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Nutritional status of forage plants and their use by wild elephants in South West Bengal, India

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Abstract: We studied the utilization pattern of wild plant species by migratory elephants in relation to their nutritive values. Migratory elephants were selective for food plants in the wilderness. Out of 52 recorded plant species, only 22 plant species were found to be utilized either fully or partially as evidenced by branch breaking, debarking, uprooting, etc. Among the plants consumed by the elephants, *Diospyros melanoxylon* was utilized the most (34.4%) followed by *Pterocarpus marsupium* (24.9%). Bark of *Buchanania lanzan* was moderately utilized (10.6%). All other recorded plants were utilized below 10 per cent. Crude protein content in utilized plants varied from 3.18 (*Shorea robusta)* to 21.25% (*P. marsupium*), and crude fibre from 20.0 (*P. marsupium*) to 54.0% (*D. melanoxylon*). Sodium, potassium, calcium, manganese, copper, and zinc contents also varied among the utilized plants Elephants foraged more on nutritionally rich plants,and because of the generally poor nutritional value of natural fodder, the migratory elephants in South West Bengal prefer nutritively richer agricultural crops.

Resumen: Nosotros estudiamos el patrón de utilización de especies silvestres por parte de elefantes migratorios en relación con sus valores nutricionales. Los elefantes migratorios fueron selectivos para escoger las plantas alimenticias en la naturaleza. De las 52 especies de plantas, sólo 22 son usadas ya sea total o parcialmente, como fue evidente por sus ramas rotas, tallos descortezados, plantas arrancadas de raíz, etc. Entre las plantas consumidas por los elefantes, *Diospyros melanoxylon* fue la más utilizada (34.4%), seguida por *Pterocarpus marsupium* (24.9%). La corteza de *Buchanania lanzan* fue utilizada con moderación (10.6%). Todas las plantas restantes tuvieron un uso menor que 10 por ciento. El contenido de proteína cruda en las plantas utilizadas varió de 3.18 (*Shorea robusta)* a 21.25% (*P. marsupium*), y el de fibra cruda de 20.0 (*P. marsupium*) a 54.0% (*D. melanoxylon*). Los contenidos de sodio, potasio, calcio, manganeso, cobre y zinc también variaron entre las plantas usadas. Los elefantes se alimentaron más de plantas ricas nutricionalmente, y debido al valor nutricional generalmente bajo del forraje natural, los elefantes migratorios en Bengala Sudoccidental prefieren cultivos agrícolas, que son relativamente más nutritivos.

Resumo: Estudou-se o padrão de utilização de espécies selvagens pelos elefantes migrantes em relação ao seu valor nutricional. Na selva os elefantes migrantes são selectivos pelas plantas alimentares. Das 52 plantas registadas, só 22 espécies foram encontradas, com base na evidência dos ramos quebrados, descascados, ou desenraizados, serem de utilização total ou parcial. Entre as plantas consumidas pelos elefantes a *Diospyros melanoxylon* foi a espécie mais consumida (34,4%) seguida da *Pterocarpus marsupium* (24.9%). A casca da *Buchanania lanzan* foi moderadamente utilizada (10,6%). Todas as outras plantas registadas

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tiveram um grau de utilização inferior a 10 por cento. O conteúdo da proteína bruta nas plantas utilizadas variou entre os 3,18 (*Shorea robusta*) e os 21,25% (*P. marsupium*), e a fibra bruta de 20,0 (*Shorea robusta*) a 54,0% (*D. melanoxylon*). Os teores de sódio, potássio, cálcio, manganésio, cobre, e zinco eram variáveis entre as plantas utilizadas. Os elefantes pastam mais plantas nutricionalmente ricas e por causa do valor nutricional geralmente pobre da forragem natural, os elefantes migrantes no Sudoeste de Bengala preferem as culturas agrícolas nutritivamente mais ricas.

Key words: Migratory elephants, nutritive value of wild plants, wild food plants.

Introduction

An animal's range of movement increases with greater body size and energy requirement (McNab 1963). Long distance travel during seasonal movement offers clear ecological advantages to elephants (Sikes 1971). Availability of food, water, barriers to free movement, spatial distribution, and diversity in habitat types may influence the home range size. Though elephants have no seasonally distinct ranges, they move widely to find food patches that are sufficiently rich with habitat resources to support them (Olivier 1978). The more diverse a region, the smaller could be the home range since elephants would be able to meet their varied seasonal requirements within a relatively restricted area. Factors such as nutritive value and toxicity are important in influencing the selection of food plants by elephants (Olivier 1978). As elephants have a digestive system which makes them particularly susceptible to toxins and tannins, they must search for plant parts which contain only small amounts of such chemicals.

In South West Bengal (SWB) elephants were abundant in Midnapur district and its adjoining areas in early 1900's (O'Malley 1911) and subsequently became rare until 1980's due to loss of forests and poor cover quality of coppice sal (*Shorea robusta*) forests (Palit 1991; Panda 1996). The reappearance of elephants in SWB started beyond mid 1980s which probably coincided with the revival of forest cover as a result of the decade old participatory forest protection initiatives involving local communities (Malhotra 1995). Since 1987, a group of elephants, totalling 40-60 individuals, has been migrating from Dalma Wildlife Sanctuary (DWS) of Jharkhand state to the vast areas of SWB forests during August-September and remains there for 6-7 months. The DWS is adjacent to the tri-junction of borders of Orissa, Jharkhand and West Bengal and the forest of the area experiences various degrees of biotic pressure due to mining activities. This has resulted in shrinking and degradation of elephant habitat, forcing elephants to move out of the traditional habitat to raid crops to meet their energy requirements and seek better habitat elsewhere (Datye & Bhagwat 1996). Moreover, the agriculture pattern in SWB has undergone changes from rain dependent to irrigated cropping for cash crops. Recovery in land cover and subsequent land-use changes in the recent years have created a habitat favourable for re-colonization (Singh *et al.* 2002). The elephant's sensitivity for crop depredation on broad spatial scale was mainly related to the arrangement of landscape through forest and agriculture matrices. Availability of moderate to high forest cover in such fragmented situation is a strategic requirement for elephants to avoid human-induced interference.

Nevertheless, over the years the herds are advancing their date of arrival to SWB and they range over large areas in order to meet their huge requirements of food, water and shelter. The absence or sparseness of the grasses in degraded areas and the presence of closed canopy forests like that of sal could be one of the reasons for seeking crops in lieu of wild grasses. The elephants spend the day time in forest patches and usually enter cultivated land only after sunset and leave before sunrise. However, elephants are now delaying their departure from SWB till sal leaves turn yellow and start shedding. So thinning of forest canopy coupled with harvesting of agriculture crops might trigger the return of elephants to the

DWS. Moreover, organized drives by local people also play an important role in forcing elephants to leave SWB.

The requirement of large home ranges with plenty of forage and water brings the elephants into greater contact with human settlements. With increase in human population elephant habitats have rapidly degraded and fragmented leading to human-wildlife conflicts such as loss of property, human life and crop damage. This has become a subject of great concern in terms of elephant conservation. Most of the forest staff remains engaged in managing the elephant menace but without any fruitful outcome, and during this period the normal activities of the forest department are hampered.

Elephants consume wild plants as well as cultivated agricultural crops. Although elephants are generally coarse feeders and they feed on a wide variety of plants, the migratory elephants in SWB selectively consume some wild plant species. The factors that influence the decision to consume or reject a plant are palatability of the item, and presence of toxic substances (Sukumar 1990). Ungulates show a positive selection of plant species and plant parts with the highest protein value (Field 1976) or minerals such as sodium (Belovsky 1981). The present study was undertaken to understand the utilization pattern of various wild food plants by the Asian elephants as part of their feeding strategy in terms of nutritive values.

Materials and methods

The study area is located in the districts of West Midnapur, Bankura and Purulia between latitudes 22° 25′ to 23°15′ North and longitudes 86° 30′ to 87°49′ East. The altitude varies from 200 m to 670 m. The soil is mainly red sandy, lateritic, and alluvial with red and black soil in a few pockets (Ghosh 1992). The study area has four major river catchments *viz*., Subernrekha, Kangsabati, Silabati and Darkeshwar. The innumerable man-made water bodies and ponds created for the purpose of domestic uses and soil-moisture conservation programme, are found in this region. The maximum temperature ranges between 42°C and 46°C during summer and in winter it varies from 8°C to 13°C. The monsoon period extends from mid-June to end of September. The average annual rainfall in the study area ranges between 1180 and 1428 mm. The forest is tropical dry deciduous dominated by sal (Champion & Seth 1968). Forests are divided into four broad categories: sal coppice, open scrub, open scrub with sporadic sal and plantations (Anon 1988). Leopard (*Panthera pardus*), sloth bear (*Melursus ursinus*), wolf (*Canis lupus*), hyaena (*Hyaena hyaena*), wild pig (*Sus scrofa*), common langur (*Semnopithecus entellus*), fox (*Vulpes bengalensis*), jungle cat (*Felis chaus*), mongoose (*Herpestes fuscus*), pangolin (*Manis crassicaudata*) and various reptiles are found in these forests. Besides migratory elephants (about 40-60), the area also supports about 35 resident elephants (Anon 2000).

Four plots, each measuring 1500 sq. m, were studied in four forests *viz*., Uthan Nayagram, Kuilibandh, Swargabati and Indkata to record the pattern of consumption of different plant species by elephants. These areas were selected because resident elephants avoid these locations. Direct observations of feeding by migratory elephants were made from a flight distance in the study area during day time. The studied plots were immediately examined after the herd left for another forest location. Total number of plants of each species consumed with respect to the total number of plants present in the plots was recorded through evidences of branch breaking, main-stem breaking, stem twisting, bark peeling, uprooting and tusk markings (Ishwaran 1983). The degree of utilization was calculated based on the ratio of total number of plants of a species consumed to total number of plants of that species in the plot. Proximate analysis of those food plants consumed by elephants has been done as per AOAC (1995). Sodium and potassium contents of food plants were estimated using Flame Photometer (Model: Flame Photometer Burner Unit-121, Sistronics). Pressure was fixed at 0.5 kg cm^{-2} and sensitivity was medium. Copper, manganese, zinc, iron and calcium contents of food plants were determined by Atomic Absorption Spectrometer (Model: Perkin Elmer A-Analyst 100).

Results and discussion

The migratory elephants consumed different plant species with varying degree of preference. Twenty two plant species *viz*., *Acacia chundra*,

Aegle marmelos, *Albizia lebbek*, *Buchanania lanzan*, *Butea superba*, *Careya arborea,Diospyros melanoxylon*, *Ficus hispida*, *Gardenia gumifera, Gmelina arborea, Ichnocarpus frutescens,* Kuttikalai (local name), *Lannea grandis*, *Mucuna pruriens*, *Pterocarpus marsupium*, *Semecarpus anacardium*, *Shorea robusta*, *Smilax macrophylla*, *Terminalia belerica, Terminalia tomentosa*, *Trewa nudiflora*, and *Zizyphus xylopyrus*, were consumed by the elephants as food plants. They consumed either the whole plant or its parts *viz*., leaf, leaf with succulent stem, bark, fruit and root. Overall utilization of food plants by migratory elephants revealed maximum utilization of *D. melanoxylon* (34.4%, n = 65) followed by *P. marsupium* (24.9%, n = 47). Though the density of *S. robusta* was highest (1723 trees in 0.6 ha) in the study area, elephants utilized it very poorly (0.2-0.7%). The bark of *F. hispida* was fully consumed wherever available. Bark of *B. lanzan* was moderately utilized (10.6%). All other plants such as *A. marmelos, L. grandis, Terminalia belerica*, and *Trewa nudiflora* were utilized below 10%. Bark of *S. robusta* was very poorly utilized (4.3%) inspite of its highest abundance in the forests. Out of total recorded plant species, five climber species *viz*., *A. chundra*, *B. Superba, M. pruriens*, *Smilax macrophylla* and *Z. xylopyrus* were found to be consumed occasionally by elephants.

The chemical values of some wild plants consumed by elephants are given in the Table 1. Per cent crude protein content varied form 3.18 (*S. robusta*) to 21.25% (*P. marsupium*). Leaf and entire plants were found to have higher crude protein than the bark and roots. *Ichnocarpus frutescens* contained highest ether extract (3.64%) followed by *P. marsupium* (3.42%) and *T. tomentosa* (3.30%). Crude fibre content ranged from 20 (*P. marsupium*) to 54% (*D. melanoxylon*). Root of *D. melanoxylon* and bark of *Careya arborea* had higher crude fibre i.e. 54 and 51%, respectively. Total ash content varied from 3.25 (*T. tomentosa*) to 8.73% (*B. superba*).

The neutral detergent fibre (NDF), acid detergent fibre (ADF) and lignin contents of some wild plants are summarized in Table 2. NDF content ranged from 57 (*T. nudiflora*) to 74% (*G. arborea*). ADF content ranged from 24.8 (*D. melanoxylon*) to 40% (*G. arborea* and *L. grandis*). Lignin content of studied plants ranged from 4 (*S. anacardium)* to 9.1% (*G. gumifera*).

Concentrations of mineral elements of some selected wild plants are given in Table 3. Sodium content of *T. tomentosa* bark was much higher (2.57 mg g^{-1}) as compared to other plants. The lowest sodium content was found in the bark of *S. robusta* (0.78 mg g^{-1}). Potassium content ranged from 18.76 mg g^{-1} (*S. robusta*) to 154.83 mg g^{-1}

Table 1. Chemical composition of some wild plants (on dry matter basis) consumed by elephants in South West Bengal forests (mean values based on 3 replicates).

Species	Part analysed	Moisture (%)	Dry matter (%)	Ether extract (%)	Crude fibre (%)	Crude protein (%)	Acid insoluble ash (%)	Total ash (%)
Butea superba	Entire plant	9.0	91.0	2.19	39.0	15.25	1.0	8.73
Careya arborea	Bark	9.4	90.6	1.10	51.0	5.37	2.0	4.41
Diospyros melanoxylon	Root	14.4	85.6	1.16	54.0	5.0	1.0	6.88
Gmelina arborea	Bark	12.0	88.0	2.27	50.0	11.37	1.0	7.91
Ichnocarpus frutescens	Entire plant	17.8	82.2	3.64	36.0	15.0	1.0	8.57
Kuttikalai (local name)	Entire plant	8.2	91.8	2.17	50.0	11.0	1.0	6.50
Ptercarpus marsupium	Leaf	12.4	87.6	3.42	20.0	21.25	2.0	8.56
Shorea robusta	Bark	7.4	92.6	3.23	40.0	3.18	2.0	5.36
Terminalia tomentosa	Leaf	9.25	90.75	3.30	22.0	9.43	2.0	3.25

Table 2. The dry matter (DM), neutral detergent fibre (NDF), acid detergent fibre (ADF) and lignin contents of some wild plants (mean values based on 3 replicates).

Species	Parts analysed	DM(%)	NDF (%)	ADF (%)	Lignin (%)
Acacia chundra	Whole plant	93.3	58.4	30.0	6.0
Buchanania lanzan	Bark	88.1	73.2	34.8	6.9
Careya arborea	Bark	90.0	69.9	36.2	7.1
Diospyros melanoxylon	Root	92.0	58.5	24.8	4.2
Gardenia gumifera	Whole Plant	87.0	68.3	39.0	9.1
Gmelina arborea	Bark	88.0	74.0	40.0	7.5
Lannea grandis	Leaf	89.6	70.0	37.7	7.8
Lannea grandis	Bark	90.0	71.2	40.0	9.0
Pterocarpus marsupium	Leaf	89.5	64.2	35.0	6.7
Pterocarpus marsupium	Bark	93.2	60.3	30.1	6.0
Semecarpus anacardium	Root	85.5	65.6	27.5	4.0
Smilax macrophylla	Whole plant	90.3	61.2	29.2	5.4
Trewia nudiflora	Bark	91.5	57.0	31.3	7.1

Table 3. Mineral composition of some selected wild plants (mg g^{-1} dry matter) (mean values based on 3 replicates).

Species	Na	K	Ca	Zn	Mn	Cu	Fe
Acacia chundra (Whole plant)	1.01	106.35	6.28	0.68	0.27	1.28	0.16
Aegle marmelos (Fruit)	1.15	112.60	0.40	0.03	0.02	0.25	0.39
Buchanania lanzan (Bark)	1.33	84.45	22.72	1.74	0.04	0.03	0.20
Careya arborea (Bark)	1.38	140.76	7.34	0.01	0.09	-	0.66
Diospyros melanoxylon (Root)	1.19	53.17	20.66	0.14	0.11	0.25	3.18
Gardenia gumifera (Whole plant)	1.56	154.83	18.80	0.01	0.30	0.09	2.05
Gmelina arborea (Bark)	1.19	101.66	19.44	0.71	0.04	0.17	0.24
Lannea grandis (Bark)	1.47	98.53	13.80	-	0.22	0.06	0.54
Lannea grandis (Leaf)	1.08	57.86	13.66	0.01	0.37	0.04	0.91
Pterocarpus marsupium (Bark)	1.7	67.26	7.52	1.26	0.06	0.23	0.20
Pterocarpus marsupium (Leaf)	1.01	67.25	8.92	3.36	0.45	0.31	0.20
Semecarpus anacardium (Root)	1.03	73.50	12.90	0.23	0.77	0.66	2.38
Shorea robusta (Bark)	0.78	18.76	1.70	0.67	0.05	1.42	0.28
Smilax macrophylla (Whole plant)	0.89	78.20	8.18	0.07	0.45	0.07	0.45
Terminalia tomentosa (Bark)	2.57	51.61	32.50	0.12	0.11	0.35	0.26
Trewia nudiflora (Bark)	1.33	54.74	25.66	0.03	0.59	0.09	0.24

(*Gardenia gummifera*). Potassium content was relatively higher in these plants except for *S. robust*a. Calcium content in bark ranged from 7.34 mg g^{-1} in *Careya arborea* to 32.50 mg g^{-1} in *T. tomentosa*. However, *A. marmelos* contained lowest amount of calcium (0.40 mg g^{-1}). Iron content ranged from 0.16 to 3.18 mg g^{-1} in studied plants. The iron content was much higher in roots of *D. melanoxylon* (3.18 mg g^{-1}) and *Semecarpus anacardium* (2.38 mg g^{-1}) than other parts of various plants analyzed. Copper content varied from 0.03 (*B. lanzan*) to 1.42 mg g^{-1} (*S. robusta*). Roots of *Semecarpus anacardium* were found to have highest amount of manganese (0.77 mg g^{-1}) followed by that in *T. nudiflora* bark (0.59 mg g^{-1}). Lowest manganese content was found in the fruits of *A. marmelos* (0.02 mg g^{-1}). Zinc content ranged from 0.01 mg g^{-1} to 3.36 mg g^{-1}.

Utilization pattern of wild plant species by migratory elephants in South West Bengal forest revealed that out of 52 plant species recorded in the studied area, elephants selectively foraged on

22 food plants. Low number of plant species consumed by the migratory elephants in the wilderness is due to their dependency on cultivated crops which have higher palatability and nutritive value than wild plants. Two plant species, *D. melanoxylon* and *P. marsupium,* were highly preferred by elephants as food. Though heavy debarking of *Pterocarpus* sp in rain forest of Malayasia was reported (Olivier 1978), Dalma elephants showed strong preference for leaves of *P. marsupium*. As *P. marsupium*, *D. melanoxylon* and *B. lanzan* are utilized more by elephants, these plants should be protected by dissuading people from cutting.

High protein content of *P. marsupium* leaves (21.2%) is a probable reason for its highest degree of utilization. Ungulates can select food of desired nutritive value by applying their nutritional wisdom (Field 1976). Debarking of many food plants by elephants has been observed in various parts of tropics (Olivier 1978). Feeding on bark may help maintain an optimum fibre: protein ratio to ensure proper digestion of protein (Laws *et al.* 1975), or supply minerals such as manganese, boron, copper, iron and calcium (Bax & Sheldrick 1963). Bark of some plants has been observed to be particularly rich in mineral elements *viz.* iron, copper and manganese in the present study. The present finding corroborates that of Dougall *et al.* (1964). In the present investigation, *B. latifolia* bark with high calcium content (22.72 mg g^{-1}) was consumed at moderate level (10.6%). However, some plant species with high calcium content *viz*., *Trewa nudiflora* (25.66 mg g^{-1}) and *Terminalia tomentosa* (32.50 mg g^{-1}) were found to be utilized very poorly (0.52%). The present findings do not agree with an earlier study (Laws *et al.* 1975) where a positive correlation between degree of debarking by elephants and calcium content of plant species was reported. The reason might be that these two plant species may contain higher amounts of toxic alkaloids leading to their poor utilization or the Ca requirement of the animal is met through feeding of agricultural crops. As elephants are known to be prone to sodium deficiency (Benedict 1936; Olivier 1978), they visit certain soils rich in minerals for salt-lick (Sukumar 1985). In the present investigation elephants consumed some plant species having higher sodium and other mineral contents. The role of trace elements *viz.* zinc, manganese, copper and iron in elephant nutrition has not been properly elucidated (Sukumar 1985). However, the analyzed plant samples contained comparatively high level of trace elements possibly due to the soil composition of South Bengal. Though some factors such as food-dispersal pattern, nutritive value and toxicity are important in influencing selection of food plants by elephants (Olivier 1978), it is unlikely that any single factor would explain the elephant's preferences (Ishwaran 1983).

The present investigation therefore, concludes that high nutritive values of plant species probably influence the decision to consume, as conveyed to the mega - herbivore through its senses. This foraging strategy of chosing nutritively richer plants results in the preference for agricultural crops over the natural fodder by migratory elephants in South West Bengal.

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