants. The cattle's and deer's also utilizes trees for the same activity but the identity of the species using the tree can easily be remarkable from the height of mark.

In Asian elephants the bouts of drinking and bathing are predominantly during the mornings and evenings hours (Seidensticker, 1984) whereas in the Wankie National Park (Africa) peak drinking activity of elephants was observed during the night (Weir and Davison, 1965). In the Way Kambas Game Reserve, elephants were observed to drink between 17.00 and 18.00 hrs. and the animals seem to prefer certain specific sites along the rivers (Santiapillai and Suprahman, 1986). Elephants generally do not drink at any point along the stream or channel but have particular drinking spots, which they visit regularly as well as particular crossing points (Mckay, 1973).

7) Resting and Sleeping

Elephants often rest for period of several hours under shade in the immediate vicinity of their feeding areas especially during hot periods. The highest number of elephants was encountered regarding to this observation between 11.00 and 15.00 hours. The resting places are not specified as far migration was concerned but during local movement their resting places are generally fixed. Standing for a long duration in cool shaded trees represents the resting and sleeping in elephants but sometimes they lying down under dense canopy of trees and take rest. Elephants often use the same areas to rest and sleep. Such elephant "resting places" have been encountered in all the forest ranges. They measure about 50-100 m² and are characterized by the places where dense vegetation covers like *Ficus bengalensis*, *Butea frondosa*, *Mallotus philippinensis* and *Adina cordifolia* were present. During the period of rest occasionally, branches of various fodder species are also plucked out for feeding purpose. Sometimes elephants also break down the twigs of trees and heave it to their body to get rid of the small insects and flies. It was observed that when elephants were on rest, calves lying down over to mud under the legs / belly of their mothers. Sometimes play behaviour was also observed among calves during the course of rest.

Within the study areas many "rest rooms" of this type are regular encountered during the hot period (mid day hours). Evidence of regular utilization of such areas was further identified through numerous dung piles that lie within the resting areas. Sometimes they also prefer to take rest between the ridges of foothills where water is present in adequate amount, besides the fact that these areas are quite cool during summer. Elephant 'rest rooms' have been encountered both within the Way Kambas Game Reserve and elsewhere in Sumatra (Santiapillai and Suprahman, 1984a). They measure 50-100m² and are characterized by the sparse or total lack of ground vegetation and scrub. Rest rooms are usually situated at the intersection of two game trails (Mckay, 1973). Asian elephants suffer more than the African Bush elephants from heat dissipation and therefore need regular access to shade during the day (Santiapillai and Suprahman, 1986). The resting follows maximum during the dry season.

8) Defecation and Urination

As a consequence of prolonged feeding activity the urination and defecation are regular phenomenon in elephants. Being a non-ruminant, the rate of passage of food through the alimentary canal is much faster than in ruminants (Santiapillai and Suprahman, 1986). In the present study defecation in elephants was observed maximum in early hours between 6.00 - 10.00 hours and between 15.00 - 18.00 hours, which was also the time to drink. During summer, they were observed to defecate during resting period under a dense tree (between 12.00-14.00 hours). It was observed that the defecating rates were similar in different age-classes.

The maximum number of times they defecates was noted in shady portion of small water bodies where sufficient amount of vegetation was available, under the dense trees like *Ficus bengalensis*, *Butea frondosa*, *Adina cordifolia* and *Mallotus philippinensis* in the area where fodder species were abundant frequently and near to the natural water source. Sometimes they defecate in rough routes in foothills and in the forest roads. Water is another major factor, which influence defecation in elephants. Study revealed that elephants defecate mostly near to the water source and just after drinking the water. Defecation in elephants was also observed during such conditions when there was anthropogenic disturbance and they got fear of that. The elephants have the tendency to defecate, whenever they crossed a forest road (Laws et al., 1975). A bimodal distribution was observed in the defecation of African elephants with peaks between 09.00 hours and 12.00 hours and between 15.00 hours and 18.00 hours (Wyatt and Eltringham, 1974), while as per the observations of another study several peaks with maximum at 09.00 - 10.00 hours and 16.00 - 17.00 hours were observed in the defecation rate of the elephants and the defecation rates are to be similar in different age classes (Coe, 1972).

9) Recognition

There is no parallel to the memory and intelligence of the elephants in the animal kingdom. Since time immemorial many stories and incidents happens, which reflects the strong memory and high intelligence of this largest terrestrial animal. They also follow a fixed pattern for their various routine activities as other wildlife do. Elephants trumped loudly whenever they are excited or aggressive. Trumpeting occurs when elephant attack, when they are surprised and when an individual has gone the wrong way and feels that it has lost contact with the herd (Oberoi, 1980). Generally groups of elephants produce these rumbling sounds, indicating that it was used in maintaining group cohesion or as a greeting sound when elephants approach each other. Most of this type of trumpeting was observed in the study areas especially in the early morning hours when they are in cheerful humor (mostly by solitary bulls), when group was feeding, if they feel any threat and when their any fellow dies.

It was also observed that elephants by producing loud noise call their other fellows. Cow elephants call their young ones by slapping their ears against the head and when companions meet, they softly peep and rumble. When they feel threatened, they often upraise their tail, stop flapping ears, beat their trunks against the ground; spread mud and produce a sound like that of a tiger. That was only the moment when they are completely ready to charge anyone.

Few of the investigations indicating rather good vision are supported by the ability of elephants to recognize objects they have seen even after a long lapse of time. Few of the workers also observed that the members of the herd of wild elephants numbering 50 to 100 individuals recognized each other individually. They also know their exact paths, even though many of these paths are used only every few months (Oberoi, 1980). During the study period it was observed that when they move outside from the protected area regarding to crop raiding and crossing the forests through human habitation, they follow a fixed route and sometimes that route even may be longer than other choices by about 2-3 kilometers but they only re-

enter to the forest area from the route they have been using. It was also observed that during the course of inter-mixing and intra-mixing between various groups, elephants trumpet loudly and produces several types of greetings and recognition sounds. Vocalization among elephants can also be noted during the pre-mating processes, when some bull elephants are associated with the group and represents their dominance and the process continues for about one to two months.

10) Pseudofights / Male-Male Aggression

Young elephants display "Pseudofights" or "play fights". During these fights young bull face each other at a distance of 5 to 10 metres. Then they raise their heads, swing their trunks over their forehead, spread the ears and rush at each other until the bases of their trunks meet. Shortly before they collide, they wrap the trunk around the partner's head or entwine it with the other's trunk. Their stiffened legs push the body forward. If neither elephant can show the other back, they stop the motion, retreat and charge again after few minutes (Oberoi, 1980).

Serious fights, which are a rare occurrence, are conducted with tremendous vigour. These fights consist of a series of head rams where by the tusks clash and the trunks wrap around each other. This type of incidence occurred in year 1999 in the month of November in Rishikesh-Dehradun national highway in which two adult bulls (one solitary bull-tusker and a bull from a herd) was involved in the fight. Another such kind of fight was observed in year 2004 in Shyampur forest range of Hardwar forest division, which was peripheral to the Chilla forest range of the RNP. During the course of this type of fights elephants trumpet loudly and represents their effectiveness for joining the groups for mating purpose. Sometimes a tusk can penetrate one of the combatants in a vital spot and kill it. Many of the workers observed this fight could be continues till death of anyone of them or until one of them ran away. Tusks are often broken during elephant fight, revealing that how much energy is involved. Male-male aggression were also denoted by several workers and called them as "pseudo fights". The aggression is basically for the mating purpose, besides few other biological requirements, like joining of group, feeding and during the course of migration.

Several times these fights were observed during the long course of study. Serious fights were accounted highest for Chilla (2002) followed by Shyampur (2004) and Barkot (2006) whereas two major fights, one in 1999 and another in 2007 were also observed during the field observations but both of these were result less. Latest serious fight was observed in April 2008 in which one sub adult bull aged about 15 years was died. Tremendous trumpeting was observed during such incidences and sometimes tusks have played the major role in killing one of the combatants through penetrating the elephant. Elephants' fight could be continues till death of anyone of them or until one of them ran away. Tusks are often broken during elephant fight, revealing how much energy was involved. Male-male aggression were also denoted by several workers and called them as "pseudo fights". The aggression is basically for the mating purpose, besides few other biological requirements like joining of group and feeding.

11) Sympathy and Co-operation

There are many observations on elephants' attempting to help injured companions and to support them and even to attempt to hold up their dead one of their group. When their any group member was injured, the entire group member attempts that by lifting up their injured comrade and by helping in various ways. In one such case in Chilla forest, a hind leg of an adult cow got injured and swelled and she moves very slowly along with friction. The most wonderful thing I observed was that about 20 elephants including calves were present there and help her in various manners like helping her in reaching the water source and other activities like feeding. They support her with the help of their trunk by pushing her and lifting her injured hind leg.

Elephants also feel grief and mourn when anyone of their fellow dies. This behavioural aspect is one of the major, which shows their cooperativeness. I once during my study period observed them in this very grievous, unique, woeful behavioural aspect, which I had never seen earlier. I was shocked to see them. It was a train accidental death of a male juvenile. When I reached the spot I saw that three cow elephant were crying and roaming continuously around 50 meter from injured fellow. When elephants saw us (I and a forest guard), trumped loudly and suddenly five other elephants came there from nearby forest and constituted a group. All of the elephants were roaming continuously till evening. As per my observation they remained without feeding for 18 hours and not letting anybody reaching near the injured fellow.

A cow giving birth was often surrounded by other cows and was protected by them. During my study period, I once saw another such type of co-operative behave among them. When cow gives birth, all the group members were responsible for caring of young one. Another interesting thing was that the mother elephant do not leave the newly born calf even she may not charge any one. For few months, I kept under my observation a cow elephant that was debilitated because of an injured trunk. The trunk although was cut partially but was still hanging from its base. There I saw that her fellow elephants help her in many ways, especially in feeding. This show, how the sympathetic, helpful as well as cooperative elephants are. During the course of this study sympathetic and co-operational behaviour was quite frequently and conspicuously observed among the elephants. There are many observations of elephants attempting to help injured companions and to support them. During many elephant hunts, an entire herd by trumpeting and screaming has approached and attempting to lift up their wounded comrade.

In year 2001, a calf was pushed over by a train and was seriously injured. The mother of that calf was continuously roaming and roaring around her baby and remained with it for one day and not letting anybody reaching near her calf. When park officials with the help of tranquillizing gun and domesticated elephant trying to uplift her calf for treatment, the cow made it difficult to carry out rescue operation, as cow continuously charges the object which came nearer to her calf whether that was domesticated elephant or motor van of the wildlife specialists, which were trying to tranquillize her. She was continuously crying with tears in eyes and trumpeting loudly and was really in big trouble, as her any effort cannot do anything for saving her baby. At that time, tranquillizing gun (which was used for making the cow unconscious) and domesticated elephant are no effective to control that cow. In general, she with her injured baby facing to about 50-60 persons watching towards both of them and I was amused to see such type of elephant-human interactions. After 24 hours (next day), when cow elephant sensed that her calf was died, she finally sorrowfully left her baby nearer to the people and go towards forest area with huge of the tears in her eyes.

In one such case in West Bengal, elephant while crossing a nallah, fell into it. It was quite in trouble and all efforts were of no use to come out. The fellow elephants moving along with this elephant came for its rescue and tried their level best to take it out, but without success. The elephants remained with it for three days and not letting anybody reaching near her. When the local people informed the forest department, officials came, and studied the situation. But elephants standing nearby made it difficult to carry out rescue operation. When elephants sensed that they have come to help out their companion, they left the spot and stood about 100 meter away, watching foresters taking out the poor creature. When the elephant finally, was taken out, each and every individual, fellow elephant came to it and greeted her (Oberoi, 1980).

12) Play Behaviour

Play behaviour was also observed on several occasions among the elephant groups. This behavioural aspect was most frequent during evening hours and especially during dry periods. The calves within the group are usually more playful than adults. When juvenile elephants are in water point they starts splash dry mud and water here and there. Sometimes they also run suddenly to few feet and quickly come back to their mothers. A group when rests under tree during hot period, they play with each other by entangling their trunks. They were also seen pushing each other with their trunks. Another interesting aspect in the study of their play behaviour is that they were seen sliding down the muddy slopes with their front legs bent back. In such a case the adult cow elephant were seen guarding the movement of their calves. They support them by bringing their trunk in their front.

It was observed during the study period that sometimes-adult cows from a group were also included in the play. Once during the study period a cow was encountered who was playing with three calves of a group. All the three calves were playing with each other through entangling their trunk and through pushing back each other and at that time cow elephant was looking after their playing activities and regularly separates each other at an interval of every 2 minutes. This type of playing behaviour was generally encountered nearer to the water stream and in evening hours.

Play behaviour among elephants mostly occurred within the calves of the herd. The adults would kick the infant, often sending him sprawling onto the ground. When the mother is feeding on grass, at least, quite often the infants are allowed to take food from the handful that the mother has collected in playful manner (McKay, 1973).

13) Association with other wild animals and affects on the Habitat

The elephant produces several effects on the habitat, which besides affecting the plant communities themselves can affect other animals leaving in the same area. On several occasions the elephant during feeding were associated with *Axis axis* (spotted deer) and *Cervus unicolor* (sambhar). Co-movements of herbivores and elephants were also observed during the study period. Elephants some times break the twigs of the trees like *Ficus bangalensis*, *Ficus glomerata*, *Bombax ceiba*, *Terminalia tomentosa*, *Syzygium cumini*, *Bauhinia variegata*, *Zizyphus mauritiana* and *Embellica officinalis* as part of their habit. The leafy portion of the twigs was consumed by ungulates. Elephants were also seen digging holes in dry riverbeds mostly during the dry season to uplift the fresh water for drinking needs. Besides, the fact that elephant do not prefer to drink impure water and for that they dig out the water from sandy area of river beds. These small water points are further utilizes by spotted deer, sambhar, mongoose, jungle fox, jackal, wild boar and birds.

Terrestrial mammals such as tiger, leopard, spotted deer, sambhar, wild boar and barking deer besides the human beings regularly use trails, which were used and maintained primarily by elephants. In general an elephant when feeding on a tree or shrub does not tear down the entire plant; rather it tends to remove small twigs and for certain species entire branches. They sometimes fell down entire part of the plant to feed on (*Dendrocalamus strictus*) and sometimes also push and twist the trees full of leaves, but are out of their range, apparently to bring to their reach. Elephants have poorly developed digestive system and therefore, raw material was removed along with dung piles, which was sometimes use by jungle fowl, peacock and termites. Another important point is that elephant play a major role in dispersal of seeds of large trees like *Dalbergia sissoo*, *Shyzygium cumini* and *Ficus glomerata* through defecating them in different parts of the forest. Elephants are having association with other wild animals, which benefits both of them - the elephant itself and the other animal in various ways like feeding and drinking (McKay, 1973).

14) Aggressive and Defensive Behaviour

Normally, elephants are not aggressive by nature while in wild but presently fragmentation of wildlife habitats has forced them towards changing their behaviour from social to aggressive. It was also pointed out that adult males are more aggressive in nature than females. The lead cow flaps her ears signaling to fellows to which the other responds by gathering together (Figure 7). Under her guidance other adults and sub-adults form a closed or semi-circular defensive formation, with the calves between them (Figure 8). Elephants also show the phenomenon of "re-directed aggression", which is usually exhibited by an object that simultaneously, evolves fear (Oberoi, 1980).

Elephant groups generally do not fear of any danger and if they feel and foresee any anthropogenic disturbance, they firstly change their way. When their calves are with them they gather together and attempt the condition. The lead cow flaps her ears and trumpet loudly signaling to fellows to which the other responds by gathering together. Under her guidance other adults and sub-adults form a closed or semi-circular defensive formation, with the calves between them. Elephants also show the phenomenon of "re-directed aggression" and this has usually exhibited by an object that simultaneously evolves fear.

Another distinct pattern of behaviour was the twiddling of the trunk, the swinging of the one of the front leg to and fro, throws mud in air and trumpet, when an elephant appears to be deciding between attack and retreat. In year 2000 a group killed a leopard, which had come suddenly on their way. Once when I was returning back from the jungle, in the evening a very surprising incident occurred in Kharkhari forest beat of the Hardwar forest range. A juvenile elephant suddenly attacked a pig. Elephant lifted the pig and threw it to the ground, and then it trampled the pig under its feet and killed it almost instantly. During the course of study elephants had charged me several times inside the forest area (during day hours) and twice outside the park area (during night study). On sensing some danger the elephants produce a band like light sound. On hearing it the whole group becomes alert and they stop all their activities to sense the impending danger. Many other incidents of killing the villagers by the solitary bulls or a group within the park area also occurred during the study period.

Defensive behaviour among elephant is quite restricted to the condition when the calves are with the herd. Solitary bull sometimes also shows the behaviour of defense. Most of the wildlife biologists observed this defensive behaviour only due to natural phenomenon, large scale of loss of their habitat by human beings and their unnatural deaths. In the present study defensive behaviour among elephants was seen only due to the interference in their any activity, especially during their movements. Indian elephants have got its own customary habits and it is a social animal with sense of survival (Oberoi, 1980). They exhibit behaviour like that of human beings, but the behaviour originates when they feel any fear and danger towards their calves and themselves too.

Typical death of a woman by an elephant

Normally, the elephants kill human beings by holding in its proboscis and crushing under its legs. However, a heart breaking scene was observed in Tibri forest beat of the Hardwar forest range. It was a case during February, 2007 when three women are cutting fuelwood inside the forest and were killed by elephants. The death of one of the women was very unusual and breath-taking. The elephant grabbed the women and broken one of the leg and hand of the women. The broken leg and hand were thrown away at a distance of 20 meter away from the body. Then, head of the women was crushed by the elephant under its leg. The skull was totally damaged and in this process the brain portion came out of head region and was thrown away at a distance of 10 meter and fell on a stone giving an impression is if it was taken out manually by some one and kept on a stone carefully. The elephant had also pulled the hairs from the head of the women and thrown away. Thereafter, the elephant crushed the chest portion of the women under its leg. The chest and skull portion were so heavily crushed and damaged that the crushed portion of the body had formed a very thin layer on the earth. It was a very heart-breaking incident and normally we do not hear or see such type of killing by an elephant. Normally, elephants just kill a person either by piercing its tusk inside the body or thrashing the person and leave the body. This particular incident indicated highly aggressive and unusual nature of an elephant.

15) Acrobatic Behaviour

Elephants are well capable to perform their body posture in acrobatic modes as circus elephants perform (Figure 9). During field observations this type of unusual behaviour of elephant was observed especially in bulls. It was on 30th April, 2007 when I was inside the forest area regarding to my research study. Suddenly, I came across a group of elephants consisting of several adult females, sub-adults and juvenile and one adult male elephant. These elephants were crossing from one compartment of the forests to another compartment. The adult male elephant was following the group at few yards distance. The adult male elephant had seen us and started running towards us up to a few meters then suddenly the adult male elephant stopped at one particular point. The incident, which I saw at this point, was quite amazing and rare; typical kind of behaviour of an elephant was observed. I saw that the elephant first touched the ground with its proboscis and then started bending on its trunk. In next scene the elephant raised one of its hind leg in the air followed by another hind leg and then right front leg. At one point of time all the three legs of the elephant were in the air and the elephant was bending on its trunk and left front leg. The incidence continued for a minute. I did not believe my eyes, seeing such a unique kind of acrobatic behaviour of an adult male elephant. I had enough time to click photographs. In fact nobody can believe that a wild elephant can do such type of activity.

Of-course, domestic elephants used for circus purposes are expected to behave in such a manner that too after a long training. After sometime the elephant came to its normal position and left the spot to join its group. I had apprehension as if there was something special in the soil at that point. Therefore, I took the soil from that spot and tasted, I did not find any special taste in the soil which could indicate that the elephant might have bent on that spot to lick the soil which could be salty in nature as elephants are known to lick the salt. It was difficult to imagine what led elephant to perform acrobatics. It leads us to conclude that this was a very typical kind of behaviour of an adult male elephant.

16) Climbing and Sliding Behaviour

An interesting feature related to unusual movement of the elephants was observed during the study period. The elephants were seen mounting easily on foothills and slide down from there (Figure 11). They sometimes use sharp slopes for their movement in which human beings can't slide down easily. During the study period on many occasions their movement on foothills and slopes were observed. The movement of the elephants was also confirmed by examining signs and impressions like: presence of dung piles, footprints, damage of the vegetation etc. This kind of movement was seen to be exercised even by the juvenile as they can also mount on foothills and use the sloppy areas of the forest. This type of movement behaviour of the elephants sometimes may prove fatal to them as there have been reports of death of the elephants especially calves due to falling down from these foothills.

During the course of study several times elephants' frequent movement on top of the hills was observed, which seems to be quite hazardous, dangerous and uncomfortable for such a huge animal. It was not easy for human beings to climb on the top of such hills. Similarly, movement of elephants, most probably of adult male elephant, in very narrow passages and deep slope was also observed during present

investigation. At one spot in Mundal forest beat (Chilla forest range) I found footprints and feeding signs of elephant movement in a very narrow passage at a height of about 30 feet. I could see that there was a climber - *Bauhinia vahlii* (Maljhan) at that spot, the favourite food item of elephant. The elephant had mounted up to that height just to feed on this fodder species. Study revealed that the wild elephants are well capable of taking any risk while exploring the new areas. It may be mentioned that the adult male elephant are more interested in such type of activities rather than a group of females with young ones and juveniles. This behavioural aspect also indicated that adult male elephants are more confident and brave enough to explore new as well as dangerous routes as also have the benefit of enjoying feeding on variety of fodder species. This kind of movement was seen to be exercised even by the juvenile as they can also mount on foothills and use the sloppy areas of the forest. This type of behaviour of the elephants sometimes may prove fatal to them as there have been reports of death of the elephants especially calves due to falling down from these foothills.

17) Long-term Bulls Association

Generally it was said that bull elephant prefers to live solitary life after attaining age of 16 years. Male elephants were observed to join groups during breeding periods; sometimes their solo movement was also observed near to groups for short duration. During the last three years, I have continuously observing six adult bull elephants (recognized bulls) living together and performing their movement inside and outside the protected area. In 2007, four of them were separated from each other for a short period during summer (March - June) either they can be seen moving together throughout the year. Study revealed that all of these have a permanent and very close association round the year. A adult bull elephant (about 50 year old) was always observed to lead the group, while they performs their movement towards human habitation areas as in few of the places villages are situated in between the different forest pockets. Several times, they were also observed in resting position under cool shaded trees like *Ficus bengalensis* and *Adina cordifolia*. Besides, their play with each other was also studied deeply during the course of study. Looking into the situation, it could be revealed that all of them prefers to live associational life and their behaviour was observed to be very faithful for each other.

Annual movements of these bulls were also traced during the study period and it was observed that during the last three years, they are utilizing only the Chilla (RNP), Shyampur and Chiriapur (Hardwar forest division) and Laldhang (Lansdowne forest division) forest ranges for their movement related activities. Any serious fight of bull elephants for mating was not observed during few previous years in this forest stretch whereas these serious fights were occasionally observed in few other forest compartments during the same period. This is one of the unusual behaviour of bull elephants, which reflects their very close and permanent associational behaviour.

18) Parental Care

Elephants are highly social animals and show parental care behaviour. Newly born babies are kept under high care by their elder ones for about 10 to 15 years and the mother nurses and suckle the calf beyond 2 to 3 years. At the same time calf started to feed on smooth vegetation under the care of their elders. When the male elephant has attained the age of 16, they prefer solitary life and separates from the herd. All the members within a group exhibit an equal responsibility to care the newly born infants but adult cow elephants are more careful towards calves as compared to bull elephants. Once an elephant herd marched to the lake with a baby elephant, which was almost motionless, virtually lifted by the mother and another cow elephant. There are many incidents of such type, which were observed during the study period. It was also observed that any herd when feeding, spreads within 50-100 meters (depending on herd size) and at that time adult bull separates from herd but the calves move with their elder one (adult cows or sub-adult cows). Calves also sometimes show play behaviour, when they were in water, they splash mud and play by entangling their trunk with other. Similarly, when calves fed or bath and when they are crossing any water stream, their elder ones are too much careful of them.

19) Elephant Communication

Most animals communicate with one another to a greater or lesser degree, and the more social a species, the more communicative it tends to be. Communication come in many forms – it may be acoustic, visual, chemical or tactile and, depending upon the message and the medium, different types of communication may be more or less effective. While there aren't any species that can compete with human language in terms of its richness and complexity, some species have relatively large vocal repertoires and

extensive communication networks. Elephants are one such species. Elephants also communicate with one another using intricate chemical and tactile signals and visual displays. Like all highly social mammals elephants have a well-developed system of communication that makes use of all of their senses – hearing, smell, vision and touch. This includes an exceptional ability to detect vibrations.

Studies on African elephants (*Loxodonta africana*) have established the fact that elephants communicate over a variety of distances from touching to perhaps 10 kilometers or more apart and they convey information about their physiological (e.g. sexual, hormonal, body condition, identity) and emotional (e.g. fearful, playful, joyful, angry, excited) state as well as communicating specific state of their intentions or desires. Elephants live in a complex society bound together by different layers of communication. Individual elephants use a combination of vocalizations, visual, tactile and chemical signals to communicate different behavioural contexts. Male and female elephants live in two rather dissimilar social worlds, and the manner in which they use their communication skills reflects their different ways of life. The survival of females and their offspring depends upon the cohesion and co-ordination of the extended family, and on their ability to compete with other groups for access to scarce resources. Their use of signals underlines the importance of the unit. They use active communication to reinforce bonds between relatives, reassure youngsters, reconcile differences between family and friends, form coalitions against aggressors, and keep in contact over long distances. Males live a more solitary life where reproductive success and survival depend to a large degree upon an individual's ability to passively detect sounds and scents of the prospective female.

Vibration through the substrate has likely been important to animals as a channel of communication for millions of years, but our awareness of vibration as biologically relevant information has history of only the last 30 years. Elephants live in a complex society in which both long-and short-distance communication plays an important role in the ability to locate mates and to maintain intra-and inter-group cohesion. Elephants use a variety of sensory channels in ways both complementary and redundant to achieve this communication, as well as to advertise physiological states, allow reliable assessment of intent, and engage in other behaviours of group living. The majority of long-distance communication is probably via infrasonic vocalizations and chemical signals, whereas usual vocalizations, chemical signals, visual and tactile displays all play a role in short-distance interactions. Wild elephants organize socially around a matrilineal family unit, composed of closely related females and their offspring. These family units have well-developed communication systems to coordinate their movements over large areas.

Time-Activity Budget

Generally elephants became active well before dawn and start their morning activities in the vicinity of the area where they spent night. During hot hours of the day various members of the group retired in available shade, whereas in the wet season they spent more time in feeding related activities. In the afternoon, begin their evening activities, which were quite similar to the morning activities. Evening hour was the time for drinking and bathing especially during summers. The feeding activity during summer was observed to be more in early morning hours and late hours in the afternoon and the mid-day is the time for rest, whereas in winter, feeding activity is near about constant but it is maximum in late evening hours. During the monsoon period, the moving and resting activity generally fluctuate because of slight restriction in movements. Resting during the monsoon largely depends on heavy rains while moving long distances, as at the onset of monsoon elephants show their long-term migration towards upper slopes in some of the areas.

Resting follows the standing of elephants in any shaded area especially in sparse cool shaded trees like *Ficus bengalensis*, *Adina cordifolia* and *Butea tetrasperma*. Animal spends more time in resting during summer because the mid-day period is too hot and elephants may not tolerate high temperature and direct sun light for a very long time. Whereas during the winter they used open areas for standing and taking the sunbath while feeding activity was also ongoing. In summer season percentage of movement found more due to lack of fodder species and shrinkage of natural water sources. At that time animals have to travel more in search of food and water, while in winter and monsoon there is abundance of fodder species and water within the park area and during that time elephants do not perform very long distances.

The time-activity budget of different seasons during 12 hours of the day (feeding, moving, resting and others) of elephants was observed for two years during the course of this long-term study (Figure 14). Feeding during the winter (11.1 hours), accounted for the highest duration followed by feeding during the summer (10.5 hours) and monsoon (9.1 hours). Movement activity accounted for 1.4 hours (winter), 1.5

hours (summer) and 1.3 hours (monsoon). Fluctuations were observed in resting activity as this largely depended upon season (0.4 hours in winter, 2.5 hours in summer and 1.4 hours in monsoon). Apart from this other activities like drinking, bathing, playing etc. accounted for 2.05 hours in winter, 0.4 hours in summer and 3.1 hours in monsoon.

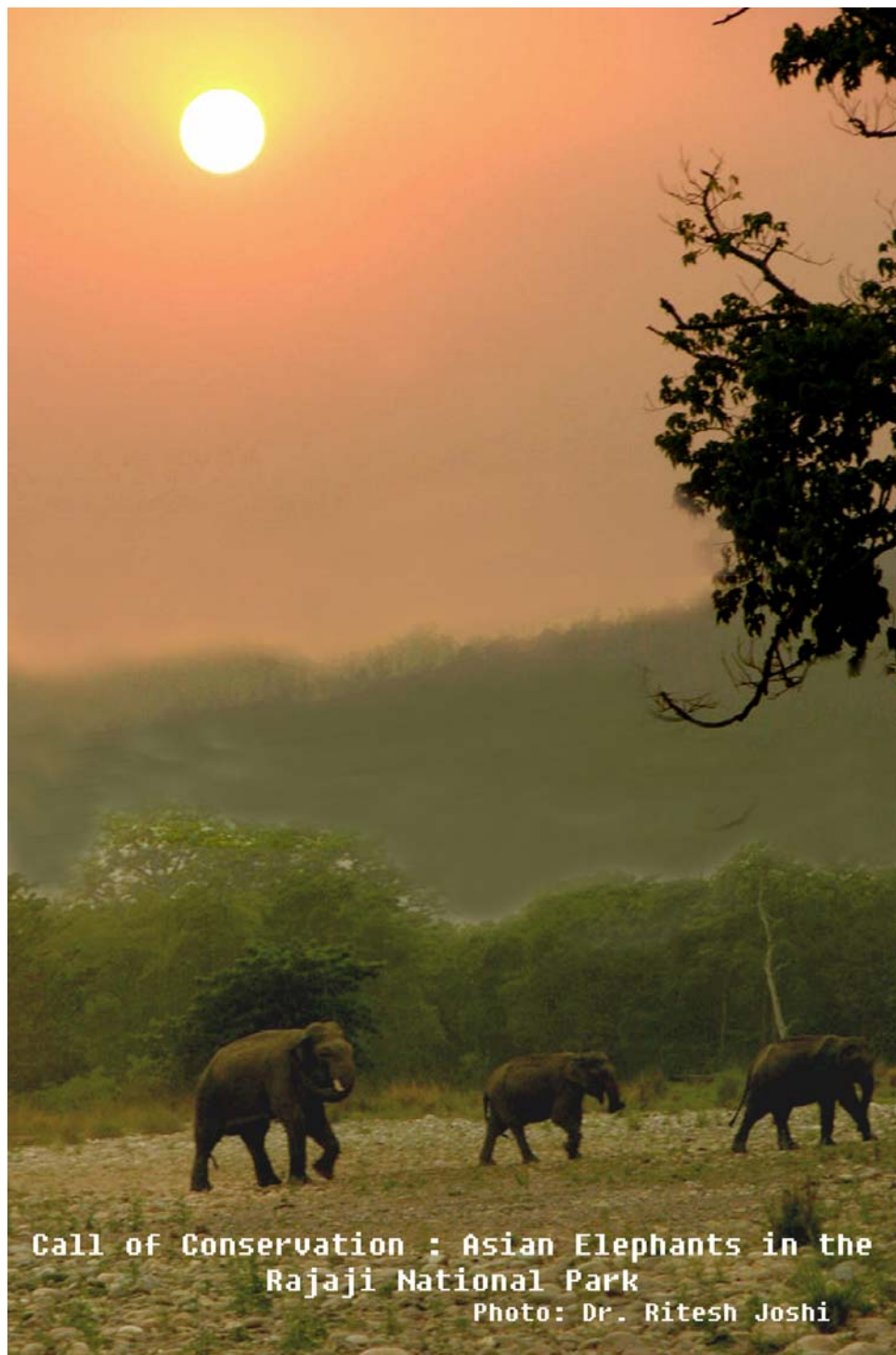


Figure 1. Elephants during the sunset in the Rajaji National Park.

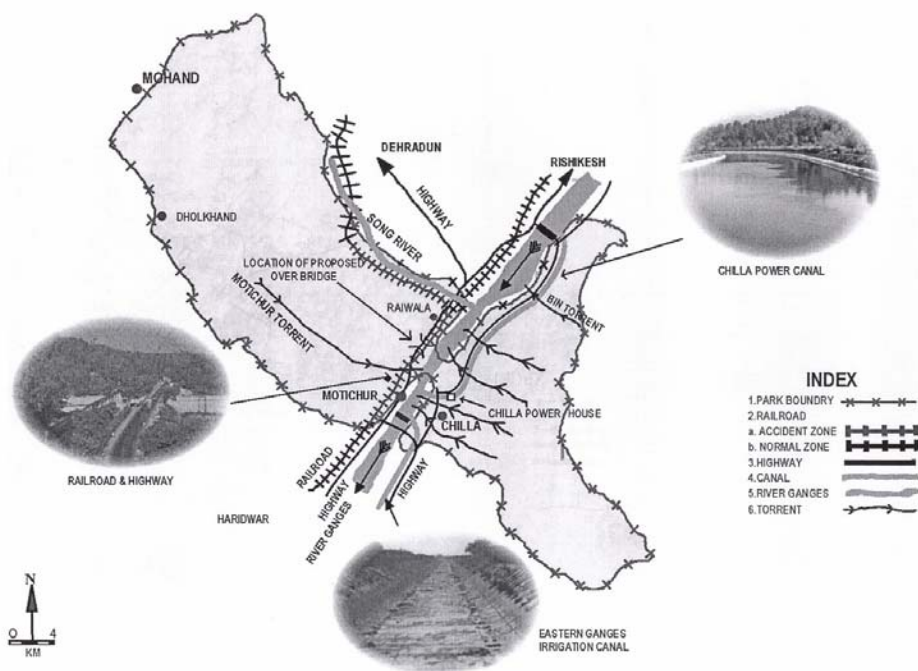


Figure 2. Map of the study area.



Figure 3. Elephants during migration.



Figure 4. Elephant calf feeding on *Tectona grandis*.

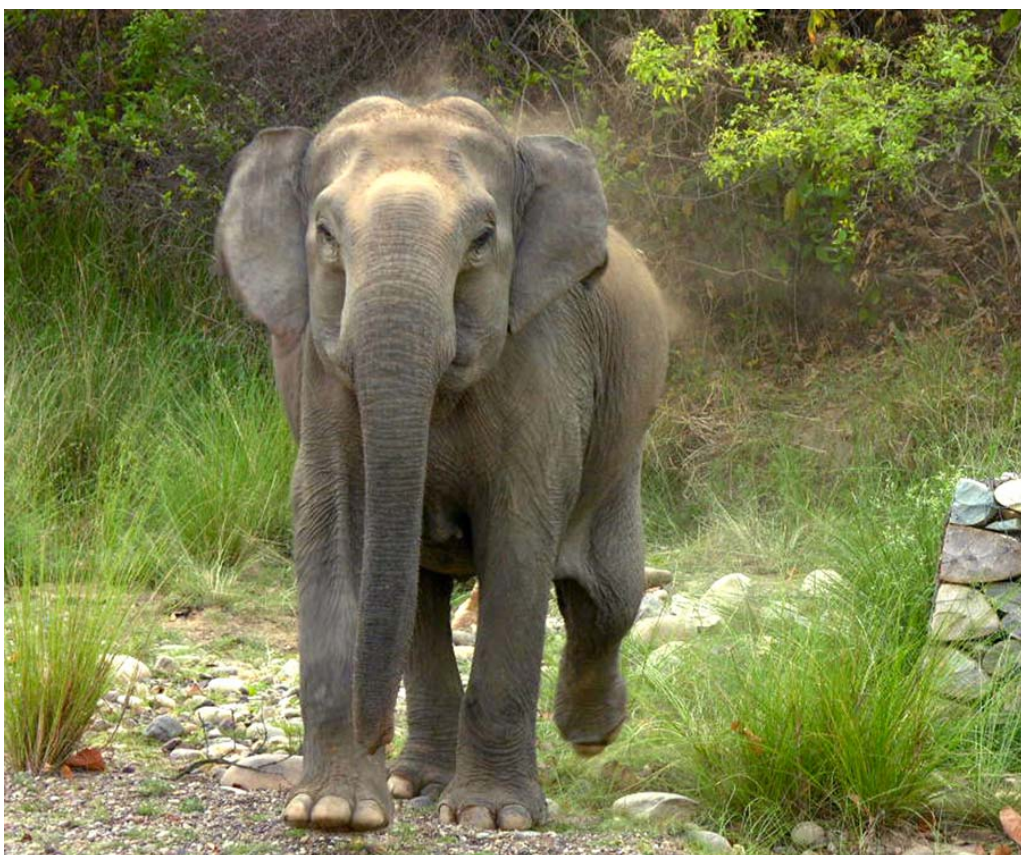


Figure 5. Charging by an adult cow.



Figure 6. Elephant is swimming in river Ganges.



Figure 7. Elephants sensing threat.



Figure 8. A seven days old calf under protection of her mother.



Figure 9. Acrobatic behaviour of an adult male elephant in the Rajaji National Park



Figure 10. Bull taking mud bath.



Figure 11. Bull standing on top of hillock



Figure 12. Recording the geo-positioning of bull elephant during his walk at highway.



Figure 13. Knowing the behaviour of wild elephant calf after a rescue.

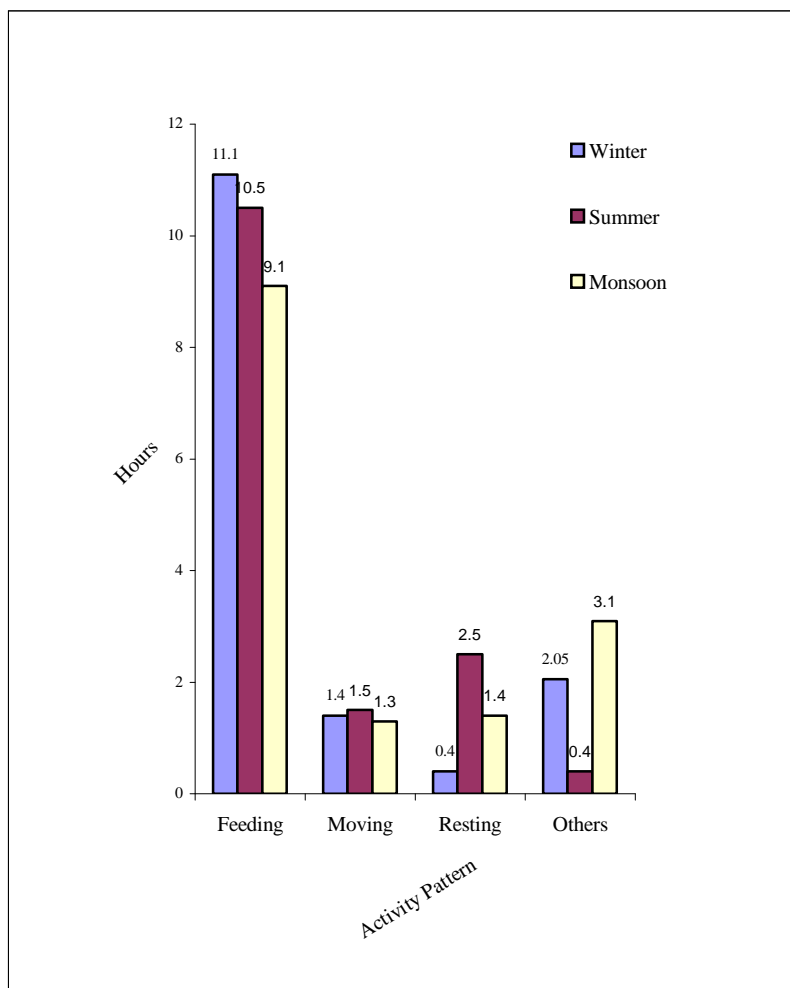


Figure 14. Comparative time-activity budget for different activities in different seasons

Discussion

Elephants are well known for their various types of behaviours such as playing behaviour, aggressiveness, social organization, parental care, pseudofights, sympathy and co-operation, recognition and communication and associational behaviour. During the recent past extensive work has been carried out on the movement pattern, habitat utilization and feeding biology of Asian elephants (Daniel, 1996; Sukumar, 1989; Santiapillai and Suprahman, 1986; Joshi et al., 2001; Williams, 2002; Joshi, 2002; Joshi et al., 2007) but the work on its behavioural biology has remained neglected. Therefore, less information is available in relation to behavioural pattern of elephants in the wild. Wild animals are closely linked to their environment and both living and non living components influence their live. During the recent past wildlife biologists has explored new conservation tools regarding to long term survival of endangered wild species but currently there is a need to obtain more and more biological information about various endangered wild species to enhance the status of their habitat and population in forested habitats.

The same populations of elephants used to perform their movements in Gohri, Chilla, Laldhang, Kotdwar, Shyampur, Chiriapur and Sonanadi forest whereas group movement was almost restricted towards Corbett National Park area as both of the forest zones are disconnected mainly due to huge amount of anthropogenic and developmental activities. It was also observed during the study period that in few of the places, elephants utilize the same feeding grounds round the year (recognised groups). Elephants inter-

change the forests of Rajaji and Corbett National Park as their part of traditional migration. But presently in few of the areas their traditional feeding grounds and corridors are denied to them, which have caused man–elephant conflict. The long-term effects will include genetic isolation, habitat fragmentation within the same forest and enhancement in the human–elephant conflict in adjoining areas. Genetic isolation of elephant populations may also increase the chances of replacement of interbreeding to intrabreeding, and thereby reduce the population persistence even for wide ranging wildlife species (Joshi and Singh, 2008a).

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). 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).

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 i.e. from January to April, 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. This grass in hill tracts become long and coarse by July and August, the elephants then shows 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, ideal breeding ground and thick population (Sinha, 1981).

During the last 4–5 years, state Government has constructed about four flyovers in Hardwar – Bijnor National Highway. As a result of anthropogenic activities about 18 kilometers forest stretch existing on both the sides of highway has got disturbed. Besides, agricultural expansion near river Ganges has led to the loss of forest wealth, which has also hindered the traditional movement of elephants. This forest stretch is one of the major corridor for elephant movement and presently has got disturbed mainly due to habitat loss around the national highway. Sometimes few of the male elephants associate to enter the forest near to river Ganges through this route. Elephants cross the national highway in the evening hours and come back to the forest area in early morning hours. Besides, elephants also utilize the Gaziwali bridge, Shyampurwali bridge and Pili bridge situated peripheral to the canal road in Ganga canal for their outside movement and to feed on the cultivated crops in nearby villages. During the study period all the villages suffering from crop raiding have been investigated. The affected villages are Jagjeetpur, Mishrpur, Panjneri, Ajeetpur and Jaipota in the western side of the conservation area and all these villages are situated peripheral to river Ganges. Villages Kangri, Ghaziwali, Shyampur, Sajanpura, Pili and Rasiabad are located peripheral to forest area and national highway whereas villages Gaidikhata, Lahadpur, Chiriapur, Vasuchandpur and Naurangabad are also situated adjacent to the forest area and national highway on south western direction of the conservation area.

The villages along the river Ganges are situated on land that was once part of the elephant's home range. Therefore, the increasing elephant – man conflict is unfortunate but inevitable. The electric fence erected along with these villages and river Ganges has presently got damaged due to lack of proper maintenance. It was observed that elephants are utilizing their traditional feeding grounds in few of the areas, which are presently denied to them and are replaced by human settlements.

The present study reveals that elephants utilize whole of the park area for their movement, but mostly they leave some of the areas for few months, as part of their seasonal migrational activities. The local movement and long term migration of elephants within the RNP shows a definite range use pattern. After the isolation of Chilla forest and Motichur forests the elephant population of the RNP has divided into two parts. Presently, elephants of Chilla and adjoining areas in the eastern part of river Ganges show the better migration between the Chilla area and Kotdwar (Lansdowne forest division) whereas the elephant populations of Hardwar, Motichur, Kansrao and Dholkhand have been isolated. Again due to large scale developmental activities inside the Dogadda forest area has caused the hindrance in their corridor area. Slowly seasonal movements and migratory routes have also undergone to minor changes. Elephants in North Bengal are pocketed but these pockets have increased in number and also changed their locations

with the passage of time. Elephants are trying to adopt themselves to the changing environment by changing their ranges, moving on to new areas and by adopting new routes (Barua and Bist, 1996).

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). In Chilla, the elephants, which were deep in the hilly terrain of north in the rainy season, gradually start moving towards the south due to scarcity of water winter season in the hilly areas. The study further reveals that the animals are directly affected by water availability and availability of fodder species inside the park area. Presence of river Ganges in Chilla area further ensures the migration of animals at the onset of summer.

Group generally comprises of adult cows, sub adult cows, infants (both sexes) and occasionally sometimes a matured bull was also seen within a group. Different groups generally do not mix up except during large scale migration. Members of a group during their feeding are usually spread within an area of 50 - 100 meters. However, the calves are always under direct touch and close to their mother. The young bulls on reaching the age of 12-14 years tend to prefer the solitary life, but at times two adult bulls may associate temporarily for their mutual understanding such as feeding together and crossing of their traditional corridors now converted into high traffic zone.

Elephants are known to feed on a wide variety of plant species. Elephants utilize 50 fodder plant species round the year in the Rajaji National Park and their movement was dependent on the seasonal availability of water and fodder species (Joshi and Singh, 2008b). Research on forest elephant feeding ecology in Nouabale – Ndoki National Park in northern Congo has shown that elephants have a general diet comprising more than 350 species (Blake, 2002). A preliminary study on elephant's habitat in the RNP area has pointed out that 30 plant species were present in this area, which are being utilized by elephants (Williams, 2002). A study on Asian elephant's foraging behaviour in southern India pointed out that elephants consumed at least 112 plant species and 85% of their diet consisted of only 25 species (Sukumar, 1990). During the dry season, 18 species of flowering plants were found to be eaten by the elephants in the Manas National Park (Lahkar et al., 2007). Another study on the conservation of Asian elephant in Bangladesh indicated that 143 plant species were present in Chunati Wildlife Sanctuary, out of which only 17 species were utilized by elephants that represents only 12% of the total local plant species (IUCN Report). Similarly, a study on the diet and foraging ecology of the Asian elephant was conducted in the Shangyong National Natural Reserve, Xishuangbanna, China and pointed out that 106 plant species were eaten by elephants as their food (Chen et al., 2006).

India's elephant populations are currently threatened by habitat deterioration, developmental activities, anthropogenic pressure inside the deeper forest regime and unregulated exploitation of natural resources. Biogeographically, the RNP is part of the Shivalik foothills (lesser Himalayas), north-west India. Scientifically it belongs to a habitat type of important conservation value about long-term survival of Asian elephant. Knowing behaviour of any species is a valuable conservation tool, which can be helpful in management and conservation of any species. Relatively little work has been carried out on the behaviour of wild elephants in India. To understand the behavioural aspects, continuous ecological monitoring was done in and around the RNP area and 19 different behaviours of elephants were observed (Figure 12 & 13). During the recent past large habitats of elephants has been fragmented mainly due to developmental activities. Human encroachments into the deeper forest regime are another major factor, which has caused hindrance in their routine activities.

The behaviour of elephants in Rajaji shows a great variance with respect to the seasons, availability of natural water and traditional movements. Currently, natural continuous forest ranges of Shivalik region 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. Genetic isolation, limitation of dispersal and 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. RNP is supposed to play an important role in maintaining the elephant population for last few years. However, few of the activities mainly of anthropogenic origin are responsible for the erratic patterns observed in the behaviour of its population. Study indicated that elephants of RNP used to perform usual as well as unusual behaviours but it has been suggested that more studies on the behaviour of elephants are required through which database management approaches could be generated, which will ensure the long-term survival and conservation of Asian elephants.

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Correspondence to:

Dr. Ritesh Joshi

G. B. Pant Institute of Himalayan Environment and Development,
Garhwal Unit, Post Box No. 92, Srinagar, Garhwal – 246 174
Uttarakhand, India

Telephone: +91 1346 252603 (O)

E-mail: ritesh_joshi2325@yahoo.com

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