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Fodder plants and foraging behaviour of Asian elephants in Srivilliputhur Elephant Reserve, Tamil Nadu, India

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The Srivilliputhur Elephant Reserve is one of India's 32 elephant reserves. It is home to wild elephants as well as other wildlife. This study aims to document the fodder plants and foraging behaviour of elephants in the Srivilliputhur Elephant Reserve. Elephants in the Srivilliputhur Elephant Reserve consumed 61 plant species from 25 different families. In the current study, the majority of the fodder plants of Asian Elephants belonged to the families of Fabaceae, Poaceae, and Malvaceae. Elephants were found to feed more frequently on trees (66%), followed by shrubs (16%), herbs (9%), and climbers (6%). It was observed that the elephants ate both the browsing tree and grazing grass species during the wet season, but browsing tree species dominated during the dry season.

Keywords: Elephant, Feeding behaviour, Fodder Plants, Srivilliputhur Elephant Reserve.

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Introduction

The International Union for Conservation of Nature (IUCN) lists extant Asian elephants (*Elephas maximus*) as endangered whereas African savanna (*Loxodonta africana*) and forest (*L. cyclotis*) elephant species as vulnerable[1]. The population of Asian elephants has estimated at 41,410 to 52,345 individuals scattered among fragmented habitats in 13 range countries in Asia, and currently occupying 5% of their historic geographic range[2]. India holds the largest population of Asian elephants (60% of the total population)[3]. The habitat of the Asian elephant (*Elephas maximus*) has been decreasing throughout their range due to habitat destruction and fragmentation resulting from human land use practices[4]. Even though elephant population has decreased, in general, the local density of elephants has increased due to habitat loss[5,6]. This has caused resource competition among the elephants and increased human-elephant conflict[7].

Elephants are long-lived animals and their survival depends upon regular migration over long distances to search for food, water, and social and reproductive partners[8,9]. As a generalist mega-herbivore, elephants consume a maximum of 150 kg of forage and 190 L of water daily[8]. Studies on the home ranges of Asian elephants have been carried out in India. These indicate home-range sizes of 250–1000 km^2 for family herds in Indian populations[10].

Elephant diet is variable depending on habitat, geographic region, season, and availability. Elephants are generalist feeders that consume whatever is available, but they can be very particular about which sections of a plant they eat and when they eat them[11]. Within their area of distribution, elephants eat a wide variety of plants and plant parts, ranging from grasses to the tree and plant parts such as leaves, branches, roots, seedlings, vines, flowers, stems, and fruits depending on seasonal availability[12]. Elephants spend 12–18 h a day feeding during which they can consume up to 10% of their body mass as fresh mass fodder[13]. Their dietary composition is also highly variable on a local scale within a geographic region[14]. Their food selection is influenced by factors such as nutrient requirements and plant palatability, texture, and phenophase[8].

Studies in India, China, Nepal, Sri Lanka, and Myanmar have demonstrated that elephants consume a diverse array of fodder[2,14-16] and studies in Thailand have detailed the limited diet of captive elephants[17]. Numerous studies on the food plants of African and Asian elephants have shown that the proportions of various plant species in the diet vary widely from one region to another. The documentation of food plant species, the rate of consumption, and seasonal diet are

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important for Asian elephant conservation in terms of habitat management and human-elephant conflict mitigation. Relatively only a few studies have been carried out in India on the food and feeding patterns of the elephants[8,13,18]. Researchers have found strong correlations between the loss of Asian elephants and reduced dispersal and survival of seeds for large fruiting trees in protected areas (PA) in India, indicating an engineering influence of elephants on forested ecosystems in Asia[19,20]. Study on Asian elephants in Srivilliputthur Elephant Reserve, Tamil Nadu (India) has not been done on the food and feeding patterns. Hence, in this present study, the authors have documented the elephants' fodder plant species and their seasonal preference in the Srivilliputhur Elephant Reserve, which is one of India's 32 elephant reserves[21].

Materials and Methods

Study area

The Srivilliputhur Elephant Reserve, located in Srivilliputhur, Tamil Nadu, occupies an area of 480 km^2 and is bordered on the south by the Periyar Tiger Reserve, on the north by the Megamalai Reserve Forest, and on the south by the Sivagiri Reserved Forest. It receives both southwest and northeast monsoon. This Elephant Reserve has diverse habitats and topographic environments that create a notable diversity of flora and fauna. Resident and migrating elephants are common in this Elephant Reserve. At present there were 150 Elephants in this reserve[21].

Data collection

The feeding habits of elephants were observed by frequent visits (nearly 15 days per month) to the study area from August 2019 to February 2021. Elephant feeding behaviour was documented by following the methods of Samansiri and Weerakoon[4].

Food trails

Herds of elephants were tracked using field binoculars from a safe distance along with the forest guards and tribal people. After observing the feeding of elephants, the plants showing the signs of being fed by elephants and the part(s) of the plant eaten were recorded. In addition, a herbarium specimen, leaf sample, 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.

Macroscopic analysis of dung

A total of 50 dung boli were collected from different parts of the study area. The bolus was separated by hand and all identifiable parts were removed. These parts were identified by comparing them with the reference collection of plant seeds and plant parts constructed during food trails.

The following data were recorded in a note to determine the feeding preferences of Asian elephants: i) plant species browsed, ii) parts of the plant eaten (leaves, branches, and/or bark), iii) habit type, and iv) local name and seasonal availability.

All the collected plants/plant parts were identified by using the standard literature such as Floras of Madras Presidency[22]; Further Illustrations on the Flora of the Tamil Nadu and Carnatic[23-25]; Flora of Tamil Nadu, India[26]; Flora of Tamil Nadu, India[27,28] and Legumes of India[29]. Using The Plant List[30] and the newly launched Plants of the World Online[31] correct accepted botanical names for the species identified were reviewed.

Results and Discussion

In the present study, a total of 61 plant species belonging to 25 families were documented as feed/fodder plants of the Asian elephants of Srivilliputhur Elephant Reserve (Table 1). In a similar study, Sukumar[32] documented that 112 plant species were used as food plants by the elephants of southern India. Chen *et al.*[15] reported that 106 plant species were being eaten by Asian elephants in the Shangyong National Natural Reserve located at

Table 1 — List of plant species consumed by elephants of Srivilliputhur Elephant Reserve

Family	Plant species (Voucher specimen no.)	Local lexicon	Habit	Parts consumed	Seasonal availability
Amaranthaceae	*Achyranthes aspera* L. (VOCC-VP 01)	Nayuruvi	Herb	Whole plant	Wet and Dry season
	Aerva lanata (L.) Juss. (VOCC-VP 02)	Kanupoolachedi	Herb	Whole plant	Wet season
Anacardiaceae	*Mangifera indica* L. (VOCC-VP 03)	Mamaram	Tree	Twigs, Fruits	Wet and Dry season

(*Contd*.)

Table 1 — List of plant species consumed by elephants of Srivilliputhur Elephant Reserve — (*Contd*.)

Family	Plant species (Voucher specimen no.)	Local lexicon	Habit	Parts consumed	Seasonal availability
Apocynaceae	*Ichnocarpus frutescens* (L.) W. T. Aiton (VOCC-VP 04)	Udhharkodi	Climber	Leaves	Wet season
	Wrightia tinctoria R. Br (VOCC-VP 05)	Veppalai	Tree	Twigs	Dry season
Arecaceae	*Phoenix sylvestris* (L.) Roxb. (VOCC-VP 06)	Echamaram	Tree	Twigs	Dry season
Capparaceae	*Crateva adansonii* DC. (VOCC-VP 07)	Mavulingamaram	Tree	Twigs	Wet and Dry season
Combretaceae	*Anogeissus latifolia* (Roxb. ex DC.) Wall. Ex Guillem. & Perr. (VOCC-VP 08)	Vekkalimaram	Tree	Twigs, Bark	Wet and Dry season
	Terminalia arjuna (Roxb. ex DC.) Wight & Arn. (VOCC-VP 09)	Marudhamaram	Tree	Twigs	Wet and Dry season
	Terminalia bellirica (Gaertn.) Roxb. (VOCC-VP 10)	Thandrimaram	Tree	Twigs	Wet and Dry season
	Terminalia chebula Retz. (VOCC-VP 11)	Kadukaimaram	Tree	Twigs	Wet and Dry season
Dipterocarpaceae	*Shorea roxburghii* G. Don (VOCC-VP 12)	Kungulium	Tree	Twigs	Wet and Dry season
Elaecarpaceae	*Elaeocarpus robustus* Roxb. (VOCC-VP 13)	Kotlampalammaram	Tree	Twigs, Fruits	Wet season
Fabaceae	*Albizia amara* L. (VOCC-VP 14)	Usilaimaram	Tree	Twigs	Dry season
	Albizia lebbeck L. (VOCC-VP 15)	Vagaimaram	Tree	Twigs, Bark	Wet and Dry season
	Acacia caesia (L.) Willd. (VOCC-VP 16)	Indu	Shrub	Twigs	Wet and Dry season
	Bauhinia racemosa Vahl. (VOCC-VP 17)	Aathimaram	Tree	Twigs	Wet and Dry season
	Cassia tora L. (VOCC-VP 18)	Thagarai	Shrub	Twigs, Flowers	Wet season
	Clitoria ternatea L. (VOCC-VP 19)	Sangoopoo	Herb	Whole plant	Wet season
	Dichrostachys cinerea (L.) Wight & Arn. (VOCC-VP 20)	Vidathalaii	Tree	Twigs, Fruit	Dry season
	Mimosa pudica L. (VOCC-VP 21)	Thottalvanagi	Herb	Whole plant	Wet season
	Pongamia pinnata (L.) Pierre (VOCC-VP 22)	Pungamaram	Tree	Twigs	Wet and Dry season
	Pterocarpus marsupium Roxb. (VOCC-VP 23)	Vengaimaram	Tree	Twigs, Bark	Wet and Dry season
	Tamarindus indica L. (VOCC-VP 24)	Puliamaram	Tree	Twigs	Wet and Dry season
Lamiaceae	*Tectona grandis* L. f. (VOCC-VP 25)	Thekkumaram	Tree	Twigs, Flower	Wet and Dry season
	Vitex altissima L. f. (VOCC-VP 26)	Mayiladunkurinchi	Tree	Twigs	Wet and Dry season
Loganiaceae	*Strychnos nux – vomica* (VOCC-VP 27)	Yettimaaram	Tree	Twigs, Fruits	Wet and Dry season
Malvaceae	*Abutilon indicum* (L.) Sweet (VOCC-VP 28)	Thuthi	Shrub	Whole plant	Wet and Dry season
	Bombax ceiba L. (VOCC-VP 29)	Ilavampanjumaram	Tree	Twigs	Wet and Dry season

(*Contd*.)

Table 1 — List of plant species consumed by elephants of Srivilliputhur Elephant Reserve — (*Contd*.)

Family	Plant species (Voucher specimen no.)	Local lexicon	Habit	Parts consumed	Seasonal availability
	Helicteres isora L. (VOCC-VP 30)	Valampurikai	Shrub	Twigs, Fruit	Wet season
	Grewia flavescens Juss. (VOCC-VP 31)	Manchaacchumaram	Tree	Twigs, Fruits	Wet and Dry season
	Grewia oppositifolia Roxb. ex DC. (VOCC-VP 32)	Vellaiachu	Shrub	Twigs, Fruits	Wet and Dry season
	Sida cordifolia L. (VOCC-VP 33)	Kurunthotti	Shrub	Whole plant	Wet season
Menispermaceae	*Cissampelos pareira* L. (VOCC-VP 34)	Vattathiruppi	Climber	Leaves	Wet season
	Tinospora cordifolia (Willd.) Miers (VOCC-VP 35)	Seenthilkodi	Climber	Leaves	Wet season
Moraceae	*Ficus benghalensis* L. (VOCC-VP 36)	Aalamaram	Tree	Twigs	Wet and Dry season
	Ficus glomerata Roxb. (VOCC-VP 37)	Athipalammaram	Tree	Twigs, Fruits	Wet and Dry season
	Ficus religiosa L. (VOCC-VP 38)	Arasamaram	Tree	Twigs	Wet and Dry season
Myrtaceae	*Syzygium cumini* (L.) Skeels (VOCC-VP 39)	Navalmaram	Tree	Twigs, Fruits	Wet and Dry season
Phyllanthaceae	*Emblica officinalis* L. (VOCC-VP 40)	Nellimaram	Tree	Twigs, Fruits	Wet and Dry season
Poaceae	*Bambusa vulgaris* Schrad. (VOCC-VP 41)	Moongil	Tree	Twigs	Wet and Dry season
	Cynodon dactylon (L.) Pers. (VOCC-VP 42)	Arukampul	Herb	Whole plant	Wet and Dry season
	Cymbopogon citratus L. (VOCC-VP 43)	Elumichaipul	Herb	Whole plant	Wet and Dry season
	Imperata cylindrica (L.) Raeusch (VOCC-VP 44)	Nanal	Shrub	Whole plant	Wet season
	Saccharum spontaneum L. (VOCC-VP 45)	Tharagupul	Shrub	Whole plant	Wet season
Rhamnaceae	*Ziziphus mauritiana* Lam. (VOCC-VP 46)	Ilanthaimaram	Tree	Twigs, Fruits	Wet and Dry season
	Ziziphus oenopolia (L.) Mill. (VOCC-VP 47)	Soorapalam	Tree	Twigs, Fruits	Wet and Dry season
	Ziziphus rugosa Lam. (VOCC-VP 48)	Kaatuilanthai	Tree	Twigs, Fruits	Wet and Dry season
	Ziziphus xylopyrus (Retz.) Willd. (VOCC-VP 49)	Mullukottan	Shrub	Twigs, Fruits	Wet and Dry season
Rubiaceae	*Haldina cordifolia* (Roxb.) Ridsdale (VOCC-VP 50)	Manjakadambu	Tree	Twigs	Wet and Dry season
	Morinda umbellata L. (VOCC-VP 51)	Nuna	Climber	Leaves, Fruits	Wet season
	Tarenna asiatica L. (VOCC-VP 52)	Thirani	Shrub	Twigs, Fruits	Wet season
Rutaceae	*Aegle marmelos* (L.) Correa (VOCC-VP 53)	Vilvam	Tree	Twigs, Fruits	Wet and Dry season
	Atalantia monophylla L. (VOCC-VP 54)	Kattuelumichai	Tree	Twigs, Fruits	Wet and Dry season
	Chloroxylon swietenia DC. (VOCC-VP 55)	Vaivumaram	Tree	Bark	Wet and Dry season
	Limonia acidissima Groff. (VOCC-VP 56)	Vilampalam	Tree	Twigs, Fruits	Wet and Dry season
	Murraya koenigii (L.) Spreng (VOCC-VP 57)	Karuveppillai	Tree	Twigs	Wet and Dry season

(*Contd*.)

Table 1 — List of plant species consumed by elephants of Srivilliputhur Elephant Reserve — (*Contd*.)

Family	Plant species (Voucher specimen no.)	Local lexicon	Habit	Parts consumed	Seasonal availability
Sapindaceae	*Sapindus emarginatus* Vahl. (VOCC-VP 58)	Poondhikottaimaram	Tree	Twigs, Fruits	Wet and Dry season
Sapotaceae	*Madhuca longifolia* (J. Koenig ex L.) J. F. Macbr. (VOCC-VP 59)	Iluppaimaram	Tree	Twigs, Fruits	Wet and Dry season
	Mimusops elengi L. (VOCC-VP 60)	Mahilamaram	Tree	Twigs	Wet and Dry season
Smilaceae	*Smilax zeylanica* L. (VOCC-VP 61)	Kalthamarai	Climber	Leaves	Wet season

Dry season - June to September; Wet season - October to December

Xishuangbanna, China. Alahakoon *et al.*[33] reported 63 elephant fodder plants in Udawalawe National Park, Sri Lanka. Divergent results may be attributable to discrepancies in sample methodology, differences in forest state (disturbed versus undisturbed), composition, and sampling area.

In the study area, during the dry season, most of the fodder plant species dry up and die, except the grasses and shrubs along the reservoir bed, which elephants use frequently. Besides, during the dry season, the highest number of elephants was seen near the reservoir beds than in other habitats. During the dry season, the elephants feed on plants like *Achyranthes aspera*, *Cynodon dactylon*, *Cymbogan citratus*, *Dichrostachys cinerea*, *Phoenix sylvestris*, and *Wrightia tinctoria*. Weerakoon *et al*.[34] state that the preferred habitats of Asian elephants are grassland and scrublands, which is supported by the findings of the current study. Elephants also seemed to feed more frequently on seasonal vegetation in the reservoir bed in the driest periods of the year, making it an important resource during the dry period. Natumi *et al*.[35] state that the habitat use of elephants is mostly influenced by vegetation biomass, vegetation cover, and water availability. All these needs seem to be fulfilled within the Srivilliputhur Elephant Reserve throughout the year; hence elephants are seen year-round at Srivilliputhur Elephant Reserve.

During extreme dry seasons, the grasses become sparse; the Asian elephants of the Srivilliputhur reserve forest shifted their grazing behaviour to browsing because more tree species were present in the study region. It was also observed that elephants ate both the browsing tree species and grazing grass species during the wet season, but browsing dominated during the dry season. Previous studies have indicated that during the wet season elephants' diet is dominated by grasses while browse dominates it in the dry season only if new grass is unavailable[4,12,18,36-38].

Elephants were found to feed more frequently on trees (66%), followed by shrubs (16%), herbs (9%), and climbers (6%). In the present study, *Albizia amara*, *A. lebbeck*, *Bauhinia racemosa*, *Pterocarpus marsupium*, *Vitex altissima*, and *Mimusops elengi* were the most consumed tree species. When the elephants fed on trees, they mostly ate the bark and stem. In the present investigation, it was observed that the *Anogeissus latifolia*, *A. lebbeck*, *Chloroxylon swietenia*, *Pterocarpus marsupium*, and *Tectona grandis* bark were consumed regularly by the elephants. Elephants' consumption of bark from various tree species may be related to macronutrient balancing as well as obtaining moisture and mineral supplements that are often unavailable during the dry season[12]. The current study supports the findings of Pradhan *et al*.[36] from Bardia National Park in Nepal, where bark consumption dominated the elephant diet during the dry season.

A few plant species (14%) were consumed as a whole, including Abutilon indicum, Achyranthes aspera, Aerva lanata, Clitoria terneata, Cynodon dactylon, Cympogan citratus, Imperata cylindrical, Mimosa pudica, and Sida cordifolia. In the current study, the majority of the fodder plants of Asian Elephants belong to the family Fabaceae, Poaceae and Malvaceae. It is similar to the study of Sukumar[2] who reported that 85% of the elephant's diet consisted of plant species from the families Fabaceae and Poaceae.

The Asian elephant is listed as Endangered by IUCN[1] and appears in Appendix 1 of CITES (Convention on International Trade of Endangered Species of Wild Fauna and Flora). There is little evidence that Asian elephants serve as a keystone species in Asia's seasonally dry tropical forests. There is evidence that habitat availability is more important

in retaining elephants than is a protection status for wildlife[39], particularly where the latter is poorly applied. In the present study, it was noted that local residents, *Paliyar* tribals, were unaware of the ecological importance of elephants and their role in sustaining the forest ecosystem. Therefore, it is necessary to improve the conservation attitudes of local residents by making them aware of the ecosystem services rendered by elephants such as seed dispersal and ultimately the existence of forest ecosystems.

Conclusion

The current study provides baseline information about different types of natural food available in the Srivilliputhur Elephant Reserve, located in Srivilliputhur, Tamil Nadu, and their relative importance in the diets of elephants in and around the Srivilliputhur Elephant Reserve. This information is important for realising successful outcomes for the conservation of Asian elephants and improved seasonal management for the long-term protection of this endangered species and its shrinking habitat.

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Conflict of interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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