PREDICTION OF FORAGE SPECIES FOR MEGAHERBIVORE (*ELEPHAS MAXIMUS*) IN COIMBATORE ELEPHANT RESERVE (CER) AT THE FOOTHILLS OF WESTERN GHATS, TAMIL NADU, INDIA

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Abstract. Coimbatore Reserve Forest forms an integral and important part of the Nilgiri Biosphere Reserve, India. The forest areas in the Mettupalayam range and Sirumugai range of Coimbatore Forest Division were selected as study areas. It was approached in a systematic-random sampling method. Two methods *viz.*, i) transact line survey method and ii) sample plot method, were used to document the native fodder species in the study area. Totally, 128 sample plots with the size of 20 x 20 m and 17 transact line surveys at 0.2% sampling intensity were used. Based on the survey, 25 fodder tree species were documented; Fabaceae is the most dominant family with 12 species. In diversity analysis, S IV showed higher tree fodder diversity in terms of Simpson D (0.69), Shannon H index (2.72) and evenness index (0.44). With respect to the grass density, the maximum grass density was observed in *Oplismenus burmannii* followed by *Dichanthium aristatum* and *Enteropogon monostachyus* which is due to geographical condition of the Coimbatore Elephant Reserve.
Keywords: *elephant, feeding behavior, fodder trees, fodder grass, diversity*

Introduction

Coimbatore Reserve Forest forms an integral part of the Nilgiris Biosphere Reserve (NBR). It covers an area of about 4662.45 sq.km, and it is recognized as the largest elephant reserve by area among the four elephant reserves of Tamil Nadu. It is one of the thirty-two elephant reserves in India and it is part of the elephant reserve project no. 8 (Ramkumar, 2014). According to the 2017 census, the elephant population was 2,761 in Tamil Nadu (WWF, 2017), supporting a significant population of elephants owing to its diverse climatic conditions and availability of food and water. Elephants play a major role as intruders in the Coimbatore Forest division, where the populations of the Eastern and Western Ghats are connected (Kannan, 2016). The forests of this division in certain places *viz.*, Jaccanari-vedar colony, Kallar-Jakanari, Kallar-Nellithurai, Aanaikatti-Veerapandi, Marudamalai-Thanikandy, Kalkothi-Walayar serve as an important migratory corridor for the animal population in the NBR as a whole, especially for elephants (Kannan, 2016; Menon, 2019). More than 20% of the reserve forest area serves as a potential corridor for elephant movement between Silent Valley National Park (Western Ghats, Kerala) and the Eastern Ghats (Sivaganesan et al., 2000).

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Due to the escarpment of steep slopes on the west and human habitations on the east, elephant migration in the CFD is typically confined to the foothills. In India, with gradually fragmented wildlife corridors, the existence and future of large home-range species like elephants are under threat (Ramkumar et al., 2017). As the eastern boundary of the CFD is shared with human habitations and agriculture grounds for approximately 350 kilometers, elephants are attracted to the agricultural crops found in the village fringes adjacent to the forest boundaries. Human-elephant conflict is at a higher level in CFD compared to other highly populated elephant habitats in South India (Ramkumar et al., 2014a).

Elephants are mega herbivores and generalist foragers with a diverse diet consisting of grasses, forbes, fruits, bark, leaves, twigs and roots (Raman Sukumar et al., 2003). Owing to the unique morphology and physiology that accompany their enormous body size; energy intake by elephants is high, but it is constrained by their rate of forage quality (Wilmshurst et al., 2000). The elephant consumes large amount of food, estimated to be 1.5-2.5 percent of its body weight in dry weight fodder (Gubbi et al., 2014). Elephants in southern India are reported to intake heavy graminoids during the wet season (Sukumar, 2006) and their diet includes 84.6% of grasses (Baskaran et al., 2010). To meet their fodder requirements, elephants move around 40 to 50 km and they fix their home range and follow these fixed routes every year in the same season. Foraging is a major factor in elephant movement and habitat selection. Unfortunately, there is a limitation of required fodder species in the forest territory area. For this reason, elephants have moved out of the habitat area to meet their fodder requirements. Due to this enormous need for food, the elephant cannot afford to be a selective feeder. Habitat management is one of the most significant concerns for elephant conservation in the CFD and it can be achieved through improved management practices by introducing fodder species. Henceforth, a deep understanding of the energetic properties of the food plants consumed by elephants is essential to comprehend the feeding pattern and the selection of fodder plants by Asian elephants (Wood et al., 2019). With this background, the present study has been conceived to explore the food spectrum and seasonal diet composition of elephants. In terms of habitat management and human-elephant conflict mitigation, such information is crucial for the conservation of Asian elephants.

Materials and Methods

Study area

The present study was conducted in Mettupalayam and Sirumugai ranges of Coimbatore Forest Division, Western Ghats, Tamil Nadu, India during April 2021-April 2022. The area falls between 10°37'and 11°31' North latitudes and 76°39'and 77°5' East longitudes. A greater part of the division is situated southwards in the Western Ghats with the north-western parts forming the lower ranges of the Nilgiris. An elephant habitat area represents 20000 ha of the study area. It was approached in a systematic random sampling method by following two methods *viz.*, 1) Transect line survey method and 2) Sample plot method which were used to document the native fodder species. Plots were laid out in 6 beats of Mettupalayam and Sirumugai ranges *viz.*, Jaccanari (site I), Sundapatti (site II), Nellimalai (site III), Hulikal (site IV), Kandiyur (site V), Kallar (site VI), Odanthurai (site VII), Kunjapanai (site VIII), Pethikuttai (site

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IX), Koothamundi north (site X), Koothamundi south (site XI) and Uliyur (site XII) and their forest types are classified as per Champion and Seth (1968) (*Table 1*).

Table 1. *Details of Forest type, Elevation and Geo referencing point of CER*

Range	Beat	Forest Type	E	GPS
Mettupalayam	Jaccanari (S I)	Southern thorn and Semi-Evergreen	350- 560 msl	11°20'15.40"N 76°56'11.24"E
	Sundapatti (S II)	Dry deciduous forest & Semi- Evergreen	350-500msll	11°18'1.24"N 76°54'39.34"E
	Nellimalai (S III)	Dry deciduous	300- 400 msl	11°16'46.51"N 76°53'1.95"E
	Hulical (S IV)	Moist deciduous	350-1100 msl	11°18'47.23"N 76°52'51.43"E
	Kandiyur (S V)	Dry deciduous	350-600 msl	11°16'18.49"N 76°52'47.58"E
	Kallar (S VI)	Dry deciduous	600-1042 msl	11°20'27.18"N 76°52'57.34"E
Sirumugai	Odanthurai (S VII)	Southern thorn	300-390 msl	11°19'11.05"N 76°55'50.27"E
	Kunjapanai (S VIII)	Moist deciduous, Semi-Evergreen and Phoenix Savannah	1000-1100 msl	11°21'30.21"N 76°55'48.06"E
	Pethikuttai (S IX)	Dry deciduous	280-350 msl	11°20'54.57"N 77° 2'0.10"E
	K. North (S X)	Southern thorn	300-350 msl	11°25'15.44"N 77° 2'3.44"E
	K. South (S XI)	Southern thorn	2800-310 msl	11°24'29.79"N 77° 0'26.16"E
	Uliyur (S XII)	Moist deciduous & Semi-Evergreen	300-350 msl	11°23'32.64"N 77° 0'2.80"E

Prediction of floral diversity

Transact lines of 2 km length were marked in the study area for exploration and documentation of fodder trees and fodder grass. The size and number of sample plots were determined using the species effort curve technique (Misra, 1968; Daniels et al., 1996). Based on the species effort curve, sample plot (Quadrat) size of 20 x 20 m was placed and systematically surveyed for all trees. Sample plots were done in the opposite direction and the distance between the sample plots were fixed as 200 m and 50 m distance from the transact line (*Fig. 1*). A sampling intensity of 0.2% was used. A total of 128 sample plots and 17 transact lines were laid out in the study area. The frequency of observation was taken twice *viz.*, summer and rainy season during the study period. The same species were recorded during the second survey. Data were collected based on the plant species that showed evidence of elephant browsing such as i) debarkation, branch breakage and uprooting, ii) footprints and iii) fresh dung heaps alongside browsed foliage. The following information was gathered to assess the elephant food spectrum: (1) plant species browsed and (2) plant components consumed (leaves, branches, and/or bark). In each plot, dbh (diameter at breast height; 1.3 m above the ground) and height of all the trees having dbh ≥ 10 cm were recorded. For fodder grass, 1sq.m bamboo frame was randomly placed and the density of grass species was recorded in percentage (DeVos and Mosby, 1971) and their GPS points were recorded

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by using Gramin 60 version GPS. By using the geo referencing point the transact lines and sample plots were marked on the Google Earth Map by using Google Earth Pro software, version 7.3 (*Fig. 2*). All the trees and grass species in the plots were identified and recorded by local/ scientific names and the samples were collected and identified by using the "Hand book of some south Indian Grasses" (Achariyar, 1921).

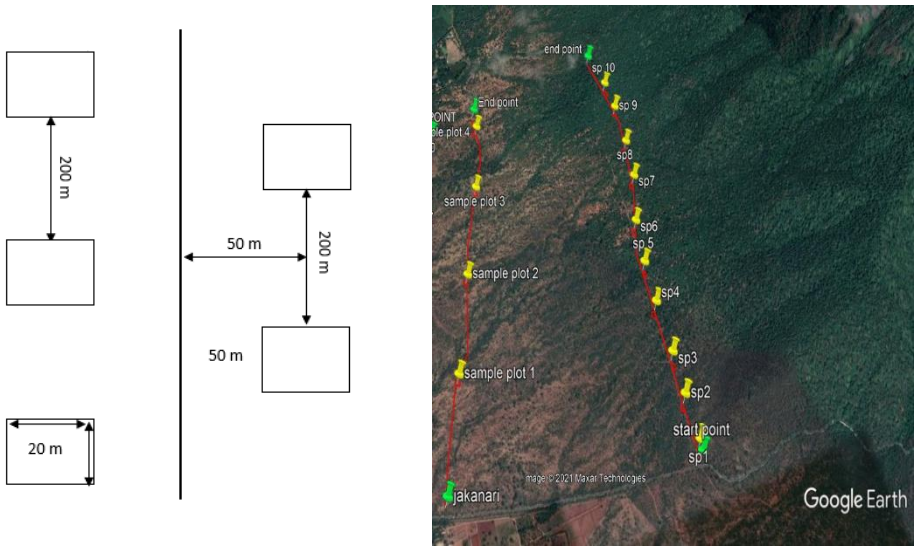

Figure 1. *Layout of transact line and sample plot*

Figure 2. *Map view of transact lines and sample plot locations. Source: Google Earth Map*

Data analysis

The important quantitative analysis like density, frequency and abundance, relative density, relative frequency, relative dominance and important value index of fodder trees and grasses were determined as per Curtis and McIntosh (1951). The quantitative characters within the study area were assessed by using the following formulae shown in *Eq. 1* to *Eq. 7*.

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$$\text{Density} = \frac{\text{Total number of individuals of a species in all quadrants}}{\text{Total number of quadrats studied}} \quad \text{(Eq.1)}$$

$$\text{Frequency (\%)} = \frac{\text{Number of quadrants in which the species occurred}}{\text{Total number of quadrats studied}} \times 100 \quad \text{(Eq.2)}$$

$$\text{Abundance} = \frac{\text{Total number of individuals of a species in all quadrants}}{\text{Total number of quadrats in which the species occurred}} \quad \text{(Eq.3)}$$

$$\text{Relative density (\%)} = \frac{\text{Number of individual of the species}}{\text{Number of individual of all the species}} \times 100 \quad \text{(Eq.4)}$$

$$\text{Relative frequency (\%)} = \frac{\text{Number of occurrence of the species}}{\text{Number of occurrence of all the species}} \times 100 \quad \text{(Eq.5)}$$

$$\text{Relative dominance (\%)} = \frac{\text{Total basal area of the species}}{\text{Total basal area of all the species}} \times 100 \quad \text{(Eq.6)}$$

$$\mathbf{IVI} = \mathbf{RD}\ (\%) + \mathbf{RF}\ (\%) + \mathbf{Rd}\ (\%) \quad \text{(Eq.7)}$$

where,
IVI= Important Value index
RD= Relative Density
RF= Relative Frequency
Rd= Relative dominance.

Species diversity indices

The following diversity indices were determined by using PAST software, version 4.03.

i) Simpson index $D = \frac{\sum n_i(n_i - 1)}{N(N-1)}$, D = Simpson index of dominance; n_i = the total number of trees of each individual species; N = the total number of trees of all species. As D increases, diversity decreases and Simpson's index was therefore usually expressed as 1-D or 1/ D (Simpson, 1949).

ii) Shannon- Weiner index H' = $-\sum p_i \ln p_i$, H' = Shannon index of diversity; p_i = the proportion of important value of the i^{th} species (pi = n_i / N, n_i is the important value index of i^{th} species and N is the important value index of all the species); ln = Natural logarithm on proportion of each species (Shannon and Weaver, 1948).

iii) Pielou's evenness index J = H/ ln S, H = - $\sum P_i \ln P_i$, S= Individuals of all the species; ln = Natural logarithm on individuals of all the species (Pielou, 1966).

iv) Margalef's index Dmg = (S-1)/ ln N, S = Total number of species; N = Total number of individuals; ln = Natural logarithm on total number of individuals (Margalef, 1968).

v) Chao 1 estimator Q_2 = Number of species occurring in two samples, F_1 = the number of singleton species, F_2 = the number of doubleton species (Chao, 1980).

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Results

Family wise distribution pattern and Dominance (IVI) of Fodder trees in CER

A total of 25 fodder tree species were identified based on the indirect evidence of feeding behaviour and on the knowledge of anti-poaching watchers and local people. Among the 25 fodder tree species, Fabaceae is the most dominant family with 12 species *viz., Acacia chundra, Acacia leucophloea, Acacia mellifera, Acacia nilotica, Acacia planifrons, Albizia amara, Albizia lebbeck, Bauhinia racemosa, Dichrostachys cinerea, Hardwickia binata, Tamarindus indica, and Pterocarpus marsupium* followed by two species found in Moraceae (*Ficus benghalensis* and *Ficus religiosa*) and Rutaceae (*Aegle marmelos* and *Limmonia acidissima)* whereas one species was found in Poaceae (*Bambusa bambos*), Cannabaceae (*Celtis philipensis*), Ulmaceae (*Holoptelea integrifolia*), Euphorbiacea (*Mallotus philipensis*), Anacardiacea (*Spondias mangifera*), Myrtaceae (*Syzygium cumini*), Combretaceae (*Terminalia arjuna*) and Lamiaceae (*Tectona grandis*) and Verbenaceae (*Gmelina arborea*) respectively (*Fig. 3*). With respect to fodder species, *Bambusa bamboos* had maximum number of individuals (150) followed by *Albizia amara* (141), *Acacia planifrons* (127), *Acacia chundra* (121), *Dichrostachys cinerea* (93) while the minimum was recorded in *Ficus bengalensis* (9), *Aegle marmelos* (4) and *Ficus religiosa* (3), respectively (*Fig. 4*). Important Value Index values ranged from 5.34 to 70.82. Among the species, *Bambusa bamboos* had a higher IVI value of 70.82 in site IV followed by *Acacia chundra* (64.26) in site X and *Albizia amara* (58.15) in site IX whereas a lower IVI value was observed in *Gmelina arborea* (5.34) in site XI (*Table 2*).

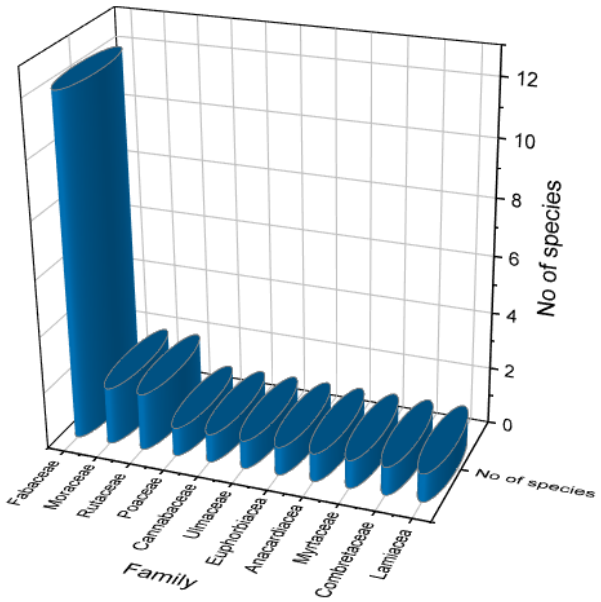

Figure 3. *Familywise distribution pattern of fodder trees in CER*

Richness, dominance and species diversity index

Among the different sites, the maximum species richness was observed in site V (15) followed by site I (13), site II, site VII and site XI with a mean value of 12 and the minimum was observed in site VIII (7) and site IX (7) and this species richness is equal

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to expected species richness (Chao-1). The Margalef index is the species richness index of vegetation in the study area. The results revealed that the Margalef index was increased with species richness. The highest species richness was registered in site V (2.72) whereas the lowest was observed in site VIII (1.32). Species evenness is a measure of the partition of the individuals of a population among the species. More than 0.50 evenness was recorded in site VI (0.91), site IX (0.87), site XII (0.82), site IV (0.44) and the lowest evenness was registered in site II (0.47) which is presiding to increase Berger Parker dominance. The maximum dominance was observed in site II (0.55) followed by site IV (0.50). Site VI and site VII (0.88) possess the maximum Simpson index whereas the minimum dominance was recorded in site IV (0.69) and site II (0.68) (*Table 3*). The highest Shannon diversity index was observed in site V (2.29) followed by site VII (2.25), site VI (2.21) and site XII (2.20) while the lowest H was recorded in SIV (1.58) (*Table 3*).

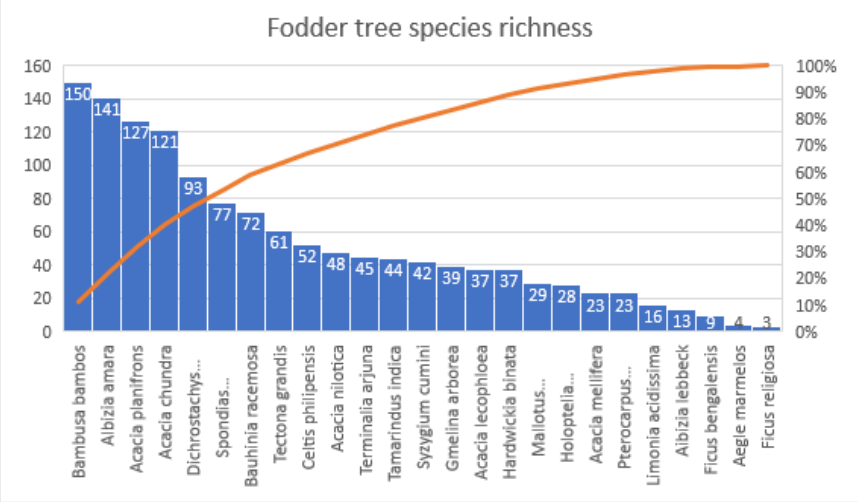

Figure 4. *Species richness for Fodder trees*

Density of native fodder grasses in CER

The results revealed that a total of 30 fodder grasses were documented in CER. Among the 12 different sites, the highest number of species was registered in site XII (19) followed by site I and site IX (15) and the lowest were observed in site X and site XI (7). With respect to grass density, the species were arranged based on the density *viz.*, *Oplismenus burmannii* (11.68%)>*Dichanthium aristatum* (10.67%) > *Enteropogon monostachyus* (9.29%)> *Chrysopogon aciculatus* (6.96%)> *Cynodon dactylon* (5.90%) > *Bulbostylis barbata* (5.57%)> *Perotis indica* (5.25%)> *Arachne racemosa* (4.93%) > *Aristida setacea* (4.62%)> *Themeda triandra* (4.10%)> *Apluda mutica* (3.60%)> *Heteropogon contortus* (3.57%)> *Chloris barbata* (3.43%)> *Melinis repens* (2.46%)> *Alloteropsis cimicina* (2.35%) > *Digitaria ciliaris* (2.12%)> *Brachiaria semiundulata* (1.69%) > *Bromus diandrus* (1.68%)> *Echinochloa colona* (1.64%) > *Kyling abrevifolia* (1.42%)> *Cyperus rotundus* (1.38%)> *Eragrostiella bifaria* (1.30%)> *Chloris virgata* (1.27%)> *Hyparrhenia hirta* (0.91%)> *Eragrostis cilianensis* (0.74%)> *Digitaria longifolia* (0.59%)> *Digitaria sangulensis* (0.33%)> *Eremochloa ophiuroides* (0.28%)> *Cenchrus ciliaris* (0.24%) and *Cymbopogon martini* (0.10%) irrespective of the sites (*Table 4*).

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Table 2. *Important value index of fodder trees in CER*

Sl. No	Tree Fodder	S I	S II	S III	S IV	S V	S VI	S VII	S VIII	S IX	S X	SXI	S XII
1	*Acacia chundra*	19.09	18.69	36.93	X	X	X	15.83	X	36.80	64.26	19.21	50.83
2	*Acacia leucophloea*	24.86	25.41	28.84	15.36	9.95	X	17.62	X	30.99	19.03	11.32	X
3	*Acacia mellifera*	21.78	X	X	X	X	X	19.69	X	26.85	20.65	X	13.89
4	*Acacia nilotica*	27.31	13.36	20.67	X	X	X	29.36	X	22.04	41.58	10.55	X
5	*Acacia planifrons*	39.00	28.50	47.00	X	41.43	X	36.51	X	47.21	29.17	15.16	51.15
6	*Aegle marmelos*	X	X	X	9.60	X	X	X	18.55	X	X	X	X
7	*Albizia amara*	8.85	77.68	42.81	X	X	X	38.69	X	58.15	16.43	11.27	25.79
8	*Albizia lebbeck*	12.27	X	15.54	12.74	11.87	X	20.38	X	X	27.68	6.16	X
9	*Bambusa bambos*	X	X	X	70.82	12.15	7.99	X	X	X	X	X	X
10	*Bauhinia racemosa*	10.13	22.23	23.98	27.76	20.47	5.90	29.89	X	X	20.17	15.10	X
11	*Celtis philipensis*	X	X	X	26.79	31.71	8.16	X	46.92	X	X	X	X
12	*Dichrostachys cinerea*	30.98	27.33	32.28	X	X	X	38.35	X	39.22	47.02	16.11	35.65
13	*Ficus benghalensis*	X	X	X	X	X	X	X	X	X	X	X	35.49
14	*Ficus religiosa*	11.20	X	X	X	X	X	X	X	X	X	X	X
15	*Gmelina arborea*	X	X	X	10.23	X	10.02	X	36.21	X	X	5.34	21.65
16	*Hardwickia binata*	40.46	16.65	26.87	X	X	10.27	32.25	X	38.73	X	X	X
17	*Holoptelea integrifolia*	X	24.76	X	25.93	13.77	10.63	X	X	X	X	X	X
18	*Limonia acidissima*	X	8.72	X	X	24.96	X	X	X	X	X	X	X
19	*Mallotus philipensis*	X	X	X	X	13.93	8.95	X	55.35	X	X	X	X
20	*Pterocarpus marsupium*	X	X	X	20.73	16.88	X	X	X	X	X	X	X
21	*Spondus mangifera*	8.96	X	X	33.10	39.07	10.28	X	31.17	X	X	7.28	36.90
22	*Syzygium cumini*	X	X	X	X	X	10.84	X	75.42	X	X	X	X
23	*Tamarindus indica*	45.10	36.67	25.07	X	12.56	10.77	21.41	X	X	14.01	14.33	28.64
24	*Terminalia arjuna*	X	X	X	X	51.24	X	X	X	X	X	X	X
25	*Tectona grandis*	X	X	X	46.94	X	X	X	36.38	X	X	X	X

*X- indicates absence of fodder trees in Coimbatore Elephant Reserve (CER)

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Table 3. *Diversity indices for fodder trees in CER*

Range	Site	Individuals	R $_{(Os)}$	Chao-1$_{(E.s)}$	Simpson1-D	Shannon H	Evenness e $^{H/S}$	Margalef	Berger-Parker
Mettupalayam	S I	90.00	13.00	13.00	0.87	2.19	0.68	2.67	0.18
	S II	142.00	12.00	12.00	0.68	1.72	0.47	2.22	0.55
	S III	97.00	11.00	11.00	0.86	2.10	0.74	2.19	0.22
	S IV	282.00	11.00	11.00	0.69	1.58	0.44	1.77	0.50
	S V	171.00	15.00	15.00	0.87	2.29	0.66	2.72	0.22
Sirumugai	S VI	61.00	10.00	10.00	0.88	2.21	0.91	2.19	0.18
	S VII	78.00	12.00	12.00	0.88	2.25	0.79	2.53	0.19
	S VIII	94.00	7.00	7.00	0.77	1.62	0.72	1.32	0.33
	S IX	38.00	7.00	7.00	0.82	1.81	0.87	1.65	0.29
	S X	94.00	10.00	10.00	0.77	1.81	0.61	1.98	0.41
	S XI	117.00	12.00	12.00	0.84	2.09	0.67	2.31	0.28
	S XII	61.00	11.00	11.00	0.87	2.20	0.82	2.43	0.20

S $_{(ob)-}$ observed species richness; Chao-1$_{(E.s)}$ – expected species richness

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Table 4. *Density of native fodder grasses in CER (%)*

Species	**S I**	**S II**	**S III**	**S IV**	**S V**	**S VI**	**S VII**	**S VIII**	**S IX**	**S X**	**SXI**	**S XII**	**mean**
Individuals	**15**	**10**	**12**	**10**	**11**	**12**	**14**	**10**	**15**	**7**	**7**	**19**	
Alloteropsis cimicina	2.27	X	5.33	9.43	7.09	X	X	X	3.30	X	X	X	**2.35**
Apluda mutica	X	X	X	16.23	11.82	10.88	X	4.26	X	X	X	X	**3.60**
Arachne racemosa	X	X	X	12.08	9.12	9.86	X	6.23	X	X	14.35	7.51	**4.93**
Aristida setacea	X	X	8.61	X	X	X	5.64	X	5.42	11.51	20.18	2.89	**4.62**
Brachiaria semiundulata	X	X	5.33	X	4.73	4.08	X	1.31	X	X	X	4.05	**1.69**
Bromus diandrus	X	5.84	X	X	X	X	5.88	X	X	8.55	X	X	**1.68**
Bulbostylis barbata	5.23	9.09	6.97	X	X	X	4.41	5.25	8.02	11.84	10.31	4.86	**5.57**
Cenchrus ciliaris	X	X	X	X	X	X	X	X	X	X	X	X	**0.24**
Chloris barbata	1.82	7.79	4.92	X	4.05	4.42	X	X	5.42	X	8.07	3.93	**3.43**
Chloris virgata	1.82	X	2.87	X	X	X	3.19	X	3.77	X	X	3.24	**1.27**
Chrysopogon aciculatus	14.77	11.04	9.43	7.92	8.78	5.44	13.24	X	7.55	X	X	4.28	**6.96**
Cymbopogon martinii	X	X	X	1.17	X	X	X	X	X	X	X	X	**0.10**
Cynodon dactylon	10.91	13.64	7.38	6.00	11.82	4.08	X	4.26	6.60	X	X	4.97	**5.90**
Cyperus rotundus	X	X	X	5.28	3.04	5.78	X	X	X	X	X	2.43	**1.38**
Dichanthium aristatum	16.82	16.23	15.57	X	9.46	4.08	11.27	X	10.14	14.14	19.28	9.02	**10.67**
Digitaria ciliaris	2.73	X	5.33	X	4.39	2.72	5.15	X	X	X	X	4.51	**2.12**
Digitaria longifolia	1.36	X	X	3.02	X	X	X	X	X	X	X	2.66	**0.59**
Digitari asangulensis	X	X	X	X	X	X	X	X	4.01	X	X	X	**0.33**
Echinochloa colona	X	X	X	X	X	X	X	9.18	6.37	X	X	4.16	**1.64**
Enteropogon monostachyus	3.41	9.09	10.66	13.21	X	10.88	8.82	10.16	X	17.76	19.28	6.82	**9.29**
Eragrostis cilianensis	X	X	X	X	X	8.84	X	X	X	X	X	X	**0.74**
Eragrostiella bifaria	1.14	X	4.51	X	X	X	6.62	X	2.83	X	X	X	**1.30**
Eremochloa ophiuroides	X	X	X	X	X	X	3.43	X	X	X	X	X	**0.28**
Heteropogon contortus	8.18	8.44	X	X	X	X	9.07	X	8.73	X	X	7.98	**3.51**
Hyparrhenia hirta	5.91	X	X	X	X	X	5.15	X	X	X	X	X	**0.91**
Kyling abrevifolia	X	X	X	X	X	X	X	17.05	X	X	X	X	**1.42**
Melinis repens	X	3.90	X	X	X	X	X	11.15	8.25	X	X	6.24	**2.46**
Oplismenus burmannii	17.95	X	X	25.66	25.68	28.91	X	31.15	X	X	X	10.87	**11.68**
Perotis indica	X	14.94	X	X	X	X	7.84	X	8.96	18.75	8.52	4.16	**5.25**
Themeda triandra	5.68	X	X	X	X	X	10.29	X	10.61	17.43	X	5.43	**4.10**
X indicate absence	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**

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Discussion

Elephants move out of the habitat due to the limited availability of food inside the forests. Besides this, the change in cropping patterns shifted from conventional cropping to cash crops like bananas and corns, especially in the elephant corridor areas of Sirumugai and Mettupalayam. These crops lure the wild elephants, which further results in human-elephant conflict. However, most of the issues flagged are only indicative observations and there is no systematic and scientific study on the documentation of native fodder trees and grasses in the elephant habitat area. Hence, the present study provides a quantitative picture of diversity and affords information on the rarity and commonness of species in a community, which is crucial for understanding the numerical structure of the community. A total of 25 species recorded in the study area is lower than that of 43 species in the Shervarayan hills (Kadavul et al., 1999). The IVI is important for assessing the ecological significance of species and for determining the extent of species dominance in a vegetative stand's structure (Curtis and McIntosh, 1951; Abdullahi, 2009). Because it incorporates diverse factors of the species in the vegetation, IVI is also a reasonable measure to estimate the overall relevance of a species. Curtis and McIntosh (1951) were used to calculate the IVI. Tree species richness in the study area showed wide variation, ranging from 7 to 15. The similar trends were in accordance with the findings of Sathya (2017) and Mandal et al. (2014) who reported that the IVI values ranged from 0.10 to 114.66 in Sathyamangalam Tiger Reserve and dry deciduous forest in Doon valley. This is because of species richness, which is significantly influenced by forest structure and species composition. High species richness is often connected to a more complex vertical structure. The present findings indicated maximum species richness compared to 10.04 to 11.24 in the tropical deciduous forest recorded by Naidu and Kumar (2016). Earlier workers reported the Margalef index for tropical moist deciduous forest, tropical dry deciduous forest, riparian forest and scrub forest were found in the range of 4.54-23.41 (Mishra et al., 2005; Reddy et al., 2008; Kumar et al., 2010; Sathish et al., 2013; Tarakeswara et al., 2018). The higher dominance reduced the species diversity and evenness (*Fig. 5*). In an evenly distributed population, J is 1. J decreases with increasing unevenness. This might be the reason for the uneven distribution of fodder trees in the Coimbatore Elephant Reserve. The present result is consistent with the findings of Naidu and Kumar (2016) and Tarakeswara et al. (2018) who found that the evenness index in tropical forests ranged from 0.60 to 0.78. Despite that, the Shannon-Wiener and Simpson's diversity indices measure distinct aspects of diversity based on the proportional weighting provided to evenness and species richness (Magurran, 1988; Beals et al., 1999). These diversity indices demonstrate that floristic diversity was equivalent across all sites. The lower value of the Simpson and Shannon index indicates the higher species diversity. The lowest Simpson index was recorded in site II (0.68) followed by site IV (0.69) and the lowest H value showed the highest tree diversity (*Fig. 6*). This might be due to the growth pattern of trees, individual species composition, climatic, edaphic, topographic factors and forest types. A similar finding was also stated by Sathya (2017) that the Simpson index and Shannon-Weiner ranged from 0.75 to 0.96 and from 2.13 to 3.61, respectively, in the Sathyamangalam Tiger Reserve, which was also observed in the present study. It was further supported by Naidu and Kumar (2016), Tarakeswara et al. (2018), and Naidu et al. (2021) who found that the Simpson index and Shannon-Weiner index for tropical forests ranged from 0.96 to 0.98 and 3.59 to 4.05, respectively. SHE analysis explains the relationship between S (species richness), H (Shannon-Wiener

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diversity index) and E (evenness as measured using the Shannon-Wiener evenness index, otherwise known as Pielou J) in the samples. The lognormal model includes an increase in richness and Shannon indices along with a decrease in evenness. Finally, in the log series model, the Shannon index remained constant while evenness decreased with increasing tree richness (Fazeli-Dinan et al., 2019). SHE analysis followed the way these parameters change with increasing sampling effort. The graph showed a plot of S, H and E for all selected sites. ln (S), ln(E), and H values were calculated cumulatively by SHE analysis. Based on SHE analysis, fodder tree diversity showed a clear log series distribution model. The results revealed that the log normal model showed fodder species richness increasing with decreasing evenness (*Fig. 7*). These results are similar to those of other researchers (Wilson et al., 2008; Salarian et al., 2015). A total of 30 fodder grasses were documented and the maximum density was observed as 11.68% in *Oplismenus burmannii* followed by *Dichanthium aristatum* (10.67%) and *Enteropogon monostachyus* (9.29%). Among the 12 different sites, the highest number of grass species was registered in site XII followed by site I and site IX and the lowest were observed in site X and site XI, which was due to the geographical condition of the CER (*Fig. 8*). The present result is in accordance with the findings of Ashok Kumar et al. (2021) who reported that the grass density ranged from 12.70 to 22.45% in tropical forest of Mudumalai Tiger Reserve.

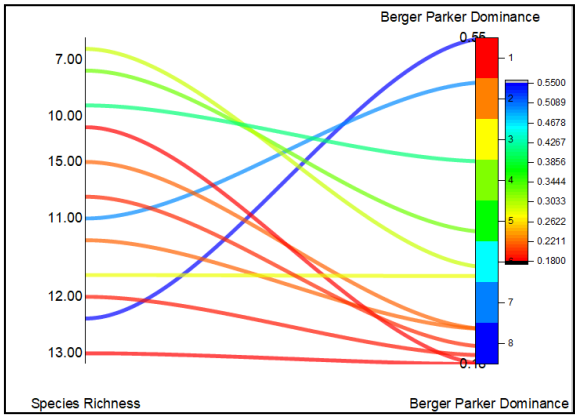

Figure 5. *Relationship between species richness and dominance*

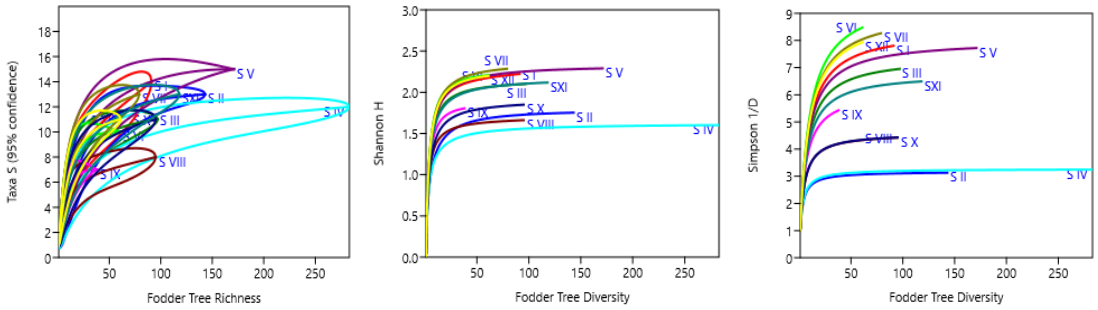

Figure 6. *Curve shows expression of Species richness, Shannon diversity and Simpson diversity indices*

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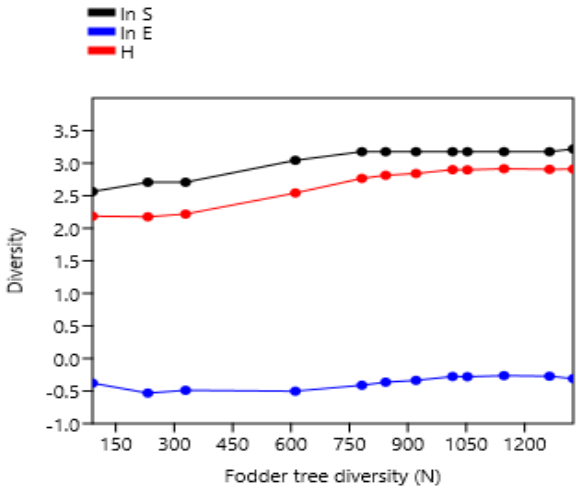

Figure 7. *SHE analysis for fodder trees*

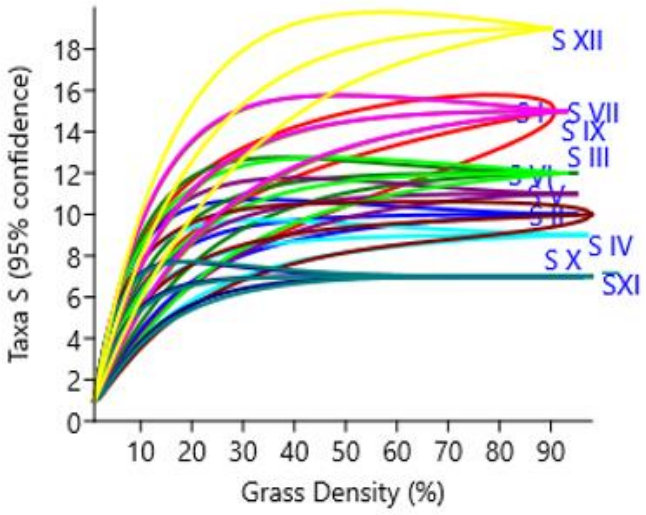

Figure 8. *Grass density (%) in different site*

Conclusion

Human-elephant conflict has evolved as a major issue in all elephant habitats in India, especially in Tamil Nadu. The mitigation of the conflict remains a major unresolved challenge for wildlife managers and stakeholders. In Tamil Nadu, beehive fencing, electrical fencing, habitat manipulation and improvement are used sustainably for mitigating the conflict, among which habitat improvement for elephants is considered to be the most effective. For this, authentic and reliable data on the diversity pattern and species composition of fodder are necessary for corridor conservation and management. Thus, the current study dealt with identifying the fodder crops based on the feeding behaviour and food spectrum of elephants. The study concluded that elephants extensively feed on ten fodder grass species *viz.*, *Cynodon dactylon*, *Dichanthium aristatum*, *Enteropogon monostachyus*, *Heteropogon contortus*, *Hyparrhenia hirta*, *Melinis repens*, *Oplismenus burmannii*, *Perotis indica* and *Themeda*

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triandra and nine (9) tree fodder viz., *Albizia amara, Bambusa bambos, Ceiba pentandra, Dichrostachys cinerea, Ficus benghalensis, Ficus religiosa, Ficus racemosa, Hardwickia binata* and *Tamarindus indica*. The feeding pattern of elephants can be suggested as a sustainable tool for reducing human elephant conflict through habitat manipulation and improvement and thus more studies have to be conducted in different elephant reserves in India.

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