

A Comprehensive Study on Ecological Aspect, Feeding Behaviour and Pugmark Analysis of Elephants in the Bordering Areas of Northern Chhattisgarh

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ABSTRACT The study attempted to examine the ecological aspect, feeding behaviour with food preferences and pugmark analysis in four blocks viz, Kunkuri, Duldula, Bagicha and Farsabahal of northern Chhattisgarh. The field study was conducted through well structured questionnaires in the affected villages/forest areas where migrated elephants were encountered. Among the different pressing issues related to farming in the study area the major obstacle was wildlife especially the elephants (55%). The most commonly consumed species belong to family Poaceae and Fabaceae (17.65%) followed by Moraceae (14.71%). Elephants extensively feed on *Artocarpus heterophyllus*, *Syzygium cumini*, *Acacia nilotica*, *A. catechu*, *Dalbergia sissoo*, *Zizyphus mauritiana*, *Aegle marmelos* and *Ficus species*, besides various grasses and shrubs. Analysis of pugmarks revealed that the circumference varied from 51.55cm to 165cm. Therefore, it is needful to carry out detailed assessment of feeding behaviour, habitat suitability and dispersal corridor for elephants in the area for better understanding, planning, conservation and management of wildlife.

INTRODUCTION

Due to social development, land use change and increasing demand of forest based needs, forests were felled intensively which resulted in significant shrinkage of wildlife habitat (Singh 2002), and led towards inter and intra species competition for food, shelter and other basic requirements. Over-exploitation of the habitat and pressure of human civilization has made the species highly vulnerable (Daniel 1996). On account of their rapidly declining natural habitat and shrinking of migratory routes and feeding grounds the elephant population is often prone to various modes of unnatural deaths due to various incidences.

The northern region of Chhattisgarh has a large elephant population. Elephants are huge feeders and consume a variety of floral species (Borah and Bhuyan 2016; Nagene et al. 2017). Various reports are available on feeding behaviour of elephants and there are great variation in their choice, preference, diet etc. depending upon the availability of fodder species (Areendran et al. 2011; Gubbi 2012; Prabu and Kumar 2016; Senthilkumar et al. 2016). Therefore, food availability in the corridors regulate the carrying capacity of elephants which define the level and

magnitude of human wildlife conflict (Thakur et al. 2015, 2016a,b).

The elephant corridor of northern Chhattisgarh is represented by rich flora and fauna biodiversity with nearly half area under forest of the total geographical area. Presently incidences related to HEC (Human Elephant Conflict) has been increasing due to substantial number of elephant migration in this region (Singh 2002). The Jashpur division has large population of tribal communities which have derived their livelihood mostly from agriculture and forest produces. The incidence of HEC directly influences the socio-economic status and livelihood of the people, posing challenges towards conservation (Thakur et al. 2015, 2016a,b). As majority of the elephants are migratory in the study, region and food availability is a prerequisite to managing their population inside the corridors, therefore, present investigation was carried out to assess the food plants availability along with pugmark analysis to track the migratory route, identification and census.

METHODOLOGY

The northern Chhattisgarh region has rich biodiversity store house and comprises some of

the major protected areas viz., Guru Ghasidas National Park, Tamorpingla, Semrasot and Badalkhol Wildlife sanctuaries which facilitate largest intact natural habitat for elephants. The study on ecological aspect, feeding behaviour and pugmark analysis of elephants in and around Jashpur region of Chhattisgarh was carried out at four blocks viz., Kunkuri, Bagicha, Duldula and Farsababar. District Jashpur is lying under northern hill zone of Chhattisgarh. It is between 22° 17" and 23° 15" North latitude and 83° 30" and 84° 24" East longitude. The tribal dominated district has abundance of natural resources and biodiversity. More than thirty-five percent area is covered under forest (25% dense forest) having various species of flora and fauna. A gradient of variation is observed more in the district in regards to topography, soil structure, soil type, rainfall pattern, vegetation, cropping pattern, fertility etc. Jashpur district is divided in two parts as per the geographical point of view. The hilly belt, the northern part is called Uperghat and southern part is called Nichghat. The *ghat* is upper on extension plateaus covering 1384 sq. kms which is about 1200 meters above sea level and is covered with hills but it also has many big mountains. Kunkuri is the hottest region in Nichghat during summer and Pandrapat is the coldest region in upper *ghat* in winter. The elevated plateau called "Pat" Nichghat is plane. Total forest cover is 56552 hectare as per 2010-11 data. The flora of Nazzul and other areas are changing frequently with the human activities and land-use. Climate, soil and biotic factors are the functions of natural vegetation. The field study was conducted in the affected villages/forest areas where migrated elephants were encountered. A total of ten percent households from each village of all blocks were randomly selected for study by informal interviews, questionnaire method, participatory rural appraisal and personal observations (Chambers 1994) and obtained data on various aspects were compiled and analysed (Thakur et al. 2015, 2016a,b). Primary sources of data included extensive field investigations in HEC areas by asking some specific questions such as existing problems, elephant behaviour, their movement, crop fed or species preferred, elephant entry track, their stay in the region, exit track to measure the pugmarks thereafter, results were documented along with opinion and expression of the respondents. Besides, elephant's traditional movement tracks,

feeding grounds were searched and observed directly. Field binoculars were also used for observing their feeding behaviour without disturbing the animal from an adequate and safe distance. Record was based on direct sighting of animal's feeding, indirect evidences like feeding sign; pugmarks impression time and fresh dung piles. All plants on which elephants were observed to feed in the study area were identified by discussing with the local people and literature.

The analysis of pugmark was done by measuring sufficient number of impression of pugmarks available in different sites to draw a suitable conclusion in this perspective. The impression of pugmark was measured for its dimensions viz., length and width (diameter) on each site. The total measured pugmarks were categorized into different size classes and their respective values were converted into percentage (Thakur et al. 2016b).

RESULTS AND DISCUSSION

Ecological Analysis of Study Site

During the study it was found that the 97.50 percent respondents have lived in study area for over 20 years and 96.25 percent people were farming in this area (Table 1). It was found that 98.75 percent of population have permanent homestead. Among the different pressing issues related to farming in the study area, the major obstacle was wildlife, especially the elephants (55%). The objective of felling trees in the study area was for timber/poles for construction purpose (96.25%) and firewood (97.50%). Most of the respondents (52.50%) were aware of ecological degradation due to increasing rate of deforestation or habitat destruction of elephants by green felling in the study area. Majority of respondents (75%) have consent and realized that wildlife is declining in the corridor because of too much hunting and illegal activities (80%). Therefore, they are in favor to stop hunting completely (90%).

Ecologically elephants are keystone species from various points of views. The present ecological analyses on elephant perspectives are well comparable with the reports of Thakur et al. (2016b) for similar geographical regions. Similar to the present finding, Geetha and Devi (2008) found that farming is the main occupation and backbone of the economy of most of the respon-

Table 1: Ecological analysis in the study sites in the corridors of northern Chhattisgarh

Query	(%)
<i>How Long Have you Lived in this Area</i>	
Less than 10 years	2.50
10- 20 years	0.00
Over 20years	97.50
<i>Give Reasons Why you Moved into this Area</i>	
Native of the area	3.75
Farming	96.25
<i>Your Homestead</i>	
Permanent	98.75
Temporary	1.25
<i>If You are Engaged in Farming, What Are the Pressing Issues</i>	
Lack of fertilizer	76.25
Lack of land	35.00
Lack of markets	3.75
Low rainfall	61.25
Wild life	55.00
<i>Area Problems</i>	
Lack of health facilities	66.25
Lack of school	0.00
No grazing area for livestock	18.75
<i>Fisheries Issues - Are You Engaged in Fishing</i>	
Yes	72.25
<i>If You Are, Do You Do it For</i>	
Subsistence reasons	65.00
<i>What are the Common Fishing Methods Used</i>	
Nets	68.75
Fishing traps	10.00
<i>If You Have Been Cutting Trees, Which of the Following Apply</i>	
Timber or poles for building	96.25
Charcoal	1.25
Clear land for agriculture	6.25
Fire wood	97.50
Hand craft	12.00
<i>Do You Think Cutting of Trees is</i>	
Increasing	0.00
Decreasing	92.25
Don't know	7.75
<i>Do You Hunt Wild Animals</i>	
Yes	8.75
No	91.25
<i>What are the Common Hunting Methods in Your Area</i>	
Snaring	1.25
Pit falls	5.00
<i>If You Hunt, for What Reason Do You Do It?</i>	
Meat for domestic consumption	6.25
<i>Do you Hunt Birds?</i>	
Yes	47.50
<i>Which of the Following Birds Do You Hunt</i>	
Geese	15.00
Other (specify)	42.50
<i>Do You Think Wildlife is Declining in Your Area?</i>	
Yes	75.00
Not sure	8.75
<i>Give Reasons if there is a Decline</i>	
Too much hunting	80.00
Shortage of land	16.25
No protection	31.25
Don't know	12.50
<i>What do You Think Should be Done?</i>	
Hunting birds should be stopped	62.25
Hunting animals should be stopped	90.00

dents in their study area (Chaudhary and Panjabi 2005). The ecological features like residential period, migration, homestead, farming system, constraints, wildlife issues etc. resembled and were supported by Thakur et al. (2016b).

Feeding of Plants by Elephant in Study Area

The flora preferred by elephants as food in the Jashpur region consisted of variety of life form as grasses, shrubs, tree leaves, bark, aquatic plants and sometimes fruits. A total of 59 species were recorded in and around study site out of which 34 species (57.63%) were observed to be favorite fodder species for elephants (Table 2). During the study period, it was observed that elephants feed comprised of about 26 species of trees (76.47%) and 8 species of grasses (23.53%). The most commonly consumed species belongs to family Poaceae and Fabaceae (17.65%) followed by Moraceae (14.71%). 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 mid-day. Sometimes it was observed that elephants were continuously feeding throughout the night. In summer, they spent their nights in open forest areas and when the day advanced they moved towards the denser forest. In Jashpur region, elephants feed on the tree species like *Artocarpus heterophyllus* (Kathal), *Dalbergia sissoo* (Shisham), *Agave sisalana* (Sisal) *Zizyphus mauritiana* (Ber), *Aegle marmelos* (Bel), *Ficus bengalensis* (Bargad), *Ficus glomerata* (Gular), *Bombax ceiba* (Semal), *Acacia catechu* (Khair), *Bauhinia variegata* (Kachnar), *Syzygium cumini* (Jamun). Besides, elephants also used various grasses and shrubs as their food resources, which included *Dendrocalamus strictus* (Bamboo), *Saccharum spontaneum* (Kans) and *Cynodon dactylon* (Doob Grass).

The availability of food resources to elephants in natural condition were studied which revealed that the foods supply of *E. maximus* consisted of grasses, shrubs, tree leaves, bark and also the fruits. Jashpur region falls in tropical deciduous forest type and hence one can assume that in this region, elephants eat seasonal food resources to provide the necessary range of nutrients. There is a distinct difference in the quantity and number of fruit species eaten by elephants and this influences elephant's

Table 2: Flora and preference of species by elephant in Jashpur region

Local name	Botanical name	Family name	Life form	Palatability
Aak	<i>Calotropis gigantea</i>	Asclepiadaceae	Shrub	NP
Aonla	<i>Emblica officinalis</i>	Euphorbiaceae	Tree	NP
Arjun	<i>Terminelia arjuna</i>	Combretaceae	Tree	NP
Baans	<i>Bambusa bambos</i>	Gramineae	Grass	P
Babul	<i>Acacia nilotica</i>	Fabaceae	Tree	P
Banana	<i>Musa paradisiac</i>	Musaceae	Tree	P
Bargad	<i>Ficus bengalensis</i>	Moraceae	Tree	P
Bel	<i>Aegle marmelos</i>	Rutaceae	Tree	P
Ber	<i>Zizyphus mauritiana</i>	Rhamnaceae	Tree	P
Beshram	<i>Ipomoea carnea</i>	Convolvulaceae	Shrub	NP
Bheluaa	<i>Semecarpus anacardium</i>	Anacardiaceae	Tree	NP
Bhera	<i>Termanalia belerica</i>	Combrataceae	Tree	NP
Char	<i>Buchanania lanzan</i>	Anacardiaceae	Tree	P
Dhatura	<i>Datura metel</i>	Solanaceae	Shrub	NP
Dhawai	<i>Woodfordia floribunda</i>	Lythraceae	Shrub	NP
Dhawra	<i>Anogeissus latifolia</i>	Combretaceae	Tree	NP
Doobi	<i>Cynodon dactylon</i>	Poaceae	Grass	P
Dumar	<i>Ficus heterophylla</i>	Moraceae	Tree	P
Ernndi	<i>Parthenium hysterophorus</i>	Asteraceae	Shrub	NP
Guava	<i>Psidium guajava</i>	Myrtaceae	Tree	NP
Gular	<i>Ficus glomerata</i>	Moraceae	Tree	P
Gulmohar	<i>Delonix regia</i>	Cacelpiniaceae	Tree	NP
Harra	<i>Termanalia chebula</i>	Combrataceae	Tree	NP
Imali	<i>Tamarindus indica</i>	Leguminaceae	Tree	NP
Jamun	<i>Syzygium cumini</i>	Myrtaceae	Tree	P
Kachnar	<i>Bauhinia variegata</i>	Fabaceae	Tree	P
Kadam	<i>Anthocephalus cadamba</i>	Combrataceae	Tree	P
Kaju	<i>Anacardium occidentale</i>	Anacardiaceae	Tree	NP
Kaner	<i>Nerium indicum</i>	Apocynaceae	Tree	NP
Kans	<i>Saccharum spp.</i>	Poaceae	Grass	P
Kathal	<i>Artocarpus heterophyllus</i>	Moraceae	Tree	P
Kekat	<i>Prosopis juliflora</i>	Fabaceae	Tree	P
Khair	<i>Acacia catechu</i>	Fabaceae	Tree	P
Khajur	<i>Phoenix dactylifera</i>	Palmaceae	Tree	NP
Kranj	<i>Pongamia pinnata</i>	Fabaceae	Tree	NP
Kusum	<i>Schleichera oleosa</i>	Sapindaceae	Tree	P
Lantana	<i>Lantana camara</i>	Verbenaceae	Shrub	NP
Mahua	<i>Madhuca indica</i>	Sapotaceae	Tree	P
Maize	<i>Zea mays</i>	Poaceae	Grass	P
Mango	<i>Mangifera indica</i>	Anacardiaceae	Tree	NP
Motha/kandi	<i>Cyperus rotundus</i>	Cyperaceae	Grass	P
Munga	<i>Moringa oriefera</i>	Moringaceae	Tree	NP
Murabba/ Sisal	<i>Agave sisalana</i>	Asparagaceae	Shrub	P
Neem	<i>Azadirachta indica</i>	Meliaceae	Tree	P
Nilgiri	<i>Eucalyptus ssp.(globu)</i>	Myrtaceae	Tree	NP
Paddy	<i>Oryza sativa</i>	Poaceae	Grass	P
Pipal	<i>Ficus religiosa</i>	Moraceae	Tree	P
Ratanjot	<i>Jatropha curcas</i>	Euphorbiaceae	Shrub	NP
Saal	<i>Shorea robusta</i>	Dipterocarpaceae	Tree	P
Sagwan	<i>Tectona grandis</i>	Lamiaceae	Tree	P
Sahtoot	<i>Morus nigra</i>	Moraceae	Tree	P
Saja	<i>Terminalia tomentosa</i>	Combrataceae	Tree	P
Semal	<i>Bombax ceiba</i>	Bombaceae	Tree	P
Senha	<i>Lagerstroemia parviflora</i>	Lythraceae	Tree	NP
Shisham	<i>Dalbergia sissoo</i>	Fabaceae	Tree	P
Siris	<i>Albizia spp.</i>	Fabaceae	Tree	P
Sitafal	<i>Annona squamosa</i>	Annonaceae	Shrub	NP
Sugarcane	<i>Saccharum officinarum</i>	Poaceae	Grass	P
Tendu	<i>Diospyros melanoxylon</i>	Ebenaceae	Tree	P

*Note: P= palatable, NP= non palatable

feeding behaviour (Thakur et al. 2016b). Elephants are known to feed on a wide variety of plant species in general diet (Blake 2002; Joshi and Singh 2008). As fruits abundance (*Aegle marmelos*, *Zizyphus mauritiana*, *Syzygium cumini* and *Ficus sp.*) increases during various seasons, therefore, elephants consumed more. The major grasses were *Imperata cylindrica*, *Oryza sativa*, *Zea mays*, *Saccharum officinarum*, *Dendrocalamus strictus* etc. and the plants or tree leaves were *Artocarpus heterophyllus*, *Ficus sp.*, *Musa paradisica*, *Acacia sp.* etc. Similar findings were also reported by Sivaganesan and Johnsingh (1995), Blake (2002), Joshi and Singh (2008) and Thakur et al. (2016b). Sivaganesan and Johnsingh (1995) reported that grass formed the major portion of elephants diet in the Mudumalai Wildlife Sanctuary, India. However, the present estimated value of preferred species was much lesser than Blake (2002) who reported 350 species on forest elephant feeding ecology in Nouabale-Ndoki National Park in northern Congo. Furthermore, Williams (2002) reported very close value (30 plant species) which is being utilized by elephants as compared to present study. From Indian perspective, Sukumar (1990) pointed that elephants fed on 112 floras and out of which eighty-five percent of their diet comprised only of 25 species. Lahkar et al. (2007) found that 18 species were eaten up by elephants during dry spell in Manas National Park. High value of preferred species (106) by elephants was also reported by Chen et al. (2006) for China. The most important species were *Themeda* spp and *Apluda mutica*. The species variation of the grasses eaten can be attributed to the different geographical locations and forage preferred by wild elephants (McKay 1973; Moss 1988; Sivaganesan and Kumar 1995; Mercy 2002; Borah and Deka 2008). The feeding habits of elephants show a great variation with respect to seasons, availability of water and movement pattern. Elephants in Jashpur region are well adapted to feed on various seasonal flora present round the year. There has been intensive logging during the past few years as the result of which many of the original tropical deciduous forest cover has disappeared.

Pugmark Analysis of Elephant

Pugmark is the footprint of animal and every individual animal species has a distinct pugmark

and it is used for identification, census and also used for tracking animal. It is possible to make an accurate identification of species, sex, age and physical condition of an animal by those trained in the field (Thakur et al. 2016b). During the analysis of pugmark on the study site it was found that the circumference varied from 51.55cm to 165cm whereas length x width varied from 22x28cm to 50x55cm (Table 3), which reflects a substantial variation/differentiation of individual in a herd in respect to their age, sex, size etc.

Table 3: Pugmark analysis of elephants in corridors of northern Chhattisgarh

Class (cm)	Length (%)	Width (%)
20-30	15	15
30-40	40	35
40-50	20	35
50-60	25	15

Generally wild elephants migrate in a fixed route called as corridor and do not stay for long in a site or habitat (Borah and Bhuyan 2016). The elephant requires a large area to derive their survival needs like food, mates, water, resting sites and look up positions; the area referred to as home range (Nagene et al. 2017). The elephant's movement was considered as key ecological factor which define herbivores distribution. Elephants cover large distances during migration and stay within different forest habitats, forest fringe or adjoining areas which is enriched with water and fodder sources (Hedges and Gunaryadi 2009; Graham et al. 2010). The analysis on elephant pugmark assessment and information related to these were limited and scarce. The range of pugmark analysis was similar to the value reported by Thakur et al. (2016b) for Sarguja division. They reported that circumference varied from 63.80cm to 172.70cm whereas length x width varied from 22x20cm to 60x55cm, which reflects a substantial variation/differentiation of individual in a herd in respect of their age, sex, size etc.

From the point of elephant conservation, Jashpur region is a rich habitat but is under biotic pressure. Rehabilitation programme of elephants is ongoing in this corridor of Chhattisgarh. In few of the areas elephant are utilizing all the forest compartments frequently to fulfill their routine requirements. Major causes of free momentum activity of elephants are agricultural

land-use change in and around the proximity of forest ranges and increasing number of anthropogenic and developmental activities. Study indicated that 34 plant species were consumed by elephants as their food but it has been suggested that different populations of elephants in the same forest stretch use some separate and specific fodder species hence more information is needed on their feeding biology to properly develop management strategies for their conservation. Therefore, management practices are needed to conserve the elephant's habitat for their long-term survival. The study helped to fill the knowledge gap of feeding/foraging behaviour and their ecology along with the determination of elephant related attributes, census and migratory route which would contribute to planning, managing and conserving to safeguard the habitat/corridors in a sustainable manner.

CONCLUSION

The present study revealed that elephants show a great variation in feeding which mainly comprises of grasses, shrubs, tree leaves, bark and fruits and their feeding which determined level of migration and movement pattern. Tree species consist of major food for elephants and their diet and they generally utilized widely distributed species round the year. Majority of the tree species were found near the villages which is also a major cause of HEC in the study area. Study further indicated that few of the fodder species are common throughout the year while few are only available to elephants in particular season of the year. Present investigation suggested that widely distributed species were utilized throughout the year whereas some other species were utilized in particular months during seasonal movement. From conservation perspectives the northern corridors is a rich habitat but due to various anthropogenic pressures site undergoes for kind attention. A total of 59 plant species were recorded out of which 34 were preferred by elephants as fodder species hence more information is required on their feeding, biology to develop proper management strategies for conservation plan. In present circumstances there is a need of hour for some applied research related to habitat improvement, eco-restoration, corridor treatment, migratory alert information system, plantation of palatable species etc. which may provide database about

ground facts that will be useful in achieving the goal of biological diversity conservation especially in conserving wildlife species that are categorized under endangered category.

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