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Feeding Behaviour of Asian Elephants in the Northwestern Region of Sri Lanka

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Introduction

The Northwestern region of Sri Lanka supports a substantially large elephant population. Population estimates range from 591 (Hendavitharana 1993) to 1500 animals (de Silva & Attapattu 1998). However, there are only a few protected areas in this region of which Wilpattu National Park is the largest intact natural habitat available for elephants. Apart from the protected areas, the only other intact natural vegetation patches are found in the catchment areas of large tanks. The remaining natural habitats include man modified habitats such as forest plantations and abandoned agricultural lands which are in different stages of natural succession.

Elephants are classified as megaherbivores and consume up to 150 kg of plant matter per day (McKay 1973; Vancuylenberg 1977). Therefore availability of food is a major determinant of carrying capacity of elephants in a given area. Previous studies on feeding behavior of Sri Lankan elephants have shown that they are generalists that feed on a wide variety of food plants (Mueller-Dombois 1972; McKay 1973; Ishwaran 1983). However all of these studies have been conducted in protected areas such as Gal Oya National Park and Ruhunu National Park. As majority of the elephants in the northwestern region occupy habitats outside protected areas, it is important to understand the availability of food for these elephants in order to properly manage this population. The aim of this investigation was to identify the food plants of elephants that range in the northwestern region and to assess their availability both in and outside protected areas.

Materials and methods

Study area: The study area is located in the northwestern region of Sri Lanka encompassing the Mahaweli system H and adjoining areas. The study area is demarcated by the towns of Puttalam in the East, Mahawa in the South, Habarana in the West, and Anuradhapura in the North. The extent of the study area is approximately 3000 km^2 and includes 15 administrative divisions. Human use patterns found within the study area can be grouped into three categories as, low use, high use and very high use.

Study animals: The exact number of elephants in the study area is not known. A census carried out by the DWLC revealed that there are 591 elephants inhabiting the northwestern region (Hendavitharana 1993). However, de Silva and Attapattu (1998) reported that this number could be as high as 1500 elephants. During the course of this study nine elephants, three adult males, a sub-adult male, three adult females and two sub-adult females were collared within the study area. Of these, three elephants were selected from a low human use area, one female was selected from a medium human use area, and the remaining five elephants were selected from very high human use areas. A summary on these elephants is given in Table 1. These elephants were located at least 4 times a month and observations were made on their feeding habits during the period January 1998 to December 1999. In addition to the elephants that were

Table 1. A description of the nine elephants collared during the study.

Location	Height [cm]	Age [years]	Sex	Human use	Social status
Karuwalagas wewa	189	8 -10	Male	Low	Herd (13-15)
Karuwalagas wewa	282	35+	Male	Low	Solitary
Karuwalagas wewa	225	30+	Female	Low	Herd (15-18)
Kumbuk wewa	192	10 - 12	Female	Medium	Herd (8-10)
Usgala wewa	180	9 - 10	Female	High	Herd (21-24)
Kala wewa	210	20 - 25	Female	High	Herd (12-16)
Turuwila	215	25 - 30	Female	High	Herd (25-29)
Turuwila	267	35 - 40	Male	High	Solitary
Galkiriyagama	310	45+	Male	High	Solitary

Feeding behaviour: Feeding behaviour of elephants was determined using both direct and indirect techniques. Whenever possible, feeding behaviour of elephants was observed directly, especially the elephants that were fitted with radio collars or members of the herd to which the collared elephant belongs. However, due to poor visibility of the terrain only a limited number of opportunities were presented to make direct observations. Therefore, three indirect techniques were utilized to determine the feeding behaviour of elephants.

Figure 1. Feeding signs observed on a food trail.

i. Food trails: The trail taken by an elephant, or a herd of elephants was followed and all the plants showing signs of being fed by elephants (Fig. 1) and the part(s) of the plant eaten were recorded. In addition a herbarium specimen, a leaf sample, a bark sample, and if fruits were available a sample of seeds were also collected to develop a reference collection that was used during the subsequent macroscopic and microscopic analysis of dung samples.

ii. Macroscopic analysis of dung: A total of 145 dung boli were collected from different parts of the study area. The bolus was separated by hand and all identifiable parts were removed (Fig. 2). These parts were identified by comparing it with the reference collection of plant seeds and plant parts constructed during food trails.

iii. Microscopic analysis of dung: This analysis was done to quantify ratios of different food types eaten by the animal in addition to identification of different food types eaten. A total of 113 dung samples were subjected to this analysis. From each dung sample, three sub samples (each weighing approximately 50 g) were removed. Each sub sample was placed in a 50 ml sample tube and 25 ml of boiling water was added, capped and mixed thoroughly, and allowed to sit for 20 minutes. Then the contents were filtered using a sieve (mesh size = 2 mm) and the filtrate was collected. Five ml of household bleach solution was added to the filtrate, mixed thoroughly and allowed to sit for 20 min. The solution was filtered using a 250-micron sieve and the residue was collected.

Figure 2. Macroscopic analysis of dung.

A small amount of the residue was placed in a counting chamber, and a few drops of water added until an even distribution was obtained. A cover slip was placed on the counting chamber and the number of dicot or monocot plant leaf epidermis or woody material that appeared on the cross points of the counting chamber was determined. One hundred such cross points were counted for each sub sample. Whenever possible plant species present in the dung sample were identified by comparing the epidermal tissue with a reference collection of plant epidermal tissue (Fig. 3) constructed from plants collected from food trails. The characters used for identification included shape and arrangement of epidermal tissue and stomata and presence of structure such as thorns hair etc.

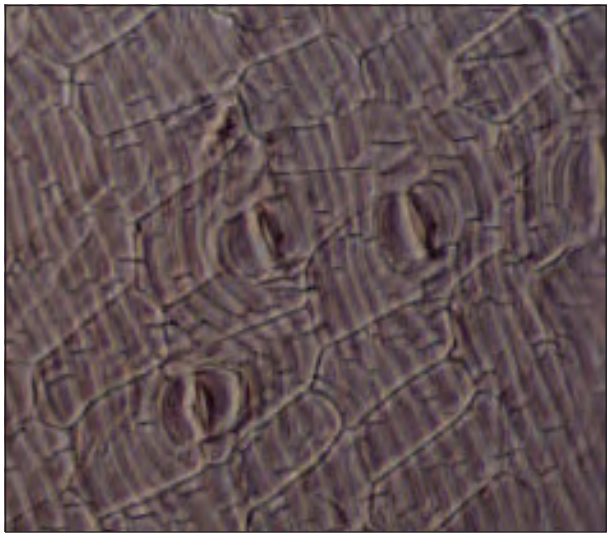

Figure 3. Microscopic analysis of dung: plant epithelium

Food availability: A total of 137, 1 km x 5 m transects were carried out in different regions of the study area. In order to compare the availability of food plants within and outside protected areas 26 of these transects were conducted in the Wilpattu National Park while the remaining 111 transects were carried out in various habitats outside the protected areas. The percentage occurrence of non cultivated plants that were eaten by elephants inside and outside the Wilpattu National park was determined based on the number of transects in which the plant was recorded relative to the total number of transects carried out. The percent occurrences of cultivated plants were not calculated, as they were not considered as naturally available food plants of elephants.

Results

A total of 116 plant species belonging to 35 families were eaten by elephants including 27 species of cultivated plants (see Table 5 for a detailed list of food plants). In many species they fed on bark alone. More than 25% of the plant species eaten by elephants belonged to family Fabaceae while 19% of the plant species belonged to family Poaceae (Fig. 4). Analysis of the habit of these food plants indicates that 53% of the plants are non tree species that can be classified as shrub, herb (including grass), or climbers (Table 2).

Microscopic analysis of dung showed that the monocot:dicot ratio in the food was highly variable within habitats as well as between habitats (Table 3). In 66% of the samples analyzed the amount of monocots was greater than dicots. Further, monocot:dicot ratio of different individuals within the same herd also showed a high degree of variability (Table 4).

Table 2. Distribution of the 116 food plant species according to the habit.

Habit	Number	%
Tree	47	41.2
Shrub	8	7.0
Herb	41	36.0
Climber	20	17.5

Availability of food plants indicated that out of 94 non crop plants eaten by elephants 67% were available in habitats outside protected areas, as opposed to 43% recorded in Wilpattu National Park (Table 5). Further when comparing food plants found both inside and outside protected areas, the percentage occurrence was higher outside the protected areas for all the plant species recorded.

Discussion and conclusions

Elephants that inhabit in the northwestern region can be defined as generalist in selection of food plants and feed on a wide variety of plants. Further, analysis of monocot:dicot ratio in diet showed that food plant selection by elephants is highly opportunistic as a high degree of variation in monocot:dicot ratio was observed both within and between habitats as well as within a given herd, even though they feed in close proximity to each other. These observations are in accordance with observations made in southeastern region of Sri Lanka (Mueller-Dombois 1972; McKay 1973; Ishwaran 1983; Wickramasinghe pers. com.). However, the overall composition of food plants was quite different from the southeastern region as only 33% of the food plants reported in southeastern region were recorded in this study (Table 5). This could be attributed to two reasons. The southwestern studies were done in protected areas (Gal Oya and Ruhunu national Parks) where there are no cultivated species, whereas in this study nearly 25% of the food plants are cultivated species. Second, this difference may have arisen due to differences in species distribution between the two regions.

Table 3. The average dicot:monocot ratios of dung collected from different regions of the study area (N indicates the number of dung samples analyzed per location).

Location	DS division	Habitat	N	Average dicot: monocot
Heeralugama	Galgamuwa	Scrub	18	0.412
Bulnewa	Galgamuwa	Scrub	4	0.133
Gojaragama	Galgamuwa	Scrub	3	1.493
Anderawewa	Galgamuwa	Forest	3	0.219
Siyambalawewa 1	Galgamuwa	Forest	3	0.320
Siyambalawewa 2	Galgamuwa	Forest	3	0.058
Amunukole	Galgamuwa	Scrub	3	1.724
Usgala	Galgamuwa	Forest	3	0.253
Thimbirigaswewa	Galgamuwa	Forest	16	1.440
19 Kanuwa	Karuwalagas wewa	Teak	3	0.022
Erabodugaswewa	Karuwalagas wewa	Forest	3	0.082
Maradankalla	Karuwalagas wewa	Scrub	3	2.556
Veheragala 1	Karuwalagas wewa	Forest	13	0.532
Veheragala 2	Karuwalagas wewa	Forest	3	0.118
Tammanwetiya	Nawagaththegama	Scrub	3	0.336
Turuwila	Tirappane	Teak	9	1.074
Rotawewa	Eppawala	Scrub	3	0.149
Rathmalwetiya	Eppawala	Scrub	3	0.459
Gammanwetiya	Giribawa	Scrub	3	0.370
Weweranwetiya	Giribawa	Scrub	3	3.627
Sangappaliya	Giribawa	Scrub	3	3.375
Nellikulama	Nuwaragam Palatha	Scrub	3	0.308

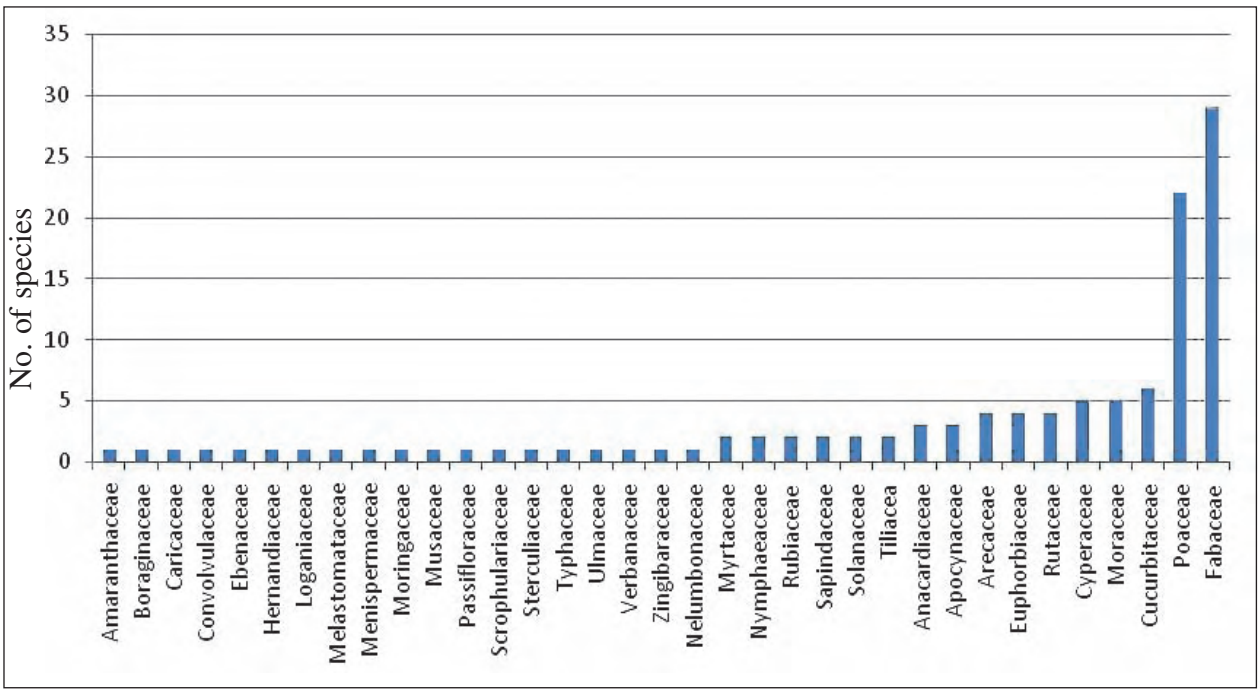

Figure 4. Distribution of food plants by taxonomic family.

Nearly 50% of the food plants of elephants belonged to the families Fabaceae and Poeaceae. This observation also agrees with observations reported in the Southwestern region. It was also observed that more than 50% of the Dicot food plants were non tree species. Further, even though a high degree of individual variation was observed in the monocot:dicot ratio in diet, in more than 66% of the samples analyzed composition was dominated by monocot, especially in juvenile elephants that tend to feed predominantly on grass species. Vancuylenberg (1977) shows that elephants are poor digesters as they can assimilate little over 50% of the food consumed. This is also evident in their dung as most of the plant matter is only partially digested. To compensate for this they consume as much as 150 kg of plant matter per day. Most perenial plant species produce toxins as a form of chemical defense against herbivory. Therefore, heavy reliance shown by elephants for non tree species could be an adaptation to avoid chemical toxin load as most of the non tree species invest less on chemical defense and instead rely heavily on physical defenses such as thorns and hairs.

It was further revealed that availability of food plants is greater in habitats outside protected areas. This could be attributed to the fact that majority of food plants are non tree species that are found in man modified habitats rather than climax vegetation that is likely to be found in the protected areas. Further, nearly 25% of the identified food plants are cultivated species, which indicates that elephants do supplement their diet with crop species. However, it should be noted that the presence of cultivated plants in dung does not result solely due to raiding of crops as it was observed that elephants feed on leftover crop plants in fallow chenas.

Table 4. The dicot:monocot ratios of different individuals of four different herds. Dung samples of different members of the herd were collected on the same date and place after homing and tracking the herd using a radio-collared elephant.

Location	1	2	3	4	5	6
Heeralugama	1.26	0.48	0.12	0.36	0.19	0.68
Thimbirigaswewa	1.90	1.78	0.47	1.70	2.57	
Veheragala	0.42	0.50	0.62			
Turuwila	1.96	0.83				

Table 5. Summary of all the plants observed to be eaten by elephants. Classification is based on Senaratne (2001). The plants were subdivided in to trees (T), shrubs (S), herbs (H) and climbers (C) and provided under the column, habit. The column designated as method indicates whether the plant was identified based on direct observations/ food trails (FT) or macroscopic/ microscopic analysis of dung (MA). The percentage occurrence was determined based on number of transects in which the plant was recorded relative to the total number of transects carried out (111 transects outside Wilpattu NP and 26 transects inside Wilpattu NP). Numbers in superscript indicate previous studies that have recorded the plant species as a food plant of elephants ([1]McKay 1973; [2]Ishwaran 1983; [3]Mueller-Dombois 1972).

Family	Scientific name	Vernacular name	Habit	Method	% occurrence	
					Out-side	Wil-pattu
Arecaceae	*Borassus flabellifer*	Tal	T	FT, MA	33	4
	Caryota urens	Kitul	T	FT	7	0
	Cocos nucifera	Pol	T	FT, MA	31	0
	Phoenix pusilla	Indi	T	FT, MA	34	9
Amaranthaceae	*Achyranthes aspera*	Gas Karalheba	H	FT	54	15
Anacardiaceae	*Anacardium occidentale*	Kadju	T	FT	8	0
	Lannea coromandelica	Hik	T	FT, MA	40	0
	Mangifera indica	Amba	T	FT, MA	16	0
Apocynaceae	*Carissa carandas*	Maha karamba	S	FT	1	4
	Carissa spinarum[1,2,3]	Heen Karamba	S	FT, MA	41	23
	Ichnocarpus frutescens	Kiriwel	C	FT, MA	40	16
Boraginaceae	*Cordia monoica*[1,3]	Lolu	T	FT, MA	25	12
Caricaceae	*Carica papaya*	Pepol	T	FT	-	-
Convolvulaceae	*Ipomoea aquatica*[1]	Kankun	C	FT	36	12
Cucurbitaceae	*Benincasa hispida*	Alu puhul	C	FT, MA	-	-
	Citrullus colocynthis	Yak komadu	C	FT	-	-
	Citrullus lanatus	Komadu	C	FT	-	-
	Cucumis melo	Kekiri	C	FT, MA	-	-
	Cucurbita maxima	Wattaka	C	MA	-	-
	Lagenaria siceraria	Diya labu	C	MA	-	-
Cyperaceae	*Actinoscirpus grossus*	Thun hiria	H	FT	10	8
	Cyperus haspan[1]	Hal pan	H	FT	74	59
	Cyperus pilosus[1]	Thunessa	H	FT	76	55
	Cyperus rotundus[1]	Kalanduru	H	FT, MA	78	58
	Fimbristylis miliacea	Mudu hal pan	H	FT	78	73
Ebenaceae	*Maba buxifolia*[1,3]	Kaluwara	T	MA	0	0
Euphorbiaceae	*Drypetes gardneri*	Eta wira	T	MA	0	0
	Manihot glaziovii	Gas manyokka	T	FT	-	-
	Manihot esculenta	Manyokka	S	FT	-	-
	Phyllanthus polyphyllus[1,2]	Kuratiya	T	FT	44	15
Fabaceae	*Acacia leucophloea*	Maha andara	T	MA	25	0
	Acacia pennata	Goda hinguru	C	FT	15	0
	Aeschynomene indica	Diya siyambala	H	FT, MA	15	8
	Albizia amara	Eaha	T	FT, MA	0	0
	Albizia lebbeck	Siriya mara	T	FT, MA	23	4
	Albizia odoratissima	Huri mara	T	FT, MA	0	0
	Albizia saman	Pare mara	T	FT, MA	0	0
	Alysicarpus vaginalis	Aswenna	H	FT, MA	0	0

Family	Scientific name	Vernacular name	Habit	Method	% occurrence	
					Out-side	Wil-pattu
	Arachis hypogaea	Rata kadju	H	FT	-	-
	Atylosia scarabaeoides	Wal kollu	C	FT, MA	0	0
	Bauhinia racemosa[1,3]	Maila	T	FT, MA	76	0
	Cassia siamea	Wa	T	FT	0	0
	Cassia tora	Peti tora	S	FT	63	23
	Clitoria ternatea	Katarodu	C	FT, MA	22	23
	Dalbergia lanceolaria	Bol mara	T	FT	0	0
	Derris scandens[2,3]	Bokalawel	C	FT, MA	59	39
	Derris trifoliata[2,3]	Kalawel	C	FT, MA	1	0
	Dichrostachys cinerea[1,3]	Andara	S	FT, MA	63	0
	Indigofera tinctoria	Nil awari	H	FT, MA	0	0
	Leucaena leucocephala	Ipil ipil	T	FT	42	0
	Macrotyloma biflorus	Kollu	C	FT	-	-
	Mimosa pudica[1]	Nidikumba	H	FT, MA	76	12
	Pongamia pinnata	Karanda	T	FT	58	19
	Tamarindus indica	Siyambala	T	FT, MA	40	23
	Tephrosia purpurea	Pila	H	FT	67	31
	Vigna marina	Me karal	C	FT, MA	-	-
	Vigna mungo	Undu	H	FT	-	-
	Vigna radiata	Mung	H	FT	-	-
	Vigna unguiculata	Cowpea	C	FT, MA	-	-
Hernandiaceae	*Hernandia nymphaeifolia*	Palatu	T	MA	0	0
Loganiaceae	*Strychnos nux-vomica*[1,2]	Goda kaduru	T	FT, MA	30	4
Melastomataceae	*Memecylon rostratum*[1,2]	Kuratiya	T	MA	0	0
Menispermaceae	*Cissampelos pareira*	Diyamittha	C	FT	0	0
Moraceae	*Artocarpus heterophyllus*	Kos	T	FT, MA	10	0
	Ficus benghalensis[1]	Mah nuga	T	FT	15	4
	Ficus racemosa[1]	Attikka	T	FT, MA	22	0
	Ficus religiosa[1]	Bo	T	FT	24	0
	Ficus virens[1]	Ahetu	T	FT	0	0
Moringaceae	*Moringa oleifera*	Murunga	T	FT	6	0
Musaceae	*Musa paradisiaca*[1]	Kesel	T	FT, MA	-	-
Myrtaceae	*Syncarpia glomerulifera*	Terpentine	T	MA	5	0
	Syzygium gardneri[1,2]	Damba	T	MA	0	0
Nelumbonaceae	*Nelumbo nucifera*	Nelum	H	MA	25	12
Nymphaeaceae	*Nymphaea nouchali*	Manel	H	MA	3	0
	Nymphaea pubescens	Olu	H	FT, MA	35	23
Passifloraceae	*Passiflora fitida*	Dal batu	C	FT, MA	47	0
Poaceae	*Cymbopogon nardus*	Heen pengiri	S	MA	13	0
	Dactyloctenium aegyptium	Putu tana	H	FT	0	0
	Echinochloa colona	Gira tana	H	FT, MA	0	0
	Echinochloa crusgalli	Wel-marakku	H	FT	0	0
	Eleusine coracana	Kurahan	H	FT, MA	-	-
	Eleusine indica[1]	Bela-tana	H	FT, MA	0	0
	Eragrostis unioloides[1]		H	FT	0	0
	Imperata cylindrica[1]	Illuk	H	FT, MA	10	0

Family	Scientific name	Vernacular name	Habit	Method	% occurrence	
					Out-side	Wil-pattu
	Isachne globosa	Batadella	H	FT	0	0
	Ischaemum rugosum[1]	Kudu kedu	H	FT	0	0
	Ischaemum timorense	Rila rat tana	H	FT	0	0
	Leersia hexandra	Layu	H	FT	0	0
	Oryza sativa[1]	Wee	H	FT, MA	-	-
	Panicum curviflorum	Meneri-thana	H	MA	0	0
	Panicum maximum	Guinea tana	H	FT, MA	49	0
	Panicum miliaceum	Meneri	H	FT. MA	-	-
	Panicum repens[1]	Etora	H	FT, MA	0	0
	Paspalum conjugatum[1]		H	FT	0	0
	Paspalum scrobiculatum[1]	Wal-amu	H	FT	0	0
	Pennisetum spicatum	Bajiri	H	MA	0	0
	Sacciolepis indica		H	FT	0	0
	Zea mays	Bada iringu	H	FT, MA	-	-
Rubiaceae	*Mitragyna parviflora*[3]	Helamba	T	FT, MA	63	35
	Morinda umbellata	Kiriwel	C	MA	25	8
Rutaceae	*Limonia acidissima*[1,3]	Diwul	T	FT, MA	42	46
	Micromelum minutum	Wal karapincha	T	FT	12	8
	Murraya koenigii[3]	Karapincha	T	FT, MA	20	4
	Pleiospermum alatum[1,3]	Tunpath kurundu	T	FT, MA	15	4
Sapindaceae	*Lepisanthes tetraphylla*[1,2]	Dambu	T	FT	52	9
	Schleichera oleosa[3]	Kon	T	MA	59	12
Scrophulariaceae	*Bacopa monnieri*	Lunuwila	H	FT	13	23
Solanaceae	*Capsicum annum*	Miris	H	FT, MA	-	-
	Solanum melongena	Ela batu	H	FT, MA	-	-
Sterculiaceae	*Pterosperomum suberifolium1*	Welan	T	FT	18	4
Tiliacea	*Grewia orientalis*[1,2]	Keliya	S	FT	80	16
	Grewia helicterifolia1	Bora damaniya	T	FT, MA	22	8
Typhaceae	*Typha angustifolia*	Hambu pan	S	FT	47	8
Ulmaceae	*Trema orientalis*	Gadumba	T	FT	22	0
Verbanaceae	*Tectona grandis*	Thekka	T	FT	16	0
Zingibaraceae	*Alpinia calcarata*	Katukiriwel	C	MA	0	0

Therefore it can be concluded that food is not a limiting factor for elephants that live outside the protected areas. However, the habitat patches that contain these food plants are small and scattered and as a result elephants have to extend their range to satisfy their dietary requirements. This would invariably bring them into conflict with man which is the main constraint in conserving these elephants.

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