International Journal of Research in Agriculture, Biology & Environment (IJAGRI)

E-ISSN : 2582-6107

DOI: 10.47504/IJAGRI.2022.V3.1.1

Volume 3 (1) 2022
Jan – Mar -2022

Study on Feeding preference and Impact of African Elephants (*Loxodonta africana*, Blumenbach, 1797; Elephantidae) on Woody species in Babile Elephant Sanctuary, Eastern Ethiopia

Taye Lemma Geleta[1] and Girma Mengesha[2]

[1]College of Natural and Computational Sciences Centre for Environmental Sciences

Addis Ababa University, Ethiopia, E-mail: lemmageletamereba@gmail.com

[2]Wondo Genet College of Forestry and Natural Resources, Hawassa University,

Addis Zoo Park, Addis Ababa, Ethiopia, E-mail: gutgirma@gmail.com

ABSTRACT

The focus of this paper is to study the feeding preference and impact of woody species on African elephants in Babile Elephant Sanctuary (BES), Eastern Ethiopia. Data were collected through purposive random and systematic sampling techniques. Seven sites from three different habitats in the sanctuary were selected by considering the availability of dung and consumed plant parts. The result showed, among 38 species browsed by elephants, 24(63.15%) were the most preferred elephant diet. Besides, from dissecting 75 dung boli of 24 plant species (yielding 2841seeds); 2009 (70%) of seeds were fed by elephants during the wet season. And, the seeds were analysed using the focal watch and indirect methods. Woody species, about 23(76.7%) in the riverine, 36 (68%) in woodland, and 19(54.3%) in bushland habitats were mainly impacted on parts of primary/secondary branches and main stem. Among these, a small size class of trees was more easily damaged by elephants. Based on research results, the following inference is drawn: identifying and documenting the dietary composition, feeding preference, and impact of elephants on woody species in BES is important to build gaps in knowledge for conservationists to design plans for restoring the species and sustaining elephants existence in the sanctuary.

Key words: Feeding Preference, Feeding Impact, Woody Species, African Elephants, Preference Indices, Important Value Indices.

1. INTRODUCTION

1.1. Background and Justification

Babile Elephant Sanctuary is one of the largest wildlife-protected areas (6982 km^2) and was established in 1970 to protect the only viable elephant population in the country and Horn of Africa. Despite its establishment, there was a mass influx of a large number of farmers and their livestock were extending from the east and northern part of the sanctuary (Sintayehu *et al*., 2016), especially more illegal settlement (Emily and Elizabeth, 2021) were expanded and affect the range of distribution considerably. Besides, the local communities around the area are highly dependent on vegetation for fencing, medicine, construction, and fuelwood. Due to this, the elephants feeding system in the sanctuary was challenged. Therefore, improving the feeding system of elephants is very important to maintain body condition (Norkaew *et al*., 2018) and increases elephants to take refuge (Moolman *et al*., 2019). Elephants can feed on ground level up to 6m tall plant parts and use two/three pairs of huge, long, rasp-like molars for milling and the incredibly versatile trunk (Debebe Dana,2018). They spend time between 12-18 hours feeding each day, with peaks in the morning, late afternoon, and around midnight (Debebe Dana, 2018; Lamichhane *et al*., 2018; Thekaekara, 2019). However, there was no time spent difference between sexes in the proportion of feeding (Phyllis and Elizabeth, 2020). Elephants show preferences for some habitats and avoid others (Roever, 2017; Ahimsa *et al*., 2018; Anabelle *et al*., 2019; Mrinmay and Nilanjana, 2021). They prefer small size classes of woody plants and large trees could be selected only when the preferred small size classes were not available (Debebe Dana, 2018; Makoshane *et al*., 2018; Anabelle *et al*., 2019). Elephants remove more material (biomass) than they finally consume and brought an effect on woody vegetation and biomass loss (Debebe Dana, 2018). They feed on various plants by browsing leaves, fruits, twigs, or stripping bark and uprooting woody trees and shrubs (Makoshane *et al*., 2018; Debebe Dana, 2018) and also consume herbs and creepers (Mahendra *et al*., 2018; Lin and Thida, 2020; Mahendra, 2020). And, they impact the relative growth, survival, and reproductive output of these species (Debebe Dana, 2018). So, identifying and recording the availability of woody species, feeding preferences of elephants, and impacts they brought are

essential to fill the gaps in knowledge for dietary sustainability of elephants. But, relatively few studies were available (Yihew Biru and Afework Bekele, 2012). Therefore, this study is important for conservationists to design a suitable plan for restoring the impacted woody species and to rehabilitate habitats for sustaining the existence of elephants in the sanctuary.

2. MATERIALS AND METHODS

2.1. Description of the Study Area

Babile Elephant Sanctuary (BES) was established in 1970, with area coverage of 6,982 km^2. It is located at 560 km distant from the capital city of Addis Ababa in the eastern part of the country; between Oromia and Ethio-Somali regional states. Its geographical position is within latitudes of 08°22'30"-09°00'30"N and longitudes of 42°01'10"- 43°05'50"E (Figure 1). It is a part of the Somali-Masai Centre of Endemism and located between the Eastern Hararge high mountain (i.e., Mountain Gara- Muleta to the west) and the Ogaden Desert to the southeast (Yirmed Demeke, 2008 cited in Emily and Elizabeth, 2021).

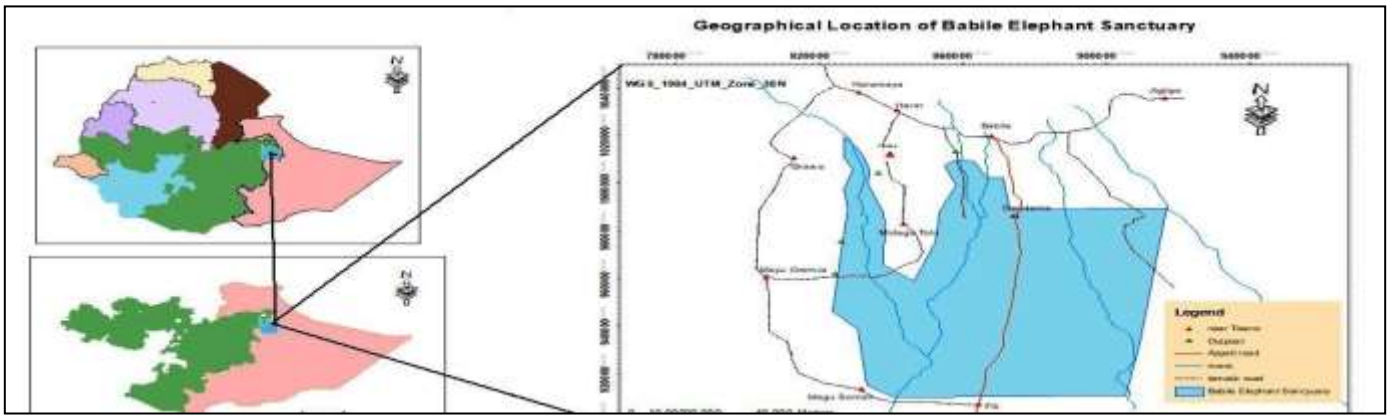

Figure 1. Map of Ethiopia showing Regional States and location of the study area

2. Reconnaissance survey

A reconnaissance survey was carried out during the first week of May 2019 (between 14/05/2019-21/05/2019) by identifying sampling sites in the study area. During reconnaissance surveys, discussion with concerned individuals, local experts and field observation were conducted. Based on the survey, three different habitats were purposively selected referring elephants visiting areas in the sanctuary. Seven sites were selected from four districts on this base. Among those: 2 riverine sites : Erer Ebada and Ebada Gamachu Peasant Association(PeAs) from Babile district: 2woodland sites -Alola and Gabibda PeAs from Mayu Muluke district, and 3 bush land sites (Bilisuma PeAs from Midega tola district and Anani- kontomu and Anani-kare gobele PeAs from Fedis district) were selected.

2.1. Study design

Line transects, having equi-distance of box plots along transect line were designed for this study. Transects were allocated in proportion to the approximate dung pile densities in all three land units following Raymond Alfred (2010). A total of 21 transects (i.e., each having 3km length); 6 in riverine,9 in bush lands and 6 in woodland habitats were lined approximately perpendicular to the base lines of left and right of Erer river and Gobele Valley. The starting point of the first transect was randomly selected and placed at 1km regular interval in each three habitats of seven sites. Each transects holds seven quadrants or box plots (each having 30 m by 30 m and 500m equi-distance). In general, from a total of 21 transects, 147 quadrants or box plots along transects were laid for this study. Distance between transects and Quadrants along transects were measured through tape metre and distance walked alternatively. To complete a transect survey, a total of 77km length of transect were walked (63km along transect and 14km between transect) between 4 September and 18 October 2019.

2.3. Methods and Data Analysis

2.3.1. Feeding preference

The feeding preference (food habits) of elephants were studied by focal scanning of targeted individuals during their feeding activity (Ashokkumar *et al*., 2021) indirectly by interviewing wildlife rangers and local residents, and identifying seeds in the dung (Amusa *et al*., 2017; Thomas *et al*., 2021). The consumed plant species, feeding remains and partly used food plants (i.e., chewed vegetation, browsed branches, debarked trees and scratched posts) by elephants and dung signs were noted and recorded (Yihew Biru and Afework Bekele, 2012; Debebe Dana, 2018). However; it was not possible to quantify the amount consumed. To assess the seeds of plant species in the elephant dung, fresh to nearly fresh boli at 5 m interval were collected to avoid collection of dung from same accumulation (Yihew Biru and Afework Bekele, 2012; Crespo, 2018; Priscilia, 2020). Dung collection was

DOI: 10.47504/IJAGRI.2022.V3.1.1

carried out following (Raymond Alfred, 2010; Collins, 2018) using box plot samples. A collected bolus was dissected by hand to identify and count the number of intact and undamaged seeds of each species (Yihew Biru and Afework Bekele, 2012). For further confirmation, the fresh collected dungs were taken to Haramaya University, Ethiopia. Vegetation data were collected from all three land units (i.e., 147 quadrants), as described in the study design. However; collection of dungs data were taken only from the two riverine habitats of Erer Ebada and Ebada Gamachu sites (i.e., 42 quadrants/each30m by 30m/ in the 6 transects or blocks) were engaged due to the presence of elephants were only occurred in those areas by default (i.e., between 14 to 18October 2019/it was wet season). Moreover; the dry season data on food preference was also gathered at the end week of December 2019.

Data analysis: Dietary compositions were analysed by identifying the different species of plants those were consumed by elephants, and computing their relative frequency, abundance and thus calculating their preference indices. Preferred species for elephants were determined by calculating preference indices of each species in the diet. Preference index (PI) was calculated by dividing percentage utilization by the percentage availability in the environment (Yihew Biru and Afework Bekele, 2012; Raj Kumar *et al*., 2016).

Using the following formula: Food preference Index (PI) = $\frac{\text{Percentage Utilization}}{\text{Percentage Availability in the environment}}$

Where, percentage utilization is the percentage of a given consumed plant as food with a ratio of all species consumed in the diet, while percentage availability in the environment is a ratio of the total number of individuals of a single species to the total number of individuals of all species observed in the all observation blocks. Moreover; the woody species composition from the sampled study areas were further investigated for all plant species that were recorded in each quadrant by calculating their relative tree density, frequency, dbh and basal area to explain species availability and its importance in the study area as showed in (Table 3.3). Measurement at the cross-sectional area of tree stems at breast height was taken to quantify the basal area of each species in each quadrant. Basal area was used as a measure of dominance, referring to the degree of coverage of species or space it occupies at the ground level (Pandey *et al*., 2016; Seta *et al*., 2019) and calculated using the following formula: BA=A= πr^2= Where, r=d/2; BA=$\pi d^2/4$; BA= Basal area in m^2/ha, d= diameter at breast height and π =3.14; Dominance=mean basal area per species X number of trees in species. Finally, The Importance Value Index (IVI) of woody species in all three land units were calculated by adding the relative dominance, relative density and relative frequency of each species following the formula that were described by (Curtis and McIntosh, cited in Pandey *et al*., 2016). Each component of IVI was calculated as follows;

Relative density = $\frac{\text{Total no. of individual species of A}}{\text{Total no. of individuals of all species}} \times 100$

Relative frequency = $\frac{\text{Frequency of occurrence species A}}{\text{Total frequency of occurrence of all species}} \times 100$

Relative dominance = $\frac{\text{Dominance of species A}}{\text{Dominance of all species}} \times 100$

At last, all the data collected on seasonal dietary composition and preferences were coded and analysed using SPSS Version 20. Through one way ANOVA analysis, correlation analysis and t-test were used to investigate it.

2.3.2. Feeding impact

The feeding impact were studied by assessing all plant specimens with their stems found within each plot and other data such as species, height, status (alive or dead) and level of impact was estimated and recorded. Following the vegetation assessment that was carried through strip transects by (Raymond Alfred, 2010; Seta *et al*., 2019). A digital photograph for each vegetation type and a GPS record at the start and end of each transect and quadrants were taken. The level of impact to a plant was estimated by observing the damage effect of each woody species and categorizing the damaged level in to groups. Six groups were categorized by giving a labelled number value 0 to 5. The six groups were: (0) no damage; (1) very little use; (2) secondary branches broken; (3) more than one primary branch broken; (4) main stem broken, heavily browsed or bark stripped and (5) whole tree uprooted (adapted from Hiscocks, 1999). Levels 1 and 2 can not only be attributed to elephants, as many other herbivores browse on the same plant species and can cause minor damage. Levels 3 to 5 however can only be attributed to elephants (Hiscocks, 1999).

Data analysis: The feeding impact of elephants on vegetation were analysed by calculating the total level of damage per species per transect; using the following formula: Σ (# trees per damage category per species per transect x damage category) (Hiscocks, 1999). The total damage per species per vegetation type and the overall total per vegetation type were also calculated. And, finally, the collected data on the impact of woody species was coded and analysed using SPSS version 20. A t-test was also used to determine or test whether there was a significant difference occurred between sampled areas (habitats) or not.

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2.4. Materials Used

Materials that was used are: Relevant published and unpublished literature, data sheets, topographic map of the area and its surroundings, computer, calculator, GPS handset, binoculars, Digital camera, measuring tape, compass, dissecting kit, rope, painting dye, microscope slide, light microscope, machete and copies of Flora of Ethiopia and Eritrea for identification, materials also required for plant samples collection like press (wooden frames, straps, flimsies, ventilators, and blotters), secateurs, and plastic and/or polythene bags and other necessary materials and field equipment were also used for this study.

3. RESULT AND DISCUSSION

3.1. Dietary preference of African Elephants

Elephants show preferences for some habitats and avoid others. In this study, 38 plant species were browsed by elephants. Among those: 15(39.5%) and 23(61.5%) were trees and shrubs respectively (Table 1). About 24(63.15%) of the species were most preferred elephant diet (i.e., species that have positive and higher value index) (Table 1).

Table 1. Preference indices (PI) for the most important species in the diet of elephants in BES

Scientific names	Family	% in the diet	% in the field	PI	P
Acacia seyel Del.(*T)	Fabaceae	9.13	2.76	3.3033	+
Acacia nilotica(L.) Wild. Ex Del.(*T)	Fabaceae	7.03	2.83	2.4790	+
Opuntia ficus-indica(L) Miller (*SH)	Cactaceae	13.35	6.57	2.0328	+
Aloe pirottae Berger (*SH)	Aloaceae	1.41	0.76	1.8480	+
Acacia oerfota (Forssk.) Schweinf. (*SH)	Fabaceae	1.41	0.78	1.7936	+
Trachilia emitica Vahl..(*T)	Meliaceae	1.17	0.78	1.4947	+
Dobera glabra (Forssk) Poir.(*SH)	Salvadoraceae	3.28	2.24	1.4670	+
Acacia robusta Burch.(*T)	Fabaceae	3.04	2.17	1.4057	+
Cordia monoica Roxb...(*T)	Boraginaceae	0.70	0.53	1.3257	+
Balanities aegyptica (L.) Del.(*T)	Balanitaceae	3.75	2.83	1.3221	+
Ochna inermis (Forssk) schweinf.expenzing (*SH)	Ochnaceae	4.92	4.15	1.1858	+
Carisaa spinarum L.(*SH)	Apocynaceae	2.34	2.07	1.1293	+
Asparagus leptoclododius(*SH)	Asparagaceae	1.64	1.45	1.1293	+
Cadaba farinosa Forssk (*SH)	Cappardiaceae	1.64	1.45	1.1293	+
Cardia ovalis R.Br.(*SH)	Boraginaceae	1.64	1.47	1.1117	+
Acokanthera schimperi (A.DC.) Schweinf.(*T)	Apocynaceae	2.34	2.14	1.0929	+
Acacia brevispica Harms.(*SH)	Fabaceae	3.75	3.53	1.0629	+
Acacia tortills (Forssk) Hayne.(*T)	Fabaceae	4.45	4.22	1.0553	+
Tamarindus indica.L.(*T)	-	3.04	2.90	1.0487	+
Terminalia brownie Fresen.(*T)	Combretaceae	4.45	4.26	1.0439	+
Grewia villosa Willd.(*SH)	Tiliaceae	1.41	1.38	1.0164	+
Berchemia discolor (Klotzsch) Hemsl.(*T)	Balanitaceae	4.22	4.19	1.0052	+
Acacia nigari(*SH)	Fabaceae	4.92	4.91	1.0021	+
Pyrostria phyllanthoidea (Baill.)Bridson.(*SH)	Rubiacaea	4.68	4.68	1.0014	+
Lanthana camara L.(*SH)	Verbenaceae	2.81	3.64	0.7719	_
Opuntia stricta (Haworth)(*SH)	Cactaceae	1.64	2.24	0.7335	_
Acacia mellifera(Vahl) Benth.(*T)	Fabaceae	1.87	2.83	0.6611	_
Capparis sepiaria L.(*SH)	Capparidaceae	0.47	0.71	0.6557	_
Capparis tomentosa Lam.(*SH)	Capparidaceae	0.47	0.76	0.6160	_
Acacia bussie Harms ex.Sjostedt(*T)	Fabaceae	3.04	4.98	0.6117	_
Grewia schweinfurthii.Burret(*SH)	Tiliaceae	2.58	4.24	0.6076	_
Euclea racemosa Murr.Ssp.(*SH)	Ebenaceae	0.94	1.54	0.6068	_
Euclea schimperi(*SH)	Ebenaceae	2.11	3.53	0.5979	_
Ziziphus spina christi (T.) Desf.(*T)	Ramanaceae	1.17	2.12	0.5524	_
Grewia erythraea Schweinf.(*SH)	Tiliaceae	0.70	1.45	0.4840	_
Dichrostachys cinerea(L.) Wight & Arn.(*T)	Fabaceae	1.64	3.55	0.4620	_
	Cont…				
Kleinia squarrosa Cufod.(*SH)	Astraceae	0.47	1.08	0.4325	_

DOI: 10.47504/IJAGRI.2022.V3.1.1

Dodonoea angustifolia L. f.(*SH)	Sapindaceae	1.17	2.90	0.4033	_

Where; % in diet = percentage occurrence of a species in the diet, % in field = percentage occurrence of a species in the field, P = preference, + = Species preference, - = Species avoidance. The asterisk (*T) and (*SH) designated for Tree and Shrubs respectively.

This result is slightly greater than that of Yihew Biru and Afework Bekele (2012) reported as elephants select 22 out of 35 species for best consumption. Similarly, (Berliani *et al*., 2018; Melissa *et al*., 2018; Susanne *et al*., 2018; Rachmat *et al*., 2020) described, due to fluctuations of resources, elephants show preferences for some habitats and avoid or dislike others. They prefer tree species to feed (i.e., especially tree fruits) and shelter (e.g., *Acacia robusta* and *Acacia tortilis*) (Appendix I: Table 1). Similarly, (Bansiddhi *et al*., 2018; Buchholtz *et al*., 2019; Scott *et al*., 2019; Luke J. *et al*., 2021) reported, as elephants spend most of the time under tree for shade. Elephants preferred or feed more trees species: *Acacia robusta, Trachilia emitica*, *Acacia nilotica* and *Acacia seyel* while *Opuntia ficus-indica*, *Aloe pirottae*, *Acacia oerfota* and *Dobera glabra* were also among shrubs (i.e., have higher values in PI) (Table 1). In this study, among *Acacia* species: *Acacia seyal* (3.3033+) and *Acacia nilotica* (2.4790+) were more preferred while *Acacia mellifera* (0.6611^{-}) and *Acacia bussie* (0.6117^{-}) were selectively avoided by elephants (Table 1). A species could be an important component of the diet and still has a negative preference value. However, Yihew Biru and Afework Bekele (2012) reported that, a selective avoidance does not necessarily mean a species is avoided completely. For example, *Acacia mellifera* and *Acacia bussie* had relatively a close frequency of occurrence in the diet (1.87 and 3.04% respectively). However; *Acacia bussie* (4.98%) was slightly greater than or abundant in magnitude than *Acacia mellifera* (2.83%) (Table 1). Therefore, even both species are important in the diet, *Acacia mellifera* was relatively preferred, while *Acacia bussie* was used less than available and it is likely that elephants will have a negative effect on *Acacia mellifera* than on *Acacia bussie* (Table 1). Elephants also showed a selective avoidance for *Kleinia squarrosa* and *Dodonoea angustifolia* (Table 1). Similarly, study by (Norman and Jonas, 2012; Peter *et al*., 2021) showed that, elephants are selective in woody plant species that are available around them (i.e., for what they eat). In general, Elephants have a difference in preference of woody species due to various occurrence of a species percentage in the diet (i.e., which is directly proportional to preference indices -PI). However, the percentage occurrence of a species in the field was inversely proportional to (PI). This might indicated that higher values of (PI), describes as the species was more preferred by elephant (Table 1).

In this study, a total of 75 dung boli were dissected from the sampled taken, yielding 2841seeds from 24 different plant species (Table 2). The total average number of woody plant seeds per bolus was 48.01 (Table 2). *Acacia bussie*, *Acacia nigrii*, *Lanthana camara* and *Opuntia stricta* had the highest frequencies of seeds in the dung (>20 %) (Table 2). Elephants were observed to feed relatively more during wet season (71%) than dry season (29 %) (Table 2).This might shows elephants were more dispersed in the sanctuary during the wet seasons. Similar findings by (S. Nandin *et al*., 2017; Mahesha *et al*., 2020) were described that however elephants show insignificant feeding difference in both seasons; they were more distributed in the wet season. In this study, some species seeds in the bolus were only observed in the dry seasons (*Balanities aegyptica*, *Dobera glabra* and *Ziziphus spina Christi*)(i.e., this might showed that the species were consumed during the dry season) (Table 2). Similarly, Lorena *et al*. (2021) were reported that there were only a few fruit tree species on which elephants feed might be observed during the dry season. And, during wet seasons (*Acacia nilotica, Dichrostachys cinerea, Ehretia cymosa, Grewia schweinfurthii, Oncoba spinosa* and *Terminalia brownie*) species seeds were only observed in the bolus (i.e., this probably indicated that the species were utilized only during wet season) (Table 2). Other than woody species, studies by Mariam *et al*. (2019) were also reported that, grasses were more consumed during wet seasons by elephants.

Table 2. Seasonal seed composition of elephant dung and mean seed per dung bolus obtained from dung analysis

Species scientific names	Family names	SFWS	SFDS	TS	% in dung	MSDB
Acacia brevispica Harms.	Fabaceae	17	6	23	0.81	0.405
Acacia bussie Harms ex.Sjostedt	Fabaceae	50	17	67	2.36	1.18
Acacia mellifera (Vahl) Benth.	Fabaceae	21	8	29	1.021	0.51
Acacia nigrii	Fabaceae	45	16	61	2.147	1.07
Acacia nilotica (L.) Wild. Ex Del.	Fabaceae	4	0	4	0.141	0.005
Acacia robusta Burch	Fabaceae	278	73	351	12.35	6.17
Acacia seyel Del.	Fabaceae	15	8	23	0.81	0.405
Acacia tortills (Forssk) Hayne	Fabaceae	72	38	110	3.87	0.02
	Cont…					
Balanities aegyptica (L.) Del.	Balanitaceae	0	19	19	0.67	0.33

DOI: 10.47504/IJAGRI.2022.V3.1.1

Berchemia discolor (Klotzsch) Hemsl.	Balanitaceae	57	15	72	2.53	1.27
Dichrostachys cinerea (L.) Wight & Arn.	Fabaceae	2	0	2	0.07	0.035
Dobera glabra (Forssk) Poir.	Salvadoraceae	0	4	4.00	0.14	0.07
Ehretia cymosa Thonn.	Boraginaceae	1	0	1	0.035	0.018
Grewia schweinfurthii.Burret	Tiliaceae	3	0	3.00	0.11	0.053
Lanthana camara L.	Verbenaceae	538	265	803	28.26	14.13
Ochna inermis (Forssk) schweinf.expenzing	Ochnaceae	19	6	25	0.88	0.44
Nocona Spinoza Forsake.	Flacourtaceae	1	0	1	0.035	0.018
Opuntia stricta (Haworth)	Cactaceae	150	61	211	7.427	3.71
Opuntia ficus-indica (L) Miller	Cactaceae	632	252	884	31.12	15.56
Ricinus communis L.	Euphorbiaceae	90	23	113	3.98	1.99
Tamarindus indica.L	Fabaceae	3	7	10	0.35	0.18
Terminalia brownie Fresen.	Combretaceae	10	0	10	0.35	0.18
Trachilia emitica Vahl.	Meliaceae	1	6	7	0.25	0.12
Ziziphus spina christi (T.) Desf.	Ramanaceae	0	8	8	0.282	0.14
Total		**2009**	**832**	**2841**	**100.00**	**48.01**

Key: SFWS Seeds found during the wet season, SFDS- seeds found during the dry season, TS= Total Seeds, MSDB- mean seed per dung bolus. The dungs were only taken from riverine habitat

In general, most of woody species were browsed during the wet season than in dry season due to availability of growing shoots, leaves and fruits. Similarly, (Norman and Jonas, 2012; Owen-Smith and Chafota; 2012; Rosemary *et al*., 2021) also reported that elephants utilized more woody species during the wet season, by eating the fruit parts, branches and grassy and growing shoots were frequently observed. In this study, the species *Opuntia ficus-indica* was highly consumed by elephants during the wet season and covers (> 31%) of all species seeds that were utilized yearly (Table 2).The fruiting of this species even consumed by humans and used as a source of income in local markets. Similarly, study by (Yihew Biru and Afework Bekele, 2012; Inogwabini *et al*., 2013) showed, elephants were frequently observed in the forest during fruiting season while local peoples disseminated to gather fruit. Aime *et al*. (2020) also reported that fruiting and mature crops were targeted by elephant raids much more. In this study, as key informants replied, climate change also affects the seasonal food availability and water for elephants. Similarly, (Whitehouse and Schoeman, 2003; Tammie Matson, 2009; Rajapandian *et al*., 2019) also reported that climate change is likely to affect these seasonal movements of elephants, but it may also affect or reduced the availability of food and water. Elephants utilized most of *Acacia* species during wet and dry season; however, the amount of utilization was high during wet season (Table 2). Similarly, Caister *et al*. (2003) were reported as *Acacia* species were palatable during wet and dry seasons; due to the high crude protein content, low fibre and high-water content of the species (Calenge *et al*. 2002; Parker *et al*. 2003). Based on direct observations and dung analysis it has been showed that, there was no significant difference among the species consumed across seasons (i.e., most of the species were consumed irrespective to seasons) (Table 2). In general, there were a significant difference amount of seeds in the dungs were observed in the wet season (Mean value *(X) = 83.71, SD=167.202;* V^2 *=27956.39, DF=23, at 95% CI*). In this study, some species like-*Acokanthera schimperi*, *Bersema abyssinica*, *Calpurnea aurea*, *Euphorbia abyssinica*, *Pinus patula* and *Pyrostria phyllanthoidea* were observed in the place where dung taken (i.e., riverine habitat) (Appendix I: Table 1). However, the seeds of the species were not observed in the diet observation (Table 2). Relatively high mean seed per dung bolus were observed when the seeds composition in the dung were increased (Table 2). This shows, there were positively correlation between seeds found during the wet/dry seasons, and mean seed per dung bolus (i.e., correlation is significant at the 0.01 level; 2-tailed t-test) were observed (Table 2). In general, the dietary composition and food preferences were used to identify those plant species that are essential for sustainability of elephants.

3.2. Basal area (BA), Relative densities and Importance value of woody species

In this study, from the sampled taken, the total floristic composition of the BES was estimated as 36(53%) shrubs and 32 (47%) trees (Table 3) (Appendix I: Table 1). Similarly, (Zalaem Woodu, 2007; Anteneh Belay and Sebsibe Demesiew, 2011) were reported as shrubs and climbers were dominated the floristic composition of the sanctuary. The domination of shrubs species might be specialization of the different species to different dispersal agents. For instance, wind can carry light seeds with thin cotyledons; due to this, some of the plant species may have a wide range of dispersal. This finding is similar with (Zalalem Wodu, 2007; Anteneh Belay and Sebsibe Demesiew, 2011) those reported, due to bird dispersed fruits and able to recolonize the areas successfully, shrubs were dominated in the floristic composition of the sanctuary. So, high dominance values species are crucial to meet the high feed requirements of the elephants. Elephants, utilize woody species in relation to their size and relative abundance. In this study, as observed in the field and key informants replied, elephants prefer small size classes of woody plants for feeding

DOI: 10.47504/IJAGRI.2022.V3.1.1

easily. However; large trees could be selected only when the preferred small size classes were not available. For instance, woody species (*Opuntia stricta*, BA=0.08M^2/ha and *Acacia tortills*, BA=1M^2/ha) in riverine; (*Berchemia discolour*, BA=1.06M^2/ha and *Euphorbia abyss inica*, BA=0.25M^2/ha) in woodland; and (*Grewia schweinfurthii*, BA=0.15M^2/ha and *Acacia nigrii*, BA=0.2M^2/ha) in bush land areas were some of the small size class of woody plants (i.e., shrubs and trees) that were utilized more by elephants in the sanctuary. (Table 3). Similarly, Laws *et al*. (1975) were reported as elephants feed only large trees when small size classes of woody plants were not occurred.

Table 3. Basal area, Dominance, Relative densities and Importance Value Indices of woody species in the three selected habitats of BES

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Scientific names	BA(M^2/ha)	Freq.	R/f (%)	Dom.	R/dom.(%)	Den.(sp//ha)	R/den.(%)	IVI	Habitat types
Acacia abyssinica Hochst.ex Benth (*T)	2.64	8	0.02	488	5.21	257	1.87	7.10	WLH
Acacia oerfota (Forssk.) Schweinf.(*SH)	0.54	2	0.50	5	0.06	56	0.40	0.97	WLH
Acacia brevispica Harms. (*SH)	0.09	2	1.54	2	0.13	4	0.11	1.78	RH
	2.18	4	0.01	116	1.23	147	1.07	2.31	WLH
	0.35	10	3.00	21	1.19	68	1.68	5.87	BLH
Acacia bussie Harms ex.Sjostedt (*T)	1.77	7	5.38	89	7.48	13	0.32	13.2	RH
	4.27	25	0.06	1644	17.54	171	1.25	18.8	WLH
	0.4	22	6.61	30	1.67	38	0.94	9.22	BLH
Acacia etbica Schweinf.(*T)	5.58	20	0.05	1618	17.26	16	0.12	17.4	WLH
	0.5	7	2.10	11	0.01	35	0.87	2.97	BLH
Acacia mellifera (Vahl) Benth.(*T)	2.18	6	4.62	46	3.87	6	0.14	8.62	RH
	0.66	11	0.03	157	1.68	240	1.75	3.45	WLH
Acacia nigrii(*SH)	1.07	8	6.15	48	4.07	63	1.52	11.7	RH
	4.9	6	1.51	926	9.88	350	2.55	13.9	WLH
	0.2	63	18.9	1118	62.41	986	24.45	106	BLH
Acacia nilotica (L.) Wild. Ex Del.(*T)	3.14	2	1.54	13	1.06	22	0.54	3.14	RH
	0.79	16	4.03	295	3.15	261	1.90	9.08	WLH
	0.25	1	0.30	1	0.03	22	1	1	BLH
Acacia robusta Burch.(*T)	2.18	32	24.6	606	51.25	97	2.35	78.2	RH
	0.6	1	0.30	2	0.13	44	1.10	2	BLH
Acacia seyel Del.(*T)	3.14	2	1.54	47	3.98	83	2.03	7.55	RH
	1.06	6	1.51	83	0.88	144	1	3.44	WLH
	0.3	2	0.60	1	0.03	11	0.5	0.91	BLH
Acacia tortills (Forssk) Hayne(*T)	1	16	12.3	72	6.09	50	1.22	19.6	RH
	1.77	17	4.28	481	5.13	313	2.28	11.7	WLH
	0.45	16	4.80	34	1.88	52	1.29	7.98	BLH
Acokanthera schimperi (A.DC.) Schweinf.(*T)	1	2	1.54	2	0.17	28	0.68	2.38	RH
	0.35	1	0.25	6.3	0.07	200	1.46	1.78	WLH
Aloe pirottae Berger(*SH)	0.35	1	0.25	1	0.01	33	0.24	0.51	BLH
Asparagus leptoclododius(*SH)	0.35	2	0.50	16	0.17	500	3.64	4.31	WLH
Balanities aegyptica (L.) Del.(*T)	2.19	7	5.38	42	3.52	30	0.73	9.64	RH
	2.64	7	1.76	256	2.73	154	1.12	5.62	WLH
	0.4	1	0.30	1	0.04	21	0.52	0.87	BLH
Berchemia discolor (Klotzsch) Hemsl.(*T)	3.14	3	2.31	9	0.80	10	0.24	3.35	RH
	1.06	35	8.82	568	6.06	170	1.24	16.1	WLH
Berchemia discolor (Klotzsch) Hemsl.(*T)	0.55	10	3.00	41	2.30	83	2.07	7.37	BLH
Bersema abyssinica (*SH)	0.54	1	0.77	4	0.32	78	1.89	2.98	RH
	1.23	10	2.52	148	1.57	133	0.97	5.06	WLH

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	0.35	4	1.20	3	0.18	25	0.62	2.00	BLH
Boscia minimifolia Chiov. (*T)	0.3	6	1.80	5	0.30	33	0.83	2.93	BLH
Cadaba farinosa Forssk(*T)	0.35	2	0.50	6	0.06	94	0.69	1.25	WLH
Calpurnea aurea (Lam.)Benth.(*SH)	1.40	1	0.77	3	0.24	22	0.54	1.55	RH
	0.79	2	0.50	5	0.06	39	0.28	0.85	WLH

Calpurnea aurea (Lam.)Benth.(*SH)	0.2	3	0.90	2	0.12	41	1.01	2.03	BLH
Capparis sepiaria L.(*SH)	0.20	1	0.25	2	0.03	133	0.97	1.25	WLH
Capparis tomentosa Lam.(*SH)	1.77	9	2.27	292	3.12	204	1.48	6.87	WLH
Cordia monoica Roxb.(*T)	0.35	1	0.25	4	0.04	111	0.81	1.10	WLH
Cardia ovalis R.Br.(*SH)	0.54	2	0.50	6	0.06	61	0.44	1.01	WLH
Carisaa spinarum L.(*SH)	0.5	1	0.25	25	0.27	139	1.01	1.53	WLH
Carisaa spinarum L.(*SH)	0.15	6	1.80	5	0.26	57	1.42	3.48	BLH
Dichrostachys cinerea (L.) Wight & Arn.(*T)	3.68	2	1.54	7	0.62	11	0.27	2.43	RH
	0.54	15	3.78	132	1.41	11	0.08	5.26	WLH
	0.15	4	1.20	9	0.49	161	3.99	5.68	BLH
Dobera glabra (Forssk) Poir.(*SH)	0.79	3	2.31	3	0.27	15	0.36	2.93	RH
	0.5	1	0.30	1	0.06	22	0.55	0.91	BLH
Dodonoea angustifolia L. f.(*SH)	0.2	3	0.76	3	0.03	56	0.40	1.19	WLH
	0.25	1	0.30	1	0.06	11	0.28	0.63	BLH
Dracaena afromontana Mild br.(*T)	0.35	28	7.05	250	2.67	284	2.07	11.8	WLH
	0.15	19	5.71	15	0.84	58	1.45	7.99	BLH
Ehretia cymosa Thonn.(*T)	0.79	1	0.77	1	0.07	11	0.27	1.11	RH
Euclea racemosa Murr.Ssp.(*SH)	0.25	2	0.50	12	0.12	256	1.86	2.49	WLH
	0.2	2	0.60	1.2	0.07	33	0.83	1.49	BLH
Euclea schimperi(*SH)	0.2	2	0.50	18	0.19	494	3.60	4.29	WLH
	0.15	32	9.61	50	2.77	115	2.85	15.2	BLH
Euphorbia abyssinica Gmel.(*SH)	0.35	1	0.77	11	0.32	4	0.27	1.36	RH
	0.25	12	3.02	346	3.69	1282	9.34	16.1	WLH
	0.25	16	4.80	180	10.04	500	12.39	27.2	BLH
Ficus sur Forssk. (*T)	0.3	2	0.60	2	0.10	33	0.83	1.53	BLH
Ficus thonningii Blume. (*SH)	0.3	2	0.50	3	0.04	61	0.44	0.98	WLH
Ficus vastaa Forssk.(*T)	0.7	4	1.01	19	0.20	75	0.55	1.76	WLH
	0.45	4	1.20	4.05	0.25	25	0.62	2.05	BLH
Grewia erythraea Schweinf.(*SH)	0.45	7	1.76	104	1.10	365	2.66	5.53	WLH
	0.15	3	0.90	2	0.09	41	1.01	2.00	BLH
Grewia schweinfurthii.Burret(*SH)	0.20	1	0.77	1	0.05	11	0.27	1.09	RH
	0.2	14	3.53	194	2.07	771	5.61	11.2	WLH
	0.15	40	12.0	138	7.72	256	6.35	26.1	BLH
Grewia villosa Willd.(*SH)	0.2	8	2.02	32	0.34	221	1.61	3.96	WLH
Jasminum floribundum(*SH)	0.5	5	1.26	45	0.47	198	1.44	3.17	WLH
Justcia schimperiana T. Anderson(*SH)	0.25	2	0.50	30	0.32	667	4.85	5.68	WLH
Kleinia squarrosa Cufod(*SH)	0.3	5	1.26	19	0.20	138	1.00	2.46	WLH
Lanthana camara L.(*SH)	0.09	10	7.69	47	3.96	598	15	26.2	RH
	0.15	1	0.30	5	0.25	333	8.26	8.81	BLH
Maytenus arbutifolia (Hochst.exA.Rich)R.Wilczek (*SH)	0.25	1	0.25	5	0.05	200	1.46	1.76	WLH
Ochna inermis (Forssk) schweinf.expenzing (*SH)	0.35	3	2.31	7	0.56	70	1.71	4.58	RH
	0.45	5	1.26	69	0.73	340	2.48	4.47	WLH
	0.1	6	1.80	1	0.07	144	3.58	5.46	BLH
Olea europaea L.cuspidata (Wall.exG. Don)Cif.(*T)	0.35	12	3.02	89	0.95	235	1.71	5.68	WLH
	0.3	6	1.80	37	2.04	226	5.60	9.44	BLH

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Oncoba spinosa Forssk.(*T)	0.7	1	0.77	1	0.06	11	0.27	1.10	RH
Opuntia stricta (Haworth)(*SH)	0.08	7	5.38	51	4.28	1003	24.43	34.1	RH
	0.25	2	0.60	1	0.06	44	1.10	1.76	BLH
Opuntia ficus-indica(L) Miller (*SH)	0.2	1	0.77	3	0.25	167	4.06	5.08	RH
Osyris quadripartita Decn.(*T)	0.4	2	0.50	1	0.01	17	0.12	0.64	WLH

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Piliostigma thonningii (Schum.)(*T)	0.2	4	1.01	46	0.49	639	4.65	6.15	WLH
Pinus patula Schiede ex Schltdl. & Cham.(*T)	2.2	1	0.77	7	0.56	22	0.54	1.87	RH
Premna schimperi Engl.(*SH)	0.2	11	2.77	61.6	0.66	311	2.27	5.69	WLH
Pittoserum viridiflorum Sims(*SH)	0.25	5	1.26	160	1.71	1424	10.37	13.3	WLH
Pyrostria phyllanthoidea (Baill.)Bridson.(*SH)	0.2	1	0.77	10	0.85	556	13.53	15.1	RH
	0.15	4	1.01	18	0.19	333	2.43	3.63	WLH
	0.1	2	0.60	1	0.06	122	3.03	3.69	BLH
Rhys glutinous (*T)	0.15	2	0.60	1	0.06	78	1.93	2.59	BLH
Rhus vulgaris Meike (* SH)	0.45	10	2.52	96	1.02	237	1.72	5.26	WLH
Ricinus communis L (*SH).	0.1	1	0.77	9	0.76	1000	24.36	25.9	RH
Scolopia theifolia Gilg. (*SH)	0.45	1	0.25	2	0.02	56	0.40	0.68	WLH
Steganotainia aralaceae Hochst.(*SH)	0.1	5	1.50	2	0.09	189	4.68	6.28	BLH
	0.2	3	0.76	9	0.09	163	1.19	2.04	WLH
Sterculia africana (*T)	0.5	2	0.60	2	0.11	22	0.55	1.26	BLH
Tamarindus indica.L(*T)	3.14	2	1.54	28	2.35	17	0.41	4.29	RH
	0.35	4	1.01	23	0.24	181	1.31	2.56	WLH
Tamarindus indica.L(*T)	0.25	3	0.90	2.5	0.00	56	1.38	2.28	BLH
Terminalia brownie Fresen.(*T)	2.64	2	1.54	26	2.23	56	1.35	5.12	RH
	0.2	12	3.02	275	2.93	127	0.93	6.88	WLH
	0.55	28	8.41	61	3.41	44	1.09	12.9	BLH
Trachilia emitica Vahl.(*T)	4.27	1	0.77	4	1.4	17	0.27	2.44	RH
Vernonia amygdalina Del.(*SH)	0.1	1	0.25	2	0.02	222	1.62	1.89	WLH
Ziziphus spina christi (T.) Desf.(*T)	1.06	3	2.31	44	3.72	30	0.72	6.75	RH
	0.45	11	2.77	48	0.51	108	0.79	4.07	WLH

Note: BA=Basal area (M^2/ha); Freq.= frequency, R/f(%)= Percentage of Relative frequency, Dom.=Dominance of the species; R/dom.(%) = Percentage of Relative dominance; spp./ha= Density of species; R/den (%)= Percentage of Relative density; IVI= Importance Value Index , RH= Riverine Habitat, WLH= Woodland Habitat, and BLH=Bush land Habitat

About 11 types of *Accacia* species were abundantly/distributed in BES (Table 3), and 9 of the species were highly utilized (Appendix Table 1). Similarly, Anteneh Belayneh (2006) and Zalalem Woodu (2007) were reported as there were wide distributions of *Accacia* species in many parts of the BES. In this study, for instance, *Acacia robusta* (51.25%), *Acacia bussie* and *Acacia etbica* (34.8%) and *Acacia nigrii* (62.41%) (Table 3) were dominated (i.e., have high relative dominance) in the riverine, woodland and bush lands habitats of BES respectively. The result showed that higher value of IVI's of woody species such as: (*Acacia robusta*, IVI= 78.2) and *Opuntia* stricta, IVI= 34.1) in riverine; (*Acacia* bussie, IVI= 18.8 and *Acacia etbica*, IVI= 17.4) in woodland habitats; and (*Acacia nigrii*, IVI=106) in bush land habitats were more utilized by elephant and considered as the most important species (Table 3). Lower IVI's may indicate that the woody species are threatened. In this study, among the top woody species browsed by elephants, *Acacia nilotica, Acacia tortilis*, *Balanites aegyptiaca, Berchemia discolor* and *Tamarindus indica* were accounted for only 3.41% the total density in riverine habitat While *Acacia etbaica, Acacia nilotica, Acacia tortilis, Balanites aegyptiaca, Berchemia discolor* and *Tamarindus indica* were accounted for only 7.97 % and 7.13% of the total density in woodland and bush land habitat respectively were suggested as highly threated species in the sanctuary (Table 3). Similar findings were reported by Anteneh Belayneh and Sebsebe Demesew (2011), *Acacia tortilis, Acacia nilotica, Acacia etbaica, Balanites aegyptiaca, Balanites glabra, Berchemia discolor,Oncoba spinosa, Salvadora persica* and *Tamarindus indica* accounted for only 1.9% of the total density, suggesting that they are highly threatened. Generally, high pressure on the preferred browse trees may further lead to declination of feed resources by which it might affect the survival of elephants.

3.3. Impact of elephants on woody species

In this study, total number of 87 (42.44%) woody species in riverine, 597(71%) in woodland and 840 (62.7%) in bush land areas were impacted by elephant. Specifically, based on woody species types; 23 (i.e., 11 trees/12shrubs) in riverine, 36 (i.e., 18 trees/18 shrubs) in woodland and 19 (i.e., 12trees/ 7shrubs) in bush land habitats were identified respectively (Appendix I: Table 1). However; about 36 woody species types (15 trees and 21shrubs) were not impacted by elephants (Appendix I: Table1). For instance, *Acokanthera schimperi* in riverine; *Rhus vulgaris* in woodland and *Grewia erythraea* in bush land habitat were some of it (Appendix I: Table1).This finding is greater number than Wodu zalalem (2007) reported as there were no impacts of elephants

DOI: 10.47504/IJAGRI.2022.V3.1.1

on 27 woody species. Elephants were negatively affected the woody plants parts of primary/secondary branches, main stem (i.e., heavily browsing/bark stripping) and whole tree uprooting were observed (Figure 3.1a and 3.1b). Similarly, findings by Hatt and Clauss (2006) and Stephenson (2007) indicated that elephants graze and browse on a wide range of plant species and exerting a major impact through felling, debarking, splitting stems, breaking leader shoots, and/or damaging trees and shrubs. For instance, breaking-off branches and pushing over/uprooting trees and shrubs by elephants were seen during data collection in one of the study site (i.e., Erer Ebada) (Figure 3.1b).

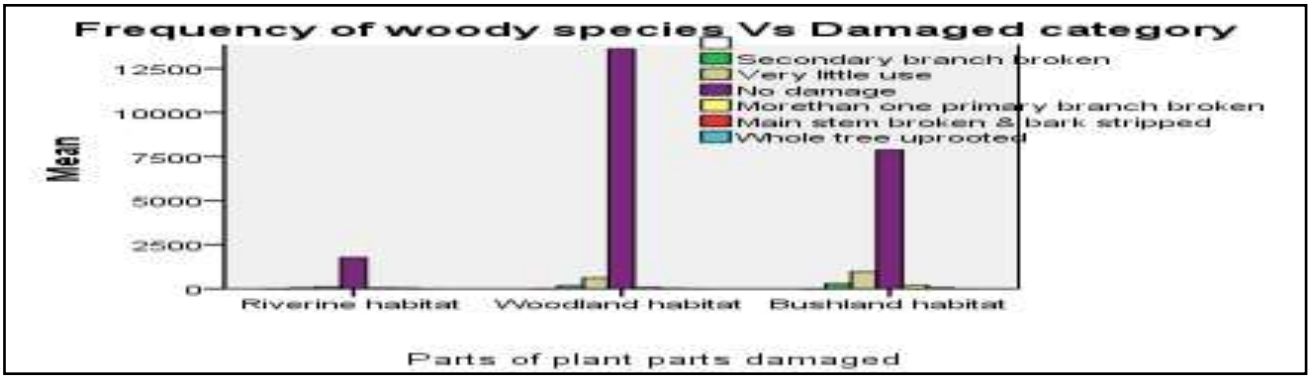

Figure 3.1a. Average frequency and parts of impacted woody species by elephants in the three land units of BES

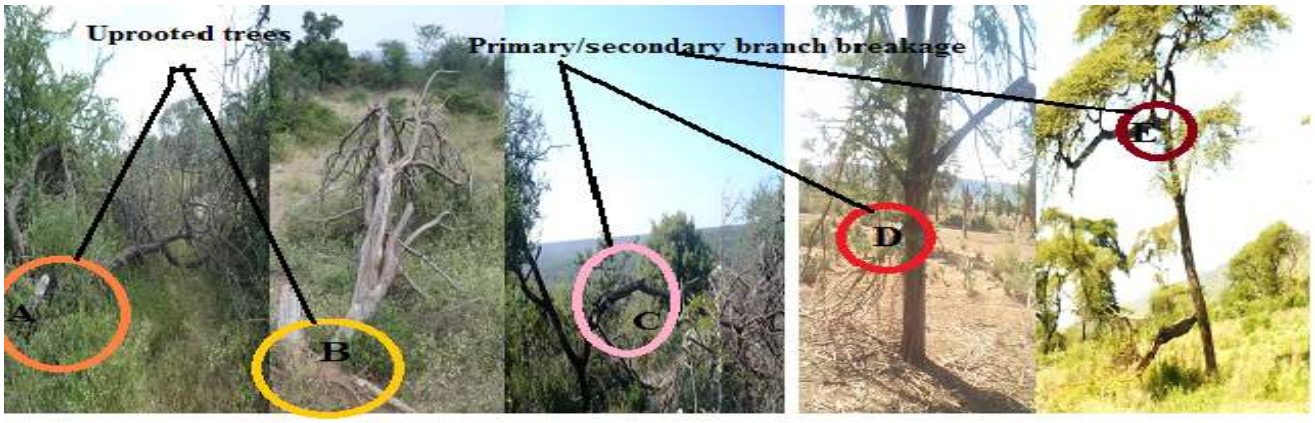

Figure **3.1b. Impacted parts of woody species by elephants in Ererebada Peasant Association of BES**

There were a significant difference were observed on average frequency and impacted woody species that were very little used by elephants and others (mean value *(X) =549, SD=439.97, V^2=193,572 and at 95%CI*). However, insignificant differences were occurred on the whole tree uprooted effects in the three land units (mean value *(x) =7, SD=3, V^2=9, at 95% CI*) (Figure 3.1a). In general, in this study, various parts of plant (i.e., leaves, bark, roots, stems and twigs) were consumed by elephants to satisfy their dietary requirements. However, the impacted plant tissues might affect the relative growth, survival and reproductive output (Figure 3.1b). Similarly, Huntly (1991) reported that elephants may have an effect on woody vegetation/biomass loss and influence the vegetation structure, community composition and ecosystem processes. Regarding average impact proportion Vs. parts of plant damaged effects, riverine vegetation's have a higher impacted proportion (0.33) of uprooted trees/shrubs than woodland vegetation (0.17) and less from bush land (0.47) (Figure 3.1c). Comparatively, more impact was occurred in bush land habitat (Fig. 3.1c) (i.e., have maximum (5) average impact proportions). In general, the overall mean proportion of impacted woody species, ranged from 0 to 5 for all impacts, and 0.08 to 5 for severe impacts following an adjusted for the relative sampling intensity (Figure 3.1c).

DOI: 10.47504/IJAGRI.2022.V3.1.1

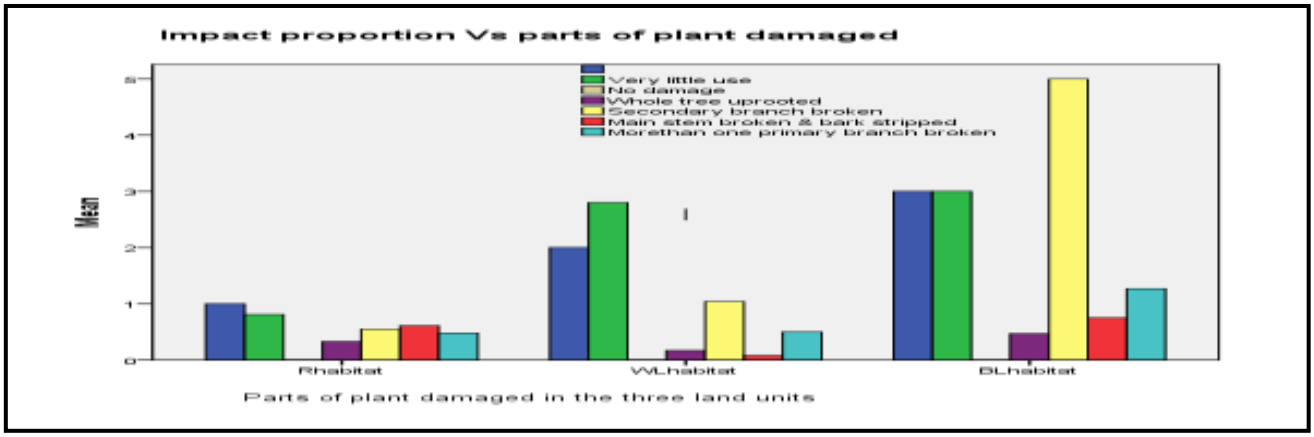

Figure 3.1c. Average proportion of impacted parts of woody species by elephants in the three land units of BES

Among trees, different proportions of impacted trees per diameter size class per vegetation types were observed in (Figure 3.1d). More saplings and small sized trees were trampled and consumed by elephants more in bush land than woodland and riverine forest habitat (Figure 3.1d) while medium sized trees and large trees were highly impacted in woodland and riverine forest habitat (Figure 3.1d). The majority of small trees and medium-and large sized trees had either broken stems breakage or entirely felled in riverine and woodland vegetation (Figure 3.1d). Similarly, Wodu zalalem (2007) reported that in the woodland habitats, large, medium and small trees sized showed an impact levels above the overall mean across all stems. In general, there were significant damaged (i.e., the highest average percentage frequency) were occurred on small trees size class (mean value *(X) =2.2 and SD= 181.6, V^2 =32,977, DF=2 at 95% CI*).

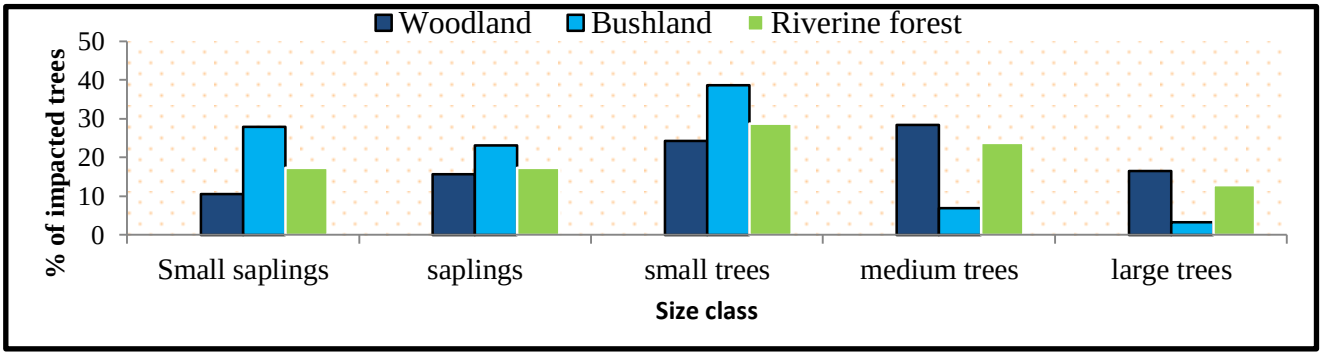

Figure 3.1d. Proportion of impacted trees per diameter size class per vegetation type

4. CONCLUSION

The study identified feeding preference and impact of African elephants on woody species composition in BES. The floristic composition of the sanctuary was dominated by shrubs (53%) than trees (47%). The elephants showed a positive and a negative preference for woody species utilized and around three -fourth of the woody species in the sanctuary were more preferred. The shrub species (*Opuntia ficus-indica* ,PI=+2.0328) and the tree species (*Acacia seyel*, PI=+3.3033) were the most preferred and consumed by elephants while tree species (*Dichrostachys cinerea*, PI=- 0.4620) and *Dodonoea angustifolia* (PI= - 0.4033) were the most un utilized. Moreover, the higher importance value indices (IVI) of woody species (i.e., *Acacia robusta* tree, IVI= 78.2 and *Opuntia stricta* shrub, IVI= 34.1) were most pioneer and have high ecologically important value in the riverine habitat of the sanctuary. However; other lower IVI's (e.g., *Acacia oerfota*, IVI=0.97 and *Acacia robusta*, IVI=0.91) of woody species were some of threatened. The dietary compositions of seeds in the dung were high in the wet season (71%) than dry season (29%) showing variation of its use across seasons. Various damage was occurred by elephant on different parts (i.e., main steam, primary and secondary branch) and stage of development of woody species (e.g., through trampling, feeding on and uprooting). Specifically, saplings and small sized trees were more negatively affected by elephants in bush lands while medium and large sized trees also highly affected in woodland and riverine habitat. In general, the high pressure on the preferred browse trees may lead to further decline in feed resources which in turn negatively affect the survival of elephants. So, this study on dietary composition, impact of elephants on woody species and food preferences of elephants brings important contributions for sustainability of elephants in the sanctuary. So, there is a need for immediate conservation measure on preferred plants species by the Elephants.

DOI: 10.47504/IJAGRI.2022.V3.1.1

ACKNOWLEDGEMENTS

We thank Addis Ababa University, the centre for Environmental science, for rearranging the study program. Special thanks also go to local peoples who were experienced in identifying the plant species, staff and scouts of BES who were helped while collecting data. I am also grateful to Ambo University for given permission to use their library. Finally, I thank the Ethiopian Wildlife Conservation Authority and Addis Ababa University for supporting some fund to carry out the study.

DECLARATION

Ethical consent for publication: Not applicable

Conflict of interest: The authors declare that there are no competing interests

Authors' contribution: Corresponding authors' work was starting from data collections, writes up of the draft, editing and approved while co-authors/supervisor work was editing and approved the manuscript.

REFERENCES

Ahimsa Campos-Arceiz ,Jamie Wadey; Hawthorne L. Beyer; Salman Saaban; Nasharuddin Othman; Peter Leimgruber (2018). Why did the elephant cross the road? The complex response of wild elephants to a major road in Peninsular Malaysia

Aimé Compaore, Djidama Sirima, Emmanuel M. Hema, Benoît Doamba, Stephanie N. Ajong, Massimiliano Di Vittorio, Luca Luiselli,(2020). Correlation between increased human-elephant conflict and poaching of elephants in Burkina Faso (West Africa). *European Journal of Wildlife Research* 66: 24, https://doi.org/10.1007/s10344-019-1329-8

Amusa, T.O., Omonu, C. Olabode, E ., Newton, N.J(2017). Population and Distribution of Forest Elephants(Loxodonta cyclotis Matschie, 1900) in Okomu National Park and Omo Forest Reserve, South- Western Nigeria. *Journal of Research in Forestry, Wildlife & Environment*, Vol. 9(2):44-56

Anabelle W. Cardoso, Yadvinder Malhi, Imma Oliveras,David Lehmann, Josue ´Edzang Ndong,Edmond Dimoto, Emma Bush *et al*.(2020). The Role of Forest Elephants in Shaping Tropical Forest–Savanna Coexistence. *Ecosystems* 23: 602–616 https://doi.org/10.1007/s10021-019-00424-3

Anteneh Belayneh (2006). Floristic description and Ethno botanical study of the natural vegetation in Babile Elephant Sanctuary, Ethiopia. M.Sc.Thesis, Addis Ababa University, Ethiopia.

Anteneh Belayneh, Sebsebe Demissew (2011). Diversity and population structure of woody species browsed by elephants in Babile Elephant Sanctuary, eastern Ethiopia: an implication for conservation, Agriculture and Forestry 3: Pp. 20-32.

Ashokkumar Mohanarangan , Sudhakar Kaliyaperumal , Swaminathan Shanmugavelu , Ajay A Desai (2021). Age-Specific Differences in Asian Elephant Defecation, Dung Decay, Detection and Their Implication for Dung Count. DOI: 10.21203/rs.3.rs-575344/v1

Bansiddhi P, Brown JL, Thitaram C, Punyapornwithaya V, Somgird C, Edwards KL, Nganvongpanit K. (2018). Changing trends in elephant camp management in northern Thailand and implications for welfare. *PeerJournal*, https://doi.org/10.7717/peerj.5996

Berliani. K., H S. Alikodra , B Masy'ud , M D Kusrini (2018). Food preference of Sumatran elephant (Elephas maximus sumatranus) to commodity crops in human-elephant conflict area of Aceh, Indonesia. *Journal of Physics*, doi:10.1088/1742-6596/1116/5/052015

Buchholtz EK, Redmore L, Fitzgerald LA, Stronza A, Songhurst A and McCulloch G (2019). Temporal Partitioning and Overlapping Use of a Shared Natural Resource by People and Elephants. *Frontiers in Ecological and Evolution* 7:117. doi: 10.3389/fevo.2019.00117

Caister, L. E., W. M. Shields & A. Gosser (2003). Female tannin avoidance: a possible explanation for habitat and dietary segregation of giraffes (*Giraffacamelo pardalis peralta*) in Niger. *African Journal of Ecology* 41: 201-213

Calenge, C., D. Maillard, J. M. Gaillard, L. Merlot & R. Peltier (2002). Elephant damage to trees of wooded savanna in Zakouma National Park. *Journal of Tropical Ecology* 18: 599-614.

Collins, N. (2018). Sumatran elephant Elephas maximus sumatranus density and habitat use in relation to forest characteristics in the Leuser Ecosystem, North Sumatra. Masters Thesis (Masters). Bournemouth University

Crespo Mingueza, Laia (2018). Presence and habitat use of the endangered Bornean elephant (Elephas maximus borneensis) in the INIKEA rehabilitation project site (Sabah, Malaysia). Master degree thesis in Biology at the Department of Wildlife, Fish, and Environmental Studies. Swidish University of Agricultural Sciences

Curtis, J.T. and McIntosh (1951). An upland forest continuum in the prairie-forest borde region of Wisconsin. Ecology 32:

Debebe Dana (2018). Impact of African Elephant (*Loxodonta africana*) on Flora and Fauna Community and Options for Reducing the Undesirable Ecological Impacts. Journal of Biology, Agriculture and Healthcare, Vol (8):7

Emily Neil and Elizabeth Greengrass (2021). Illegal settlement in the Babile Elephant Sanctuary is threatening the resident elephant population**.** *Oryx*, DOI: 10.1017/S0030605320001088

DOI: 10.47504/IJAGRI.2022.V3.1.1

Hatt, J M; Clauss, M. (2006). Feeding Asian and African elephants *Elephas maximus* and *Loxodonta africana* in captivity. *International Zoo Yearbook* 40(1):88-95

Hiscock's K. (1999). The impact of an increasing elephant population on the woody vegetation in southern Sabi and Wildtuin, South Africa. Koedoe 42(2): 47 – 55.

Huntly, N. (1991). Herbivores and the dynamics of communities and ecosystems. *Annual Review of Ecology and Systematics.* Vol. 22,477–503.

Inogwabini, B.-I., Mbende, L., Bakanza, A., & Bokika, J. (2013). Crop damage done by elephants in Malebo Region, Democratic Republic of Congo. *Pachyderm, 54,* 59-65. Retrieved from https://pachyder mjournal.org /index.php /pachyderm /article/ view/340

Lamichhane BR, Persoon GA, Leirs H, Poudel S, Subedi N, Pokheral CP, et al. (2018). Spatio-temporal patterns of attacks on human and economic losses from wildlife in Chitwan National Park, Nepal. *PLoS ONE* 13(4): e0195373.https: //doi.org/10.1371/journal.pone.0195373

Laws, R.M., Parker, I.S.C., and Johnstone, R.C.B. (1975). Elephants and their habitats. The Ecology of Elephants in North Bunyoro, Uganda. Oxford, Clarendon Press. 376 pp.

Lin, Thin Zar, and Thida Myint (2020). "Utilization of Plants by Working Elephants in East Bago Region.", 3 rd. Myanmar Korea Conference, *Research Journal* Vol.3 (3): 963-971

Lorena Benitez, Simon A., Queen Borough (2021). Fruit trees drive small-scale movement of elephants in Kibale National Park, Uganda.The Scientific *Journal of the Association for Tropical Biology and Conservation,* 53(6):1620-1630. https://doi.org/10.1111/btp.13010

Luke J. Wilson, M Timm Hoffman, Angela J., Ferguson, David H.M. Cumming (2021). Elephant browsing impacts in a Zambezian *Baikiaea* woodland with a high density of pumped waterholes. *Global energy and conservation,* https://doi.org/10.1016/j.gecco.2021.e01854

Mahendra K. Satapathy (2020). Addressing the Issues of Hidden Hunger: Looking For Plants as Food Resources In The Wild. Department of Botany, Regional Institute of Education (NCERT), International Journal of Education & Social Sciences, 1(1):11-21

Mahendra K. Satapathy, Sidhanta S. Bisoi* and Sanjeeb K. Das (2018). Study of floral diversity from rural pockets of Odisha, India: Plants for fun and games. International Journal of Biodiversity and Conservation, Vol. 10(5), pp. 246-257, DOI: 10.5897/IJBC2017.1134

Mahesha, Perera; Rajnish, Vandercone (2020). Some aspects of seed dispersal by Asian elephants (Elephas maximus) in Kaudulla National Park, Sri Lanka. *Current Science* Vol. 118 (4):648-654

Makoshane Q. Seloana, Jorrie J. Jordaan, Martin J. Potgieter, Johan W.Kruger (2018). Feeding patterns of elephants at the Atherstone Collaborative Nature Reserve. *African Journal of Ecology,* https://doi.org/10.1111/aje.12422

Mariam Tsalyuk, Werner Kilian, Bjorn Reineking, Wayne arcus Getz (2019). Temporal variation in resource selection of African elephants follows long-term variability in resource availability. *Ecological society of America,* 89(2):1-19. https://doi.org/10.1002/ecm1348

Melissa H. Schmitt, Adam Shuttleworth, David Ward, and Adrian M. Shrader (2018). African elephants use plant odours to make foraging decisions across multiple spatial scales *Animal Behaviour,* pp.1-41

Moolman L, Ferreira SM, Gaylard A, Zimmerman D, Kerley GIH (2019). The decline of the Knysna elephants: Pattern and hypotheses. *South African Journal of Science,* 115(3/4):7 https://doi.org/10.17159/ sajs.2019/4805

Mrinmay Mandal and Nilanjana Das Chatterjee (2021). Geospatial approach-based delineation of elephant habitat suitability zones and its consequence in Mayurjharna Elephant Reserve, India. *Environment, Development and Sustainability* 23:17788–17809. https://doi.org/10.1007/s10668-021-01412-1

Norkaew T, Brown JL, Bansiddhi P, Somgird C, Thitaram C, Punyapornwithaya V, et al. (2018). Body condition and adrenal glucocorticoid activity affects metabolic marker and lipid profiles in captive female elephants in Thailand. PLoS ONE 13(10): e0204965. https://doi.org/10.1371/journal.pone.0204965

Norman Owen-Smith, Jonas Chafota (2012). Selective feeding by a mega herbivore, the African elephant (*Loxodonta africana*).*Journal of Mammalogy* 93(3): 698–705, https://doi.org/10.1644/11-MAMM-A-350.1

Owen-Smith N, Chafota J (2012). Selective feeding by a mega herbivore, the African elephant (*Loxodonta africana*). J Mammal 93:698–705. https://doi.org/10.1644/11-mamm-a-350.1

Pandey K.P., Adhikari Y. P., Weber R, M.(2016). Structure, Composition and Diversity of Forest along Altitudnal Gradients in the Himalayas, Nepal. *Applied Ecology and Environmental Research,* DOI:10.15666/aeer/1402_235251

Parker, D. M., R. T. F. Bernard & S. A. Colvin. (2003). The diet of a small group of extra-limital Giraffe. *African Journal of Ecology* 41: 245-253

Peter F. Scogings, Stuart Demmer, Dawood Hattas (2021). Spinescence and Total Phenolic Content Do Not Influence Diet Preference of a Critically Endangered Megaherbivore, but the Mix of Compounds Does. *Journal of Chemical Ecology,* 47:322–333. https://doi.org/10.1007/s10886-021-01258-x

Phyllis C. Lee and C. Elizabeth Webber (2020). Play in Elephants: Wellbeing, Welfare or Distraction? Behaviour and Evolution Research Group, Psychology, Faculty of Natural Sciences, University of Stirling, Stirling FK9 4LA, UK

DOI: 10.47504/IJAGRI.2022.V3.1.1

Phyllis C. Lee and C. Elizabeth Webber (2020). Play in Elephants: Wellbeing, Welfare or Distraction? Behaviour and Evolution Research Group, Psychology, Faculty of Natural Sciences, University of Stirling, Stirling FK9 4LA, UK

Priscilia Wangui Kinyanjui (2020). Effects of African elephant (Loxodonta africana) Population on vegetation around water points in Arabuko Sokoke forest, Kilifi country, Kenya. A Thesis Submitted in partial fulfillment for the Degree of Master of Environmental Science in the School of Environmental Studies of Kenyatta University.

Rachmat B. Suba, Nils G. P. Beveridge, Wawan Kustiawan , Geert R. de Snoo , Hans H. de Iongh, Sip E. van Wieren, Young Hae Choi & Hye Kyong Kim (2020). Food preference of the Bornean elephant (Elephas maximus borneensis) in North Kalimantan Province, Indonesia, and its conservation implications. *Conservation and Ecology*, DOI: 10.26107/RBZ-2020-0090 , RAFFLES BULLETIN OF ZOOLOGY 68: 791–802

Raj Kumar Koirala, David Raubenheimer , Achyut Aryal, Mitra Lal Pathak and Weihong J (2016). Feeding preferences of the Asian elephant (Elephas maximus) in Nepal. *Bio Med Central Ecology* 16:54, DOI 10.1186/s12898-016-0105-9

Rajapandian Kanagaraj,Miguel B. Araujo,Rathin Barman,Priya Davidar,Rahul De,Dinesh K. Digal,G. V. Gopi,A. J. T. Johnsingh,Kashmira Kakati,Stephanie Kramer-Schadt et al. (2019). Predicting range shifts of Asian elephants under global change(2019). Journal of conservation and biogeography, 25(5): 822-838, https://doi.org/10.1111/ddi.12898

Raymond Alfred (2010). Density and Population Estimation of the Bornean Elephants (Elephas maximus borneensis) in Sabah. Borneo Species Programme, WWF-Malaysia. *Journal of Biological Sciences* 10 (2): 92-102

Roever, C.L., van Aarde, R.J., Chase, M.J.(2017). Similarity in habitat preferences impedes human elephant coexistence. Botswana documents, library.wur.nl

Rosemary P. Mramba Valeri N. Mlingi (2021). The utilisation of woody species by male and female elephants in the Serengeti National Park, a nutrient-rich savanna .*European Journal of Wildlife Research* 67: 75

S. Nandin, P. keerthipriya, T.N.C. Vidya (2017). Seasonal variation in female Asian elephant social structure in Nagarahole Bandipur, southern India. *Journal of Animal Behaviour*, 134(1):135-145, https;//doi.org/ 10.1016 /J.anbehav./ 2017.10.012

Scott Schlossberg, Michael J., Robert Sutcliffe (2019). Evidence of a Growing Elephant Poaching Problem in Botswana. Curent Biology29:13, pp: 2222-2228. https://doi.org/10.1016/j.cub.2019.05.061

Seta, T., Demissew, S. & Woldu, Z.(2019). Floristic diversity and composition of the Biteyu forest in the Gurage mountain chain (Ethiopia): implications for forest conservation. *Journal of Forest Research* 30(1): 319–335. https://doi.org/10.1007/s11676-018-0623-8

Sintayehu W., Anteneh B., Sena, Mohammed., Kasshaye A., Fekede R., TibebeM.and Michael Chase (2016). Elephants (Loxodonta africana) Ecology and Conservation in Babile Elephant Sanctuary

Stephenson, P. J. (2007). WWF Species Action Plan: African Elephant, 2007-2011. WWF, Gland.

Susanne Marieke Vogel, Willem Frederik de Boer , Moses Masake, Anna Catherine Songhurst, Graham *et al.* (2018). Do African savanna elephants (Loxodonta africana) eat crops because they crave 2 micronutrients? https://doi.org /10.1101/67339.

Thekaekara Tarshish (2019). Living with Elephants, Living with People: Understanding the Complexities of Human-Elephant Interactions in the Nilgiris, South India. PhD thesis The Open University. DOI: https://doi.org /10.21954 /ou.ro.000102d4

Thomas Breuer, Mireille Breuer-Ndoundou Hockemba, Samantha Strindberg (2021).Small-scale dung survey reveals high forest elephant density and preference for mixed species forest in an intact protected area. *Biodiversity and Conservation* 30:2671–2688. https://doi.org/10.1007/s10531-021-02214-7

Whitehouse, A. M. and D. S. Schoeman (2003). Ranging behavior of elephants within a small, fenced area in Addo Elephant National Park, South Africa. *African Zoology* 38: 95-108

Yihew Biru and Afework Bekele (2012). Food habits of African elephant (*Loxodonta africana*) in Babile Elephant Sanctuary, Ethiopia. *International Society for Tropical Ecology*. 53(1): 43-52, 2012.

Yirmed, Demeke (2008). The Ecology and Conservation of The Relice Elephant Population in the Horn of Africa. Four years report. Addis Abeba, Ethiopia.

Zelalem Wodu (2007). Elephant and anthropogenic impacts on Woody plant species in Babile Elephant Sanctuary, Eastern Ethiopia. MSc thesis, Addis Ababa University

DOI: 10.47504/IJAGRI.2022.V3.1.1

7. Appendix I: Table 1. Availability of plant species and browsed plants part by elephants in the seven selected sites of BES

Scientific names	Family names	Local names	Babile district (RH)		Mayu district (WLH)		Fedis district (BLH)		Midega district (BLH)	Remark
			Gemachu PeAs	Erer Ebada PeAs	Gabbibda PeAs	Aloola PeAs	Anani PeAs (Kare-Gobee)	Anani PeAs (kontomu)	Bilisuma PeAs	Browsed plants part
Acacia abyssinica Hochst.ex Benth (*T)	Fabaceae	Laftoo	0	0	1	0	0	0	0	
Acacia brevispica Harms. (*SH)	Fabaceae	Hamareesa	1	0	1	1	1	0	1	Bark, leaves, growing shoots
Acacia bussie Harms ex.Sjostedt (*T)	Fabaceae	Haloo	1	1	1	1	1	1	1	Bark, leaves & growing shoots
Acacia etbica Schweinf.(*T)	Fabaceae	Doodoti	0	0	1	1	1	1	1	
Acacia mellifera(Vahl) Benth.(*T)	Fabaceae	Bilila	1	1	1	1	0	0	0	Bark, leaves & growing shoots
Acacia nigrii(*SH)	Fabaceae	Sophensa	1	1	1	1	1	1	1	Bark, leaves & growing shoots
Acacia nilotica(L.) Wild. Ex Del.(*T)	Fabaceae	Serkema	1	1	1	1	1	0	0	Bark, leaves & growing shoots
Acacia oerfota (Forssk.) Schweinf.(*SH)	Fabaceae	Ajjoo	0	0	0	1	0	0	0	Bark, leaves & growing shoots
Acacia robusta Burch(*T)	Fabaceae	Wangayo	1	1	0	0	0	0	1	Bark, leaves & shoots

DOI: 10.47504/IJAGRI.2022.V3.1.1

Cont…

Acacia seyel Del.(*T)	Fabaceae	Wachuu	1	1	0	1	1	1	0	Bark, leaves & growing shoots
Acacia tortills(Forssk) Hayne(*T)	Fabaceae	Dadacha	1	1	1	1	1	0	1	Bark, leaves & growing shoots, & roots
Acokanthera schimperi (A.DC.) Schweinf.(*T)	Apocynaceae	Kararoo	0	1	1	1	0	0	0	
Aloe pirottae Berger(*SH)	Aloaceae	Hargesaa	0	0	0	1	0	0	0	Leaves
Asparagus leptoclododius(*SH)	Asparagaceae	Kelemsare	0	0	1	1	0	0	0	Bark, leaves & growing shoots, & roots
Balanities aegyptica (L.) Del.(*T)	Balanitaceae	Badanoo	0	1	1	1	0	1	0	Leaves & fruits
Berchemia discolor (Klotzsch) Hemsl.(*T)	Balanitaceae	Jajabaa	1	1	1	1	1	0	1	Leaves & fruits
Bersema abyssinica (*SH)	Melianthaceae	Hargesaa/rete /	0	1	0	0	0	0	0	
Bersema abyssinica Fresen.(*T)	Melianthaceae	Haroresaa	1	0	1	1	0	1	0	
Boscia minimifolia Chiov.(*T)	Cappardiaceae	Megegaa	0	0	0	0	1	0	1	
Cadaba farinosa Forssk.(*T)	Cappardiaceae	Kelkelcha	0	0	1	1	0	0	0	Bark, leaves & growing shoots
Capparis sepiaria L.(*SH)	Capparidaceae	Rigagange	0	0	0	1	0	0	0	Leaves
Capparis tomentosa Lam.(*SH)	Capparidaceae	Gamaroo	0	0	1	0	0	0	0	Bark, leaves & growing shoots
Cordia monoica Roxb.(*T)	Boraginaceae	Odaa	0	0	0	1	0	0	0	Leaves
Cardia ovalis R.Br.(*SH)	Boraginaceae	Mandheroo	0	0	1	1	0	0	0	Leaves
Carisaa spinarum L.(*SH)	Apocynaceae	Agemsa	0	0	1	0	1	1	0	Bark, leaves & shoots
Calpurnea aurea (Lam.) Benth.	Fabaceae	Cheekaa	0	1	0	1	0	1	0	

DOI: 10.47504/IJAGRI.2022.V3.1.1

(*SH)

Cont…

Clausena anisata (Willd.) Benth.(*SH)	Rutaceae	Ulumaaye	0	0	0	0	0	0	0	
Scolopia theifolia Gilg.	Flacourtaceae	Muka digaa	0	0	1	1	0	0	0	
Cordia monoica Roxb.(*T)	Boraginaceae	Odaa	0	0	1	1	0	0	0	Leaves
Dichrostachys cinerea(L.) Wight & Arn.(*T)	Fabaceae	Jirmee	1	0	1	1	1	0	1	Bark, leaves & growing shoots
Dobera glabra (Forssk) Poir.(*SH)	Salvadoraceae	Adee	0	1	0	0	1	0	1	Bark, leaves & growing shoots
Dodonoea angustifolia L. f.(*SH)	Sapindaceae	Itacha	0	0	1	1	0	0	1	
Dracaena afromontana Mild br.(*T)	Agavaceae	Rukeesaa	0	0	1	1	1	1	1	
Ehretia cymosa Thonn.(*T)	Boraginaceae	Ulaaga	1	1	0	0	0	0	0	
Euclea racemosa Murr.Ssp.(*SH)	Ebenaceae	Hameesa	0	0	0	1	1	0	0	Leaves
Euclea schimperi(*SH)	Ebenaceae	Meeasaa	0	0	1	1	1	1	1	
Euphorbia abyssinica Gmel.(*SH)	Euphorbiaceae	Adaami	0	1	1	0	0	0	1	
Ficus sur Forssk.(*T)	Moraceae	Harbu	0	0	0	0	0	0	1	
Ficus thonningii Blume.(*SH)	Moraceae	Daambi	0	0	1	1	0	0	0	
Ficus vastaa Forssk.(*T)	Moraceae	Qiltu	0	0	1	1	0	0	1	
Grewia erythraea Schweinf.(*SH)	Tiliaceae	Dheeka	0	0	1	0	0	1	0	Bark, leaves & growing shoots
Grewia villosa Willd.(*SH)	Tiliaceae	Ogoomdi	0	0	1	1	0	0	0	Bark, leaves & growing shoots
Grewia schweinfurthii.Burret (*SH)	Tiliaceae	Midhugure	0	1	1	1	1	1	1	Leaves
Jasminum floribundum(*SH)	Oleaceae	Biluu	0	0	1	1	0	0	0	
Justcia schimperiana T. Anderson (*SH)	Acanthaceae	Dhumuga	0	0	1	1	0	0	0	
Kleinia squarrosa Cufod(*SH)	Astraceae	Luqqoo	0	0	0	1	0	0	0	Leaves

DOI: 10.47504/IJAGRI.2022.V3.1.1

Lanthana camara L.(*SH)	Verbenaceae	Beke arkate	1	1	1	1	1	0	0	Leaves
				Cont…						
Maytenus arbutifolia (*SH) *(Hochst.exA.Rich) R.Wilczek*	Celastraceae	Kombolcha	0	0	0	1	0	0	0	
Ochna inermis (Forssk) schweinf.expenzing(*SH)	Ochnaceae	Alibal	1	1	0	1	1	1	1	Bark, leaves & shoots
Oleo European L.cuspidata (Wall.exG. Don)Cif.(*T)	Oleaceae	Ejersa	0	0	1	1	1	0	1	
Oncoba spinosa Forssk.(*T)	Flacourtaceae	Jilbo	1	0	0	0	0	0	0	
Opuntia stricta (Haworth)(*SH)	Cactaceae	Qanchare	1	1	0	0	1	0	0	Freshy leaves & fruits
Opuntia ficus-indica(L) Miller(*SH)	Cactaceae	Tini	1	0	0	0	0	0	0	
Osyris quadripartita Decn.(*T)	Santalaceae	Watoo	0	0	0	1	0	0	0	
Piliostigma thonningii (Schum.)(*T)	Caesalpiniaceae	Laaluu	0	0	0	1	0	0	0	
Pinus patula Schiede ex Schltdl. & Cham.(*T)	Pinaceae	Shiwashiwe	1	0	0	0	0	0	0	
Pittoserum viridiflorum Sims(*SH)	Pittospoporaceae	Kersame	0	0	1	0	0	0	0	
Premna schimperi Engl.(*SH)	Verbenaceae	Urgeesaa	0	0	1	1	0	0	0	
Pyrostria phyllanthoidea (Baill.)Bridson. (*SH)	Rubiacaea	Sutanaqaphu	1	1	1	1	0	0	1	Bark & leaves
Rhus glutinosa (*T)	Anacrdiaceae	Tateesa	0	0	0	0	0	0	1	
Rhus vulgaris Meike(*SH)	Anacrdiaceae	Dabobesa	0	0	1	1	0	0	0	
Ricinus communis L.(*SH)	Euphorbiaceae	Kobo/Guloo	0	1	0	0	0	0	0	
Steganotainia aralaceae Hochst.(*SH)	Apiacee	Hudhaa jaldoo	0	0	1	0	0	1	0	
Sterculia africana(*T)	Sterculiaceae	Garii	0	0	1	1	0	1	0	

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*Tamarindus indica.*L(*T)	Fabaceae	Roqaa	1	0	1	1	0	0	1	Bark, leaves, growing shoots & fruits
Terminalia brownie Fresen.(*T)	Combretaceae	Birensa	0	1	1	1	1	1	1	Leaves, shoots &fruits
Trachilia emitica Vahl.(*T)	Meliaceae	Unuunu	0	1	0	0	0	0	0	
Vernonia amygdalina Del.(*SH)	Astraceae	Ebicha	0	0	1	0	0	0	0	
Ziziphus spina christi (T.) Desf.(*T)	Ramanaceae	Kurkura	1	1	1	0	0	0	0	Bark, leaves, growing shoots& fruits
			22	**25**	**46**	**45**	**20**	**16**	**23**	

Key: Local names of the species described in Afaan Oromo Language; *T= trees, *SH= shrubs; absence (0) and presence (1) of the species

DOI: 10.47504/IJAGRI.2022.V3.1.1