



## **Food and feeding behaviour of Asiatic elephant (*Elephas maximus* Linn.) in Kuldiha Wild Life Sanctuary, Odisha, India**

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### **Abstract**

The feeding behaviour of Asiatic elephant (*Elephas maximus*) with food reference was studied in Kuldiha Wildlife Sanctuary in Odisha during 2007 to 2009. Though the study area houses a good number of plant species only 71 species were identified as elephant fodder plants. The food trail of elephant was observed as twig breaking, bark peeling, branch breaking, stem twisting uprooting and flower plucking in different regions of study area during different seasons. Alteration of predominantly browsing strategy with that of grazing around the year was related to seasonal variation of food plants. Consumption of tree species (56%) was highest as compared to shrubs (20%), herbs (14%) and climbers (10%). A high degree of variation in dicot- monocot ratio (61:10) was marked during identification of elephant fodder plant by direct observation. Microscopic analysis of dung showing a high degree of variation in average dicot- monocot ratio suggested that the food plant selection of elephant was highly opportunistic and seasonal. The elephants extensively fed on the plant species like *Careya arborea*, *Kydia calycina*, *Helicteres isora*, *Mallotus philippinensis*, *Aegle marmelos*, *Zizyphus mauritiana*, *Bauhinia racemosa*, *Bauhinia vahlii*, *Mimosa pudica*, *Asparagus racemosus*, *Smilax zeylanica* and *Diosporea* species. They were fond of *Madhuca indica* (Mahula) flowers in winter and fruits of *Mangifera indica* (Mango) in summer. They were never found feeding on *Tectona grandis* and *Eucalyptus maculate* inside the study area.

### **Key words**

Asiatic elephant, Feeding behaviour, Kuldiha Wild Life Sanctuary

### **Introduction**

Elephants are classified as megaherbivorous and consume up to 150 kg of plant matter per day (Samansiri and Weerekoon, 2007). Hence availability of food is a major determinant of carrying capacity of elephants in a given area. Feeding behaviour of *Loxodonta african* and *Elephas maximus* have been approached from 3 general perspectives : Descriptive observation of feeding behaviour in wild, measurement of various indices of condition from culled animals and assessment of the chemical composition of food items (Osborn, 2004). Studies on food plants of African and Asian elephants have shown that the proportion of various plant species in the diet vary widely from one region

to another. Several studies have attempted to assess the factors that influence the diet selection in different habitats (De villers *et al.*, 1991). Elephants keep constantly on move looking for the necessary supply of food and sources of water (Davies, 2008). The total time spent in feeding by an elephant varies between 12 and 19 hr per day. Elephants are generalist feeders and tend to eat what is available to them, but they can be very specific about which parts of a plant they eat and when.

The objective of this investigation was to document the elephant fodder plant species and their seasonal consumption during 2 years in relation to feeding habit in Kuldiha Wild Life Sanctuary.

## Materials and Methods

**Study area:** The study area comprises the hill ranges of Kuldiha Wild Life Sanctuary having 3 forest ranges namely Kuldiha, Tenda and Devigiri in the district of Balasore, Odisha. The sanctuary lies within 21°- 45' to 21°-30' N latitudes and 80°-30' to 80°- 45' E longitudes enclosing an area of 272.75 sq. km. The sanctuary is floristically rich with 290 floral species housing the largest land animal *Elephas maximus*. 81 elephants were reported in the year 2010. The landscape is hilly with moderate to steep slopes with average elevation of hill peak around 350m from the sea level. The temperature ranges from 40° to 42°C during summer and goes below up to 6°C in winter. Three small rivers, Tangna, Kamala and Usatal nala are the main water sources of the sanctuary. It was recognized as wild life sanctuary in 1984 by Government of Odisha and as an Elephant Reserve through "Project Elephant" by Government of India with the major aim of maintaining the viable population of Asian elephant in their natural habitat. The methods applied for this research work was based both on direct and indirect techniques during 2007 to 2009.

**Direct method:** 3 forest ranges searched for elephant for about 10-12 hrs a day starting early in the morning and 4 hours in the afternoon before sunset. A pair of (Nikon 8 x42) binoculars were used for identifying the elephant number, sex and individual elephant in a herd. The identification based on physical markings such as cuts, size, shape of the holes in ears, lumps on the body and shape of the tail (Moss, 2001), Goswamy *et al.* (2007). The food trail taken by an elephant or a herd of elephants was followed and all the plants on which they fed were collected after the herd moved away. Night time movement of elephants was tracked using fresh sign of dung, footprints, and feeding signs to the location where the elephants were seen on the previous day. Species among the fodder plants were identified as per Saxena and Braham (1989). Feeding samples of leaf, bark, stem and fruits collected during direct observation were compared with subsequent microscopic analysis of dung.

**Indirect method:** This analysis was done as per the procedure of Samansiri and Weerakoon (2007) to qualify and quantify different food species eaten by the elephant. A total 27 dung samples were subjected to this analysis. From each sample 3 sub samples (each weighing 50 gm) were removed. Each sub sample was placed in a 50 ml sample tube and 25ml of boiled water was added to it. The tube was capped and mixed thoroughly and allowed to sit for 20 min. Then the contents were filtered using a sieve (mesh size of 2 mm) and the filtrate was collected. 5 ml of house hold bleach solution was added to the filter, mixed thoroughly and allowed to sit for 20 min. The solution was filtered using a 250 micron sieve and the residue was collected. A

small amount of the residue was placed in a counting chamber. A few drops of water added until an even distribution was obtained. Then a cover slip was placed on the counting chamber. The number of plant epidermis or woody materials that appeared on the cross points of the counting chamber was counted. One hundred cross points were counted for each sub sample. The counted samples were identified as dicot or monocot by comparing their epidermal tissue with the reference collection. Identifying characters were based on the shape, arrangement of epidermal tissue, stomata and presence of structures such as thorns and hairs.

**Time activity budget:** Timely activities of elephant was noted for 3 alternative days in a week. The herd that comes to sight early in the morning was followed till evening. The feeding, moving and resting time of individual elephant of a herd was noted. After long term observation of 2 years the average time activities were calculated seasonally for comparison.

## Results and Discussion

A total 71 (Dicot-61, Monocot-10) plant species belonging to 37 families of 19 orders were recorded along with their life forms and parts consumed by elephants (Table 1). 44% of total plants were non-tree species classified as shrubs, herbs (including grass) and climbers. Microscopic analysis of dung (Table 2) showed that the average dicot monocot ratio was highly variable. The quantitative amount of dicot was greater during summer. During rainy season the monocot exceeded the dicot, but in winter there was a little variation.

During summer, elephants mainly utilized the bark of different trees as their food. It was observed that bulls removed such bark with the help of their tusk but cows wrapped their trunk round the tree or branch and many times knocked the tree altogether and then debarked it for feeding. They also searched for fruits of different species. They were so fond of mango that often they congregated under mango trees to eat the ripe fruits. This habit facilitated elephant census in the forest habitat. Elephant census was otherwise known as mango census of elephants. Elephant showed penchant love for the flowers of *Madhuca indica* (Mahula). During February and March, they parked themselves under the Mahula trees and fed on flowers that fell on the ground. They also used their trunks for plucking flowers. During rainy season, they mainly fed upon grasses alongwith leaves, branches, roots and tubers. During November to January, they came to open areas for standing and taking sun bath while feeding. The total amount of plant matter removed by the elephant was not fully consumed. A relatively large part was dropped to the ground as such, sometimes utilized by other herbivorous

**Table 1** : Identified elephant food plant species, their life form and the plant parts eaten

Order	Plant species	Local name (Oriya)	Parts eaten
Ranales	<i>Polyathia longifolia</i>	Debadaru (Tree)	Leaf
Theals	<i>Shorea robusta</i>	Sal (Tree)	Leaf
Parietales	<i>Crateva magna</i>	Varuna (Tree)	Leaf
Malvales	<i>Bombax ceiba</i>	Simile (Tree)	Leaf
	<i>Grewia helicterifolia</i>	Sonaranga (Tree)	Leaf
	<i>Kydia calycina</i>	Kapasia (Tree)	Leaf
	<i>Helicteres isora</i>	Murmuika (Tree)	Leaf
	<i>Pterospermum canescens</i>	M champa (Shrub)	Leaf Bark
	<i>Sterculia villosa</i>	Kodal (Tree)	Leaf
Euphorbiales	<i>Bridelia retusa</i>	Kasi (Tree)	Leaf
	<i>Embllica officinalis</i>	Anala (Tree)	Leaf
	<i>Mallotus philippinensis</i>	Kamalagundi (tree)	Leaf
	<i>Trewia nudiflora</i>	Panigambhari (Tree)	Bark
Urticales	<i>Celtis cinnamomea</i>	Parbatakaian (Tree)	Leaf
	<i>Artocarpus heterophyllus</i>	Panasa (Tree)	Leaf, Bark, Fruit
	<i>Ficus benghalensis</i>	Bara (Tree)	Leaf, Bark
	<i>Ficus glomerata</i>	Dimiri (Shrubs)	Leaf, Fruit
	<i>Ficus religiosa</i>	Aswatha (Tree)	Leaf, Twigs
	<i>Ficus retusa</i>	Jari (Tree)	
	<i>Streblus asper</i>	Sahada (Shrub)	Leaf, Twigs
Geraniales	<i>Hugonia mystax</i>	Chuliginka (Climber)	Leaf, Twigs
	<i>Aegle marmelos</i>	Bela (Tree)	Fruit
	<i>Atalantia monophylla</i>	Narguni (Tree)	Leaf
	<i>Limonia acidissima</i>	Kaitha (Tree)	Bark, Twigs
	<i>Glycosmisconmis pentaphylla</i>	Chauldhua (Shrubs)	Leaf
	<i>Mangifera indica</i>	Amba (Tree)	Fruit
Sapindales	<i>Schleichera oleasa</i>	Kusuma (Tree)	Leaf
Rhamnales	<i>Zizyphus mauritiana</i>	Barkoli (Shrubs)	Leaf
	<i>Zizyphus oenoplia</i>	Kontaklia (Shrubs)	Leaf
	<i>Zizyphus xylopyrus</i>	Ghonto (Shrubs)	Leaf
	<i>Cissus quadrangularis</i>	Hadabhanga (Shrubs)	Tree
Santalales	<i>Loranthus sp.</i>	Malanga (Shrubs)	Tree
	<i>Bauhinia racemosa</i>	Ambalota (Climber)	Leaf
	<i>Bauchinia vahlii</i>	Siali (Climber)	Leaf, Bark, Twigs
	<i>Tamarindus indica</i>	Tentuli (Tree)	Leaf, Fruit.
	<i>Cassia fistula</i>	Sunari (Tree)	Leaf, Twigs
	<i>Acacia ferruginia</i>	Kantachira (Climber)	Leaf
	<i>Acacia leucophloea</i>	Gohera (Tree)	Leaf
	<i>Acacia torta</i>	Dontari (Herb)	Leaf
	<i>Dichrostachys cinerica</i>	Vurtuli (Shrubs)	Leaf
	<i>Mimosa pudica</i>	Lajakuli (Shrubs)	Leaf
	<i>Albizzia procera</i>	Siris (Tree)	Leaf, Twigs
	<i>Butea monosperma</i>	Palasa (tree)	Leaf, Tree
	<i>Pterocarpus santalinus</i>	Kanchana (Tree)	Root
	<i>Pterocarpus marsupium</i>	Pia sal (Tree)	Leaf
Myrtales	<i>Dalbergia sissoo</i>	Sisoo (Tree)	Leaf
	<i>Anogeissus latifolia</i>	Dhaura (Shrubs)	Leaf
	<i>Terminalia chebula</i>	Harida (Tree)	Leaf
	<i>Terminalia belerica</i>	Behada (Tree)	Leaf
	<i>Syzygium cumini</i>	Jamu (Tree)	Leaf
	<i>Careya aroboorea</i>	Kumbhi (Tree)	Leaf Fruit
	<i>Lagerstroemia parviflora</i>	Sidha (Tree)	Bark
Ebenales	<i>Madhuca indica</i>	Mahula (Tree)	Fruit Leaf
	<i>Manilkara hexandra</i>	Khirkoli (Shrubs)	Leaf
	<i>Mimusops elengi</i>	Baula (Tree)	Leaf
	<i>Diospyros melanoxylon</i>	Kendu (Tree)	Leaf, Root Fruit
Oleales	<i>Carissa spinarum</i>	Dudhkoli (Shrubs)	Leaf

	<i>Strychnos nuxvomca</i>	Kochila (Tree)	Leaf
Polemoniales	<i>Ipomoea sp.</i>	Amari (Herbs)	Tree
Rubiales	<i>Randia dumetorum</i>	Potuaphala (Shrubs)	Leaf
Spadicifloreae	<i>Typha angustata</i>	Hatia ghasa (Herbs) (Monocot)	Leaf, Root
	<i>Calamus sp.</i>	Beta (Herbs) (Monocot)	Leaf, Root
Glumielopeae	<i>Brachiaria sp.</i>	Ghasa (Herbs) (Monocot)	Leaf, Root
	<i>Cynodon dactylon</i>	Dubaghas (Herbs) (Monocot)	Leaf, Root
	<i>Oryza sativa</i>	Dhana (Herbs) (Monocot)	Leaf, root Fruit
	<i>Zea mays</i>	Maka (Herbs) (Monocot)	Leaf, Root Fruit.
Liliflorae	<i>Dioscorea sp.</i>	Bana alu (Climber) (Monocot)	Root
	<i>Asparagus racemosus</i>	Satabari (Climber)(Monocot)	Leaf Root
	<i>Smilax zeylanica</i>	Muturi (Climber) (Monocot)	Leaf
Scitamineae	<i>Musa paradisiaca</i>	Kadali (Herbs) (Monocot)	Tree, Fruit

Tree = 40 Numbers(56%), Shrubs = 14 numbers(20%); Herbs =10 numbers (14%), Climber= 7 numbers (10%) ; Dicot species =61, Monocot species =10

**Table 2 :** The average dicot-monocot ratio of elephant dung at different habitats of study area around the year

Season	Habitat	N	Dicot species per sample	Average dicot	Monocot per sample	Average monocot	Average Dicot : Monocot
Summer	Shrub	3	8,9,6	7.67	5,5,2	3.0	2.556
	Forest	3	21,19,18	19.33	7,5,4	5.33	3.627
	Sal	3	29,32,20	27.0	13,5,6	8.0	3.375
Rainy	Shrub	3	2,2,1	1.67	3,2,4	3.0	0.556
	Forest	3	13,5,10	9.33	21,13,27	20.33	0.459
	Sal	3	1,0,3	1.33	23,17,13	17.66	0.075
Winter	Shrub	3	14,16,10	13.33	18,5,8	10.33	1.290
	Forest	3	9,23,11	14.33	19,17,6	14.0	1.024
	Sal	3	8,12,9	9.66	13,5,9	9.0	1.074

N= The number of dung sample analysed per habitat

thus representing associational behaviour. They broke entire favourite plants (*Aegle marmelos*, *Dalbergia sisso*), peeled off bark of few plant species (*Bombax ceiba* and *Ficus bengalensis*), uprooted the plants with the help of trunk and forefoot, consumed succulent grass species along with the entire clump and root, fed extensively on the mixed vegetation including trees, grasses shrubs and climbers.

Irrigated and monsoon crop raiding from adjoining area by elephants during March-April and November – December was a common observation. The major crops were *Oryza sativa* (Dhan), *Zea mays* (Maka), *Musa paradisiaca* (Kadali). Elephants often left the forest to feed crops of nearby villages usually during night. They entered into tribal villages after sunset and returned the forest area before dawn. Frequently, the same herd or single bull was reported in crop raiding continuously for about 3 to 4 days. Consumption of stored crops and country liquor from the tribal houses by the elephants were also reported. It was observed that the home elephants did not join with the immigrants during crop raiding.

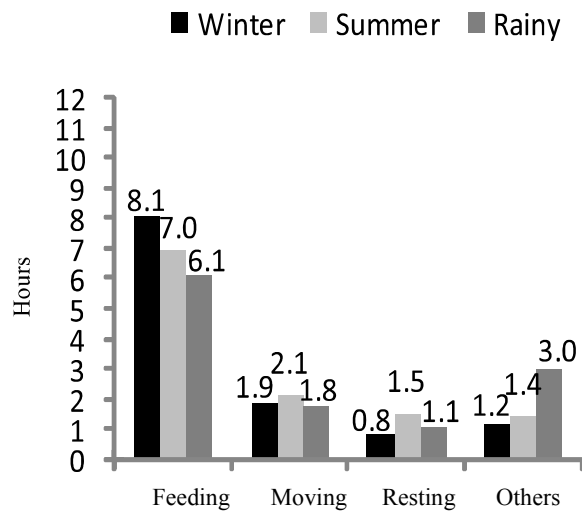
Seasonal variation in time activity budget for 12 hr day regime (feeding, moving, resting) of elephant was

observed for two years (Fig.1). Feeding during winter (8.1 hr) accounted for the highest duration followed by feeding in summer (7.0 hr) and monsoon (6.1 hr). Movement activity accounted for 1.9 hr (winter), 2.1 hr (summer) and 1.8 hr (monsoon). Fluctuations were observed in resting activity as it depends upon season, 0.8 hr in winter, 1.5 hr in summer and 1.1 hr in monsoon. Other activities like drinking, bathing, playing etc. accounted for 1.2 hr in winter 1.4 hr in summer and 3.0 hr in rainy season.

The study of time activity budget by Joshi and Singh (2008) suggested that feeding during winter accounted for the highest duration followed by summer and monsoon.

Though Kuldiha Wild Life Sanctuary comprises about 290 floral species, the study enumerated only 71 plant species as elephant fodder plants. It was only 24% of the flora of the sanctuary. Consumption of tree species (56%) was highest as compared to shrubs (20%) herbs (14%) and climbers (10%).

Elephants are known to feed on a wide variety of plant species. Samansiri (2007) pointed out that elephants are poor digesters as they assimilate little over 50% of the



**Fig.1:**Comparative time-activity budget for different activities in different season

food consumed. This is also in co-relation with my findings when the elephant dung was analysed microscopically. To compensate for this they consume as much as 150 kg of plant matter per day. In an earlier study Guy (1976) recorded 133 species of elephant fodder plants belonging to 95 genera and 41 families at Sengwa reserve in Zimbabwe. 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). Studies on feeding behaviour of wild Asian elephants in Rajaji National park suggested that elephants consume 74% of tree species, 14% of grass species 8% of shrub species and 4% of climber species out of total 262 floral plant species Joshi and Singh (2008). During the dry season 18 species of flowering plants were found to be eaten by the elephants in Manas National Park (Lahkar *et al.*, 2007). Another study in the conservation of Asian elephant in Bangladesh indicated that 143 plant species were present in Chunati Wild Life Sanctuary, out of which only 17 species were utilized by elephants that represents only 12% of the total local plant species (IUCN, 2007). Also a study on the diet and foraging ecology of the Asian elephant was conducted in Shangyong National Natural Reserve, Xishuangbanna, China and pointed out that 106 plant species were eaten by elephants as their food (Chen *et al.*, 2006).

The present study revealed that tree species consists of major food for elephants. The variation in average dicot and monocot ratio obtained by dung analysis indicated that selection of food by elephants was highly opportunistic and seasonal. Browsing was high during the dry season, gradually declined and became transitional with grazing

during monsoon whereas it was dominated by crop raiding during winter season. This result was also pointed out in Sebu region of Zimbabwe by Osborn (2004). Nair and Jayson (1992) identified teak as an important fodder species for the elephants in Parambikulam Wild Life Sanctuary, Kerala in India. Negintal (1993) reported the leaves and bark of teak as fodder element in Nagarhol National Park, South India. However, it is in contrast with the aforesaid findings that though teak plants are available in plenty in Kuldiha, still elephants were not observed to feed on these. Sukumar (1989) found out elephants feeding on Eucalyptus but it was also not seen in the present study area.

Kuldiha Wild Life Sanctuary represents the best home land of Asiatic elephants showing an increasing population since fifteen years. It seeks a keen attention of elephant's feeding biology management for the long term survival of this largest land animal.

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