International Journal of Sciences: Basic and Applied Research (IJSBAR)

ISSN 2307-4531
(Print & Online)

http://gssrr.org/index.php?journal=JournalOfBasicAndApplied

Dietary Composition and Food Preference of African Elephant (*Loxodonta africana*) in and around Chebra Churchura National Park, Ethiopia

Adane Tsegaye[a]*, Afework Bekele[b], Anagaw Atikem[c]

[a,b,c]*Departments of Zoological Sciences, Addis Ababa University, PO Box 1176, Addis Ababa, Ethiopia*

[a]*Email: Adanetsegaye263@yahoo.com , Adotsega@gmail.com/+251-913-35-70-56*

[b]*Email: Afeworksimegn@gmail.com*

[c]*Email: Anagawam@gmail.com*

Abstract

Seasonal dietary composition and food habits of the African elephant (Loxodonta africana) were studied in Chebra Churchura National Park, Ethiopia. Plant species consumed by elephants were studied by examination of fresh feeding signs following focal groups of elephants using opportunistic direct feeding observations and the observation of elephant feeding sign on food trails (elephant feeding routes). Elephant feeding sign survey was conducted by scoring the different signs according to the frequency of species with feeding signs and part of the plant consumed. Elephants consumed a total of 109 plant species belonging to 34 families (not including crops). 99 species were recorded using feeding signs observation and day time feeding records in focal sample observation, while the remaining 10 species were recorded as consumed feeding sign. Family Fabaceae contributed the largest (13.42%), proportion of their diet while Solanaceae is the least (0. 37%). Based on the overall percentage contribution, Phoenix reclinata was the most consumed plant species which accounted for 1.95%. Oxytenanthera abyyssinica ranked second (1.85%). Seasonal availability of 23 foraged species was observed in the diet of elephants during the wet season but absent during the dry season. 86 forage pecies were available to the elephant populations, both during the wet and dry seasons. In CCNP, out109 of the species, 44 plant species were grazed and browsed intensively (≥1%) by elephants and these covered 54.3 % of the diet of elephants.

Keywords: Browse; dietary composition; elephant; feeding sign; Chebra Churchura; food preferences.

---

* Corresponding author.

1. Introduction

Larger ruminants are less selective in their dietary choice than smaller species. Being the largest extant herbivore the African elephant (*Loxodonta africana*) is the least selective among herbivores in the dietary range [11]. The digestive system of elephants is used to eat an extremely wide range of vegetable matter. The physiological adaptations of both African and Asian elephants are well adapted to living in diverse habitats by exploiting a wide spectrum of plant species. Their physiological adaptations, like the large prehensile trunk, dentition and digestive system, help to collect and process vast quantities of diverse plant food items required compensating for an extremely poor digestive ability. The nutritional demands of the elephant's large body mass are undoubtedly critical to the survival of the species [24]. However, such physiological adaptations alone are not sufficient especially in tropical ecosystems which show large variance in climate, food quality and quantity. To exploit the highly changing heterogeneous tropical environments efficiently, additional behavioural adaptations may also be necessary [24]. As a generalist feeder elephants have a destructive effect on trees [11]. Depending on the woody plant species affected, the plant parts and size impacted, elephants have a potential to transform savanna woodlands into almost treeless grasslands [8] or shrub lands [11]. Elephants are known to feed on a wide variety of species. Their diet includes grass, herbs, bark, fruit and tree foliage. Grass may make up 70% of the elephants' diet during the wet season. In savanna habitats large proportions of browse contributes to their diet as the dry season progresses. The diet of elephants may include as many as 230 species with leaves, twigs, bark and fruit constituting over 90% of all items consumed [27]. Fruit is an important component of a forest elephant's diet in contrast to savanna elephants. Trees contribute up to three quarters of the species [2, 27].

The nutritional needs of calves are exclusively met by milk consumption for the first three months of life and calves begin to feed independently after this age [12]. They will start eating solid food at about 4 months but remain dependent on milk. According to Guy [10], large adult elephants may consume 0.15 to 3 tons of plant products per day and about 225 liters of water daily [23]. Generally the availability of daily diet consumption and water source keep elephants within a circle of 25 km (Mundy, 2006). According to Owen Smith [16] the body mass of African elephants may reach up to 6,000 kg for males, and 2,800 kg for females and their dietary intake is approximately 1% of the dry weight of daily body mass. However, little is known about the diet composition and feeding preference of elephants in Ethiopia generally and particularly in CCNP. The feeding patterns and habit of African elephants may be changed due to fluctuations of seasonal changes in distribution, home range size and habitat selection. Elephants show preferences for some habitats and avoid others [17].

2. The study area and Method

2.1. The study area

Chebera Churchura National Park (CCNP) is located in the southwestern part of Ethiopia, in the newly established South Western Ethiopia Administrative Region. The Park is located between Dawro and Konta Zones. It covers an area of 1410 km^2 and lies between the coordinates 36^o 27'00''- 36^o 57'14''E and 6^o56'05''- 7^o 08'02''N [26].

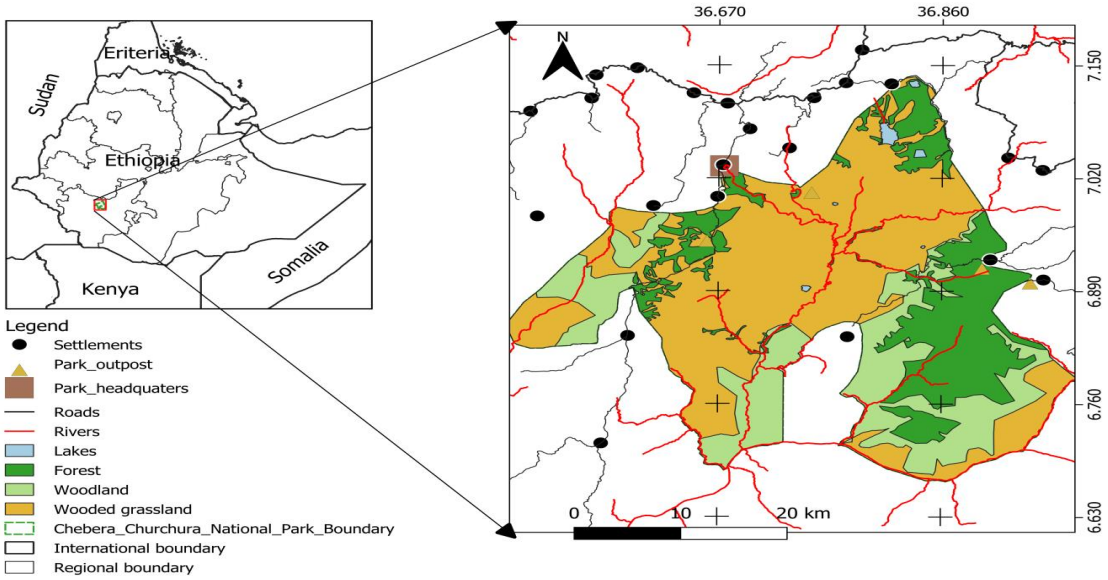

Figure 1: Map showing the location of the Chebera Churchura National Park

Chebera Churchura National park is home to almost one third of the national elephant population and has a high diversity of flora and fauna. Chebera Churchura is characterized by relatively hot climatic conditions. The average amount of annual rainfall in the area varies from 1000 to 3500 mm. The area has a uniform and long rainfall season (between March and September with a peak in July). The dry season is from November to February, with mean maximum temperatures varying between 27 and 29^{o}C. The hottest months are January and February while, the coldest months are July and August with the mean maximum and minimum temperatures of 28^{o}C and 12^{o}C, respectively [29]. The vegetation cover of the area is categorized as; wooded grassland, woodland, montane forest and riparian forest. Wooded grassland accounts for 55.6% of the study area. It covers most of the undulating landscapes above the floor of the valleys and gorges. Although the grass species show local variation, the dominant grass species includes elephant grass *Pennisetum* sp [26]. The tree species are deciduous and include *Combretum* sp. in association with *Terminalia albiza*. Woodland habitat covers about 13.2% of the total area while the riparian forest habitat covers only 3% of the total area of the Park. The montane forest habitat covers about 27.2% of the total area of the Park. Dominant tree species include *Juniperus procera*, *Podocarpus falcatus* and other broad leaved species [29]. Montane forest vegetation occurs in the eastern and northwestern highlands of the study area. It is dominated by tree species and characterized by a crown cover of up to 50%, with multistoried structure. Climbers and saprophytes are important floristic components of the habitat. Riparian forest covers about (4%) along the course of the rivers, Zigna, Shoshima, Wala, Tikurwuha, Mensa, Oma and other small seasonal tributaries. This habitat is characterized by mixed vegetation type composed of large trees and herbaceous species. Dominant plant species in this habitat are *Ficus* sp., *Phoenix* sp., *Costa* sp., *Albizia grandibracteata*, *Chionanthus mildbraedii*, *Grewia ferruginea*, *Aspilia mossambicensis*, *Arundo donax* and *Ehretia cymosa* [1,25]. The principal ethnic groups found around CCNP are Dawro and Konta Nationalities. Other minority groups include Tsara, Menja, Mena and Bacha. Dawro ethnic groups inhabiting the eastern highland and few areas of the southeastern lowland areas. Konta ethnic group occupies the north and northwestern highland areas [6]. Mixed agricultural practices are the main

livelihood of the majority of the inhabitants living around the Park. They practice traditional agricultural systems that combine perennial and annual cultivation with livestock rearing.

2.2. Methods

2.2.1. Dietary Composition

Plant species consumed by elephants were studied by examination of fresh feeding signs following focal groups of elephants using opportunistic direct feeding and observations of elephant feeding sign on food trails (elephant feeding routes) [3,5]. Evidence of feeding sign included elephant footprints, fresh dung piles nearby to browsed foliage and identifying characteristics of plant damage caused by elephant browse such as debarkation, branch breaking and uprooting were also used during data collection [3,5]. During field surveys the following data were recorded. The feeding routes observed that was taken by elephants were followed by field researchers and all plant species showing signs of being consumed by elephants were recorded, collected, pressed and identified with the help of a taxonomist. Plant samples were preserved in plant press for identification following standard procedures [3,4,5] and for confirmation from the National Herbarium, Addis Ababa University. Data on food preference were gathered during the wet season for 45 consecutive days each year from (July to August 2020-2021) and March to April 2020-2021 for the dry season.

1. 2.2. Feeding sign score

The relative frequency (percentage) of feeding sign was calculated to yield a feeding sign score. Feeding signs were ranked according to the frequency of plant species with feeding signs like browsing, bark, stem and foliage removed and/or grass species consumed [3] Elephant feeding sign survey was conducted by scoring the different signs according to the frequency of species with feeding signs and part of the plants consumed [3,5]. Total feeding score was calculated by multiplying the frequency of each plant species showing feeding signs with total feeding sign score of that species. Total feeding score of each species was multiplied by 100 and divided by the total feeding score of all species to calculate an index equivalent to utilization percent [18]. Data were analyzed using Microsoft Excel and SPSS Version 20. Quantitative data obtained were analyzed using chi-square test.

3. Results

A total of 109 consumed plant species belonging to 34 families (not including crops) were identified (Table 1). Out of these, 99 species were recorded using feeding signs observation and day time feeding records in focal sample observation, while the remaining 10 species were observed as consumed feeding sign. Family *Fabaceae* contributed the largest (13.42%), proportion of their diet while *Solanaceae* is the least (0. 37%). Based on the overall percentage contribution, *Phoenix reclinata* was the most consumed plant species which accounted for (1.95%). *Oxytenanthera abyyssinica* ranked second (1.85%) (Table 1). Out of the total 109 species consumed by the elephants 64 species in 25 families were woody plant species and covered (59.24%) of the total feeding score, 42 species in 19 families were herbs and contributed (36.95%) of the total feeding score while 3 species consumed as family *Poacea*e were grasses and contributed the least (3.81%) of the total feeding score (Table 1).

In CCNP out of the 109 species consumed 44 plant species were grazed and browsed intensively (≥1%) by elephants and covered 54.34 % of the diet of elephants (Table 1). Out of these, 23 foraged species were consumed by the elephants only during the wet season (Table 1). A total of 86 forage species were consumed both during the wet and dry seasons. The plant species that were consumed intensively (≥1%). The plant species foraged by elephants in CCNP significantly varied with season. More diversified species were consumed during the wet season than in the dry one. The diversity index showed that those species foraged during the dry season were also foraged during the wet season. However, some the plant species foraged during the wet season were not consumed during the dry season (Table 1). ($\chi 2 = 11.51$, df =1, $P < 0.05$).

Table 1: Plant species consumed by elephants during the wet and dry seasons in CCNP

Species	Dry	Wet	Total	Percent (%)
Acalypha cf. ornata A. Rich.	36	71	107	0.98
Acalypha List of ciliate	22	49	71	0.65
Albizia gummifera	48	59	107	0.98
Albizia malacophylla	29	48	77	0.71
Albizia schimperiana	43	51	94	0.86
Allophylus abyssinicus (Hochst.) Radlk.	25	62	87	0.79
Allophylus cobbe.	13	36	49	0.45
Aspilia mossambicensis	22	52	74	0.68
Baphia abyssinica Brummitt	52	39	91	0.83
Bersama abyssinica Fresen.	45	46	91	0.83
Bridelia sp.	79	38	117	1.07
Canna indica L	51	50	101	0.92
Carissa spinarum L.	45	46	91	0.84
Celtis africana Burm. F	43	34	77	0.70
Celtis sinensis	31	30	61	0.56
Chionanthus mildbraedii	25	26	51	0.46
Combretum collinum Fresen.	48	73	121	1.11
Combretum molle	74	99	173	1.59
Combretum paniculatum	46	72	118	1.10
Combretum glutinous	46	72	118	1.10
Combretum adenogonium	76	97	173	1.59
Commelin aimberbis	102	77	179	1.64
Commelina Africana	81	30	111	1.02
Cordia africana Lam.	104	47	151	1.41
Croton macrostachyus	62	22	84	0.77
Croton xalapensis	57	17	74	0.68
Cussonia arborea A. Rich.	15	36	51	0.46
Dalbergia lactea Vatke	37	40	77	0.70
Deinbollia kilimandscharica Taub.	61	61	122	1.12
Desmodium dichotomum	99	14	113	1.03
Dombeya buettneri	13	25	38	0.34
Dombeya torrida	28	29	57	0.52
Dracaena fragrans	85	52	137	1.25
Dracaena steudneri Engler	35	41	76	0.69
Ehretia cymosa	33	32	65	0.58
Entada Africana	85	88	173	1.59
Entada abyssinica	61	68	129	1.18
Erythrina abyssinica	23	28	51	0.46
Faurea speciosa Welw.	24	43	67	0.61
Ficus exasperata	89	23	112	1.02
Ficus ovata Vahl	93	30	123	1.13
Ficus sur	114	27	141	1.29

Ficus sycomorus L.	86	46	132	1.21
Ficus vasta Forssk.	122	35	157	1.44
Flueggea virosa (Willd.) Voigt.	61	51	112	1.03
Gnidia glauca (Fresen.) Gilg	-	131	131	1.20
Grewia flavescens Juss.	-	110	110	1.01
Grewia mollis	-	108	108	0.99
Guizotia scabra (Vis.) Chiov.	-	117	117	1.07
Hibscus ovalifolius	92	21	113	1.03
Indigofera sp.	-	99	99	0.91
Lantana trifolia L.	103	20	123	1.13
Lantana camara	99	20	119	1.10
Leonotis ocymifolia	-	104	104	0.95
Leonotis nepetifolia	-	78	78	0.71
Lepidotrichilia volkensii	71	77	148	1.36
Lepidotrichilia senckenberg	27	22	49	0.45
Lonchocarpus laxiflorus	58	50	108	1.99
Marantochloa leucantha	52	26	78	0.71
Maytenus senegalensls.	41	46	87	0.79
Maytenus undata	75	34	109	1.00
Millettia ferruginea	60	73	133	1.22
Mucuna stans	-	123	123	1.12
Oxyanthus speciosus DC	40	41	81	0.74
Oxytenanthera abyyssinica	-	201	201	1.84
Panicum ruspolii	67	94	161	1.48
Paullinia pinnata L.	-	75	75	0.68
Pavonia urens Cav.	-	107	107	0.98
Phoenix reclinata	158	54	212	1.94
Phyllanthus ovalifolius	-	71	71	0.66
Piliostigma thonningii	99	24	123	1.13
Piper Capense Temez	88	13	101	0.92
Plectranthus sp.	87	16	103	0.94
Polysciasfulva	64	22	86	0.79
Pouteria altissima	41	46	87	0.79
Premna odorata	30	31	61	0.56
Premna schimperi	-	59	59	0.54
Premna senensis	-	59	59	0.54
Protea madiensis Oliv.	62	60	122	1.12
Pterolobium stellatum	61	18	79	0.72
Pycnostachys sp.	-	87	87	0.79
Ricinus communis L.	-	95	95	0.87
Sapium ellipticum	49	20	69	0.63
Schrebera alata	39	58	97	0.89
Senna baccarinii	-	117	117	1.07
Setaria megaphylla (Steud.)	25	26	52	0.47
Sida rhombifolia	-	91	91	0. 83
Sida schimperiana	-	111	111	1.02
Solanum incanum L.	10	56	66	0.60
Solanum nigrum	10	31	41	0.37
Stereospermum kunthianum Cham.	71	68	139	1.27
Syzygium guineense	42	44	86	0.79
Tamarindus indica L.	22	16	38	0.34
Tamarindus indica spp	22	16	38	0.34
Teclea simplicifolia	61	63	124	1.14
Terminalia brownie	103	70	173	1.69
Trichilia dregeana Sond.	28	31	59	0.54
Tylosema fassoglensis	64	19	83	0.76
Vangueria sp.	-	85	85	0.78
Vangueria infausta	-	74	74	0.68
Vepris dainellii	85	72	157	1.44
Vepris nobili	12	41	53	0.48

Vernonia amygdalina Del.	67	30	97	0.89
Vernonia galamensis	43	20	63	0.57
Vernonia auriculifera Hiern	36	39	75	0.68
Vernonia cf. filigera Olivo	-	125	125	1.14
Vernonia ischnophylla Muschl.	-	97	97	0.89
Zanha golungensis	57	50	107	0.98
Total	4838	6038	10876	100

Elephants showed a high preference for different parts among plant species. Elephants consumed the whole parts of 48 species in 21 families and contributed 4929 (24.34%) total feeding score; Leaves of 54 species in 25 families contributed 6232 score (30.78%) of the total score, Bark of 24 species in 12 families 5621 score (27.76%) of the total score while, 48 species of fruits (3653) in 21 family contributed the least (18.04%) of the total score. (Table 2). Concerning the feeding preference on different parts of the plants we obtained that elephants in CCNP preferred leaves (30.97%) to stem/bark (27.76%). Whole parts of grass and herbaceous species consumed contributed 18.04%) while fruit contributed 18.22%. However, the difference was not significant ($\chi 2$=779.92, P value>0.05). High relative frequency of utilization of encountered plant species observed were Phoenix reclinata (3.14%) followed by *Oxytenanthera abyyssinica* (2.97%) and *Combretum molle* (2.16%) while *Tamarindus indica* and *Dombeya buettneri* were the least encountered (1.8%) (Table 2).

Table 2: Parts of plant species consumed by elephants and total feeding sign in CCNP

Family	Species	Total feeding score	Percentage (%)	Parts Consumed
Arecaceae	Phoenix reclinata	636	3.14	Leaves, bark and fruits
Poaceae	Oxytenanthera abyyssinica	603	2.97	Leaves and stem
Combretaceae	Combretum molle	519	2.56	Leaves, bark and fruits
Combretacea	Terminalia brownie	519	2.56	Leaves, bark and fruits
Fabaceae	Entada Africana	519	2.56	Leaves, bark and fruits
Euphorbiaceae	Combretum adenogonium	519	2.56	Leaves, bark and fruits
Boraginaceae	Cordia africana Lam.	453	2.24	Leaves, bark and fruits
Moraceae	Ficus sur	423	2.08	Leaves, bark and fruits
Bignoniaceae	Stereospermum kunthianum Cham.	417	2.06	Leaves, bark and fruits
Moraceae	Ficus vasta Forssk.	417	2.06	Leaves, bark and fruits
Moraceae	Ficus sycomorus L.	396	1.95	Leaves, bark and fruits
Fabaceae	Entada Africana	387	1.86	Leaves, bark and fruits
Moraceae	Ficus ovata Vahl	369	1.82	Leaves, bark and fruits
Sapindaceae	Deinbollia kilimandscharica Taub.	366	1.80	Leaves, bark and fruits
Combretaceae	Combretum collinum Fresen.	363	1.79	Leaves, bark and fruits
Euphorbiaceae	Combretum paniculatum	354	1.75	Leaves, bark and fruits
Euphorbiaceae	Ficus exasperata	336	1.65	Leaves, bark and fruits
Euphorbiaceae	Flueggea virosa (Willd.) Voigt.	336	1.65	Leaves, bark and fruits
Commelinacea	Commelina Africana	333	1.64	Leaves, bark and fruits
Sapindaceae	Zanha golungensis	321	1.64	Leaves, bark and fruits
Rutaceae	Vepris dainellii	314	1.55	Leaves and Bark
Oleaceae	Schrebera alata	291	1.43	Leaves, bark and fruits
Fabaceae	Albizia schimperiana	282	1.39	Leaves, bark and fruits
Fabaceae	Baphia abyssinica Brummitt	273	1.34	Leaves, bark and fruits
Fabaceae	Millettia ferruginea	266	1.13	Leaves and bark
Rutaceae	Teclea simplicifolia	248	1.22	Leaves and bark
Proteaceae	Protea madiensis Oliv.	244	1.20	Leaves and bark
Euphorbaceae	Albizia malacophylla	231	1.14	Leaves, bark and fruit
Fabaceae	Dalbergia lactea Vatke	231	1.14	Leaves and bark

Dracaenaceae	Dracaena steudneri Engler	228	1.12	Whole part
Rubiaceae	Vangueria sp.	222	1.09	Leaves, bark and fruit
Fabaceae	Lonchocarpus laxiflorus	216	1.06	Leaves and bark
Euphorbiaceae	Albizia gummifera	214	1.05	Leaves and bark
Moraceae	Ficus exasperate	213	1.05	Leaves, bark and steam
Apocynaceae	Carissa spinarum L.	182	0.89	Leaves and bark
Commelinaceae	Commelin aimberbis	179	0.88	Whole part
Fabaceae	Pouteria altissima	174	0.85	Leaves and bark
Sapindaceae	Maytenus senegalensls.	174	0.85	Leaves and bark
Malvaceae	Syzygium guineense	172	0.84	Leaves and bark
Euphorbaceae	Croton macrostachyus	168	0.82	Leaves and bark
Rubiaceae	Oxyanthus speciosus DC	162	0.80	Leaves and bark
Poaceae	Panicum ruspolii	161	0.79	Whole part
Fabaceae	Tamarindus indica L.	152	0.75	Leaves, bark and fruit
Asteraceae	Vernonia auriculifera Hiern	150	0.74	Leaves and bark
Gramineae	Lepidotrichilia volkensii	148	0.73	Whole part
Rubiaceae	Croton macrostachyus	148	0.73	Leaves and bark
Dracaenaceae	Dracaena fragrans	137	0.67	Whole part
Proteaceae	Faurea speciosa Welw.	134	0.66	Leaves and bark
Thymelaeaceae	Gnidia glauca (Fresen.) Gilg	131	0.64	Whole part
Boraginaceae	Ehretia cymosa	130	0.64	Leaves and bark
Asteraceae	Vernonia amygdalina Del.	126	0.62	Whole part
Asteraceae	Vernonia cf. filigera Olivo	125	0.61	Whole part
Fabaceae	Mucuna stans	123	0.60	Whole part
Legume	Piliostigma thonningii	123	0.60	Whole part
Moraceae	Lantana trifolia L.	123	0.60	Whole part
Sapotaceae	Celtis africana Burm. F	122	0.60	Leaves and bark
Sapotaceae	Pouteria altissima	122	0.60	Leaves and bark
Vebenase	Lantana camara	119	0.58	Whole part
Lamiaceae	Premna schimperi	118	0.58	Leaves and bark
Asteraceae	Guizotia scabra (Vis.) Chiov.	117	0.57	Whole part
Euphorbiaceae	Bridelia sp.	117	0.57	Whole part
Fabaceae	Senna baccarinii	117	0.57	Whole part
Fabaceae	Desmodium dichotomum	113	0.55	Whole part
Malvaceae	Hibscus ovalifolius	113	0.55	Whole part
Malvaceae	Sida schimperiana	111	0.54	Whole part
Tiliaceae	Grewia flavescens Juss.	110	0.54	Whole part
Celastraceae	Maytenus undata	109	0.53	Whole part
Celasfraceae:	Grewia mollis	108	0.53	Whole part
Euphorbiaceae	Acalypha cf. ornata A. Rich.	107	0.52	Whole part
Malvaceae	Pavonia urens Cav.	107	0.52	Whole part
Lamiaceae	Vepris dainellii	106	0.52	Leaves and bark
Lamiaceae	Leonotis ocymifolia	104	0.51	Whole part
Lamiaceae	Plectranthus sp.	103	0.50	Whole part
Araliaceae	Chionanthus mildbraedii	102	0.50	Leaves and bark
Araliaceae	Cussonia arborea A. Rich.	102	0.50	Leaves and bark
Fabaceae	Erythrina abyssinica	102	0.50	Leaves and bark
Cannaceae	Canna indica L	101	0.49	Leaves and bark
Piperaceae	Piper Capense Temez	101	0.49	Whole part
Fabaceae	Indigofera sp.	99	0.48	Whole part
Asteraceae	Vernonia ischnophylla Muschl.	97	0.47	Whole part
Asteraceae	Vernonia amygdalina Del.	97	0.47	Leaves and bark
Euphorbiaceae	Ricinus communis L.	95	0.46	Whole part
Malvaceae	Sida rhombifolia	91	0.45	Whole part
Melianthaceae	Bersama abyssinica Fresen.	91	0.45	Leaves
Lamiaceae	Pycnostachys sp.	87	0.42	Whole part
Sapindaceae	Allophylus abyssinicus (Hochst.) Radlk.	87	0.42	Leaves
Araliaceae	Polysciasfulva	86	0.42	Whole part
Lamiaceae	Vangueria sp.	85	0.41	Whole part

Fabaceae	Tylosema fassoglensis	83	0.40	Whole part
Fabaceae	Pterolobium stellatum	79	0.39	Leaves
Marantaceae	Marantochloa leucantha	78	0.38	Whole part
Oleaceae	Leonotis ocymifolia	78	0.38	Whole part
Cannabaceae	Celtis africana Burm. F	77	0.38	Whole part
Sapindaceae	Paullinia pinnata L.	75	0.37	Whole part
Asteraceae	Aspilia mossambicensis	74	0.36	Whole part
Euphorbiaceae	Phyllanthus ovalifolius	71	0.35	Whole part
Moraceae	Acalypha cf. ornata A. Rich.	71	0.35	Whole part
Euphorbiaceae	Sapium ellipticum	69	0.34	Whole part
Solanciace	Solanum incanum L.	66	0.32	Whole part
Lamiaceae	Premna schimperi	59	0.29	Whole part
Meliaceae	Trichilia dregeana Sond.	59	0.29	Leaves
Sterculiaceae	Dombeya torrida	57	0.28	Leaves
Poaceae	Setaria megaphylla (Steud.)	52	0.25	Whole part
Meliaceae	Allophylus abyssinicus (Hochst.)	49	0.24	Leaves
Meliaceae	Lepidotrichilia volkensii (Giirke) Leroy	49	0.24	Leaves
Solanaceae	Solanum incanum L.	41	0.20	Whole part
Fabaceae	Tamarindus indica	38	0.18	Leaves
Malvaceae	Dombeya buettneri	38	0.18	Whole part
Total		20244	100	

4. Discussion

Studying interactions between elephant and habitats is valuable for assessing the welfare of elephant populations, their habitats and the possibility of long term co-existence with the surrounding communities [3,15]. Former studies on the feeding ecology of African elephants in tropical forest indicted that they feed on diverse plant species and different parts of plants showing a declining trends in diversity towards savanna ecosystems and elephant habitats that are influenced by human induced factors. Studies on the feeding ecology of African elephants showed that 230 species were consumed with leaves, twigs, bark and fruit in tropical forests [27]. The diversity declines as we move towards tropical savanna ecosystems up to 120 different species (De Boer and his colleagues 2000). While recent study carried out in Babile Elephant Sanctuary confirmed that only 73 species were consumed by elephants due to the decline in species diversity by human induced factors such as settlements and agricultural expansion in the Sanctuary [3]. The result of the present study in CCNP confirmed that 109 plant species were consumed by elephants. The result goes in line with the findings of De Boer and his colleagues [7] who mentioned that elephants consumed up to 120 different species in tropical savanna ecosystem. Relatively higher number of species in the present study might be due to a very well protected biodiversity with little human interference in CCNP that made more diverse plant species available for the elephants [26]. The finding of the present study confirmed that although elephants are less selective bulk feeders they showed preference to some extent to some of the species in CCNP. The result of this study goes in line with the findings of Mwambola and his colleagues [15] who mentioned that even though elephants are generalist feeders as herbivores they showed preference on some plant species over others. Studies showed that variations in the composition of elephant diet depend up on factors such as; localities, available species and season [3,15]. The result of this study showed that nearly all of the plant species consumed by elephants during the dry season in CCNP were also consumed during the wet season. However, higher diversified species were consumed during the wet season than the dry one. As the dry season progressed the diversity of the species

consumed by elephants decreased. This change in food composition of elephants may be due to seasonal availability of some grass and herbacious species in CCNP. Seasonality of some species may have an influence for variations in the composition of species consumed during both seasons. The result of the present study was against the findings of Williamson [28] who mentioned that elephant diets consumed in Hwange National Park, Zimbabwe was almost fully composed of woody plant species during both seasons. Mwambola and his colleagues [15] also mentioned that there was no variation on the species composition of plants consumed by elephants during wet and dry seasons in Rubondo Island National Park (RINP), Tanzania. The result of this study also confirmed that browse contributed to the majority of elephant diet during both dry and wet seasons. This might be due to almost all of the woody plant species consumed by elephants during the dry season were also consumed during the wet season. The result of the present study goes in line with the findings of Admasu [1], Biru and Bekele [3] who mentioned that browse contributed to the majority of elephant diet during both wet and dry seasons in Chebra Churchura National Park and Babile Elephant Sanctuary respectively due to the presence of most plant species consumed by elephants during both dry and wet seasons. Although elephants are less selective in feeding the result of this study showed that some plant species where highly preferred by elephants over others. During the present study *Phoenix reclinata* was the most preferred species followed by *Oxytenanthera abyyssinica* and *Combretum molle* while, *Tamarindus indica* and *Dombeya buettneri* were the least preferred ones. The result of the present study agree with the findings of Biru and Bekele [3] who noted that among the species consumed by elephants *A. robusta* and *O. ficus-indica* were the most preferred ones while *C. molle* and *G. flavescens* were selectively avoided. During the present study, different plant parts were consumed by elephants. Palatability of the plant parts and the height of the plant might be among the factors that contributed to the observed differences. During the present investigation feeding the whole parts of grass and herbaceous species and debarking, browsing and breaking on woody plants species were the most commonly observed mode of feedings in CCNP. The present study showed that leaves, bark and fruits were parts of woody plant species selectively consumed by elephants. Preference for different parts of the plants showed variations between species and seasons. The result of this study confirmed that elephants showed high preference for leaves of woody plant species over bark/steam and fruits while, consuming the whole parts of grass and herbaceous species contributed to a considerable amount of the total feeding score next to leaves, followed by fruit which contributed relatively the least. The result of the present study goes in line with the findings of Mwambola and his colleagues [15] who mentioned that among different plant parts of woody plant species consumed by elephants leaves were the most preferred part and more consumed than stem/bark in Rubondo Island National Park, Tanzania. Unlike other woody plant species, elephants in CCNP consumed the whole parts (leaves, stem and fruits) of *Phoenix reclinata* species including the inner part of the stem. Elephants were also observed easily breaking the stem of *Phoenix reclinata* species and feeding on the inner part of the stem which seems to be highly destructive to the species beside their positive role in seed dispersal by feeding on the fruits. The result of this study agrees with the findings of Mwambola and his colleagues [15] who mentioned that contrary to other woody plant species elephants showed preference to chewing on the inner section of the stem of *Phoenix reclinata* species.in Rubondo Island National Park (RINP), Tanzania. Habitat utilization patterns of elephants in CCNP were confined to riparian vegetation and wooded grassland habitats avoiding the most abundant habitats such as grassland with scattered tress and montene forests. This might be due to factors associated to availability of permanent water source, preferred plant species and security issue. Moreover,

grassland with scattered trees and montene forest habitats are located at the marginal sites from the Park Centre which were frequently visited by poachers. The finding of this study was against the findings of Biru and Bekele [3], Mwambola and his colleagues [15], who noted that almost all habitats were equally utilized by elephants in Babile Elephant Sanctuary, Ethiopia and Rubondo Island National Park (RINP), Tanzania. Limitations of the study this study did not cover important element such as the influence of the growing elephant population on the different vegetation types and the preferred plant species in their habitats. Further study is needed to understand the influence due to the feeding behaviour of the elephants. This will provide foundation to explain scientifically the impact of the growing elephant population on the vegetation cover and the preferred plant species within the Park boundary.

5. Conclusion

Based on the findings of this study African elephants have successfully adapted to survive in Chebra Churchura National Park, Ethiopia. They showed their adaptation to the habitats by consuming wide varieties of plant species including trees, shrubs, herbs and grasses. The existing habitats are able to support the survival of elephants and other animals in the area. The forest structure is still closed and intact, but the rapid growth of large herbivores including elephants in CCNP may lead to over utilization of limited resources in the area. As a result forests may be transformed to shrubs and grasslands. There is significant relationship between increased age and number of elephants and the level of destruction in conservation areas. Hence increased number of elephants may impose loss of suitable habitats to herbivores. Further study is needed to understand the influence of the growing elephant population on the different types of vegetation and preferred plant species due to the feeding behaviour of the elephants. This will provide foundation to explain scientifically the impact of the growing elephant population on the vegetation cover and the preferred plant species within the Park boundary.

6. Conflict of Interests

The authors have not declared any conflict of interests.

Acknowledgements

The authors greatly acknowledge Addis Ababa University for their logistic and research financial support. Moreover, the authors wish to thank staff members of Chebra Churchura National Park, the local people of Dawuro and Konta Zones, and their local administrators for their kind cooperation, patience, hospitality, and willingness to share their knowledge during discussion about the conservation challenges of the study area.

References

[1]. Admasu M (2006) History and Status of The Population of African Elephants (*Loxodonta africana*, Blumenbach, 1797) and Human-Elephant Conflict in Chebra Churchura National Park, Ethiopia. MSc. Thesis, Addis Ababa University, Addis Ababa.

[2]. Alexandre D Y (1977) Role diss Èminateur des ÈlÈphants en fÙret Tai CÙte d'Ivoire. Terre Et Vie 32: 47-72.

[3]. Biru Y, Bekele A (2015) Food habits of African elephant (*Loxodonta africana*) in Babile Elephant Sanctuary, Ethiopia. Trop Ecol 53(1): 43-52.

[4]. Bridson D, Forman L (1992) The Herbarium Handbook (revised edn.). Royal Botanic Garden, Whitstable Litho Printers Ltd., Kew.

[5]. Chen J, Deng L, Zhang L, Bai Z (2006) Diet composition and foraging ecology of Asian elephants in Shangyong, Xishuangbanna, China. Acta. Ecol Sinica 26: 309-316.

[6]. Datiko D (2013) Species Composition, Distribution, Habitat association, Feeding Ecology of Small Mammals, and Conservation Challenges in Chebera Churchura National Park. PhD Thesis, Addis Ababa University, Addis Ababa.

[7]. De Boer WF, Prins HHT (1990) Large herbivores that strive mightily but eat and drink as friends. Oecologia 82: 264–274.

[8]. Dublin HT, Sinclair ARE, Mc Glade J (1990) Elephants and fire as causes of multiple stable states in the Serengeti-Mara wood lands. J Anim Ecol 59: 1147 –1164.

[9]. Guy PR (1976) The feeding behavior of elephant (*Loxodonta africana*) in the Sengwa Area, Rhodesia. South. Afr J Wildl Res 6(1): 55-63.

[10]. Laws RM, Johnstone RCB (1975) Elephants and their habitats. The Ecology of Elephants in North Bunyoro, Uganda. Oxford.376 pp.

[11]. Laws R M, Parker ISC (1970) Recent studies on elephant populations in East Africa. J Zool Lond 21: 319-359.

[12]. Lee P C, Moss C J (1986) Early maternal investment in male and female African elephant calves. J Behav Ecol. 18: 353-361.

[13]. Megaze A (2015) Population status, demography and time budget of the African buffalo (*Syncerus caffer* Sparrman, 1779) and anthropogenic impacts in Chebera Churchura National Park, Ethiopia. PhD Thesis, Addis Ababa University, Addis Ababa. 195pp.

[14]. Mekonnen A (2019) Ecology of Common Hippopotamus (Hippopotamus amphibious, Linnaeus, 1758) and Conflict Incidence with Human Around Chebra Churchura National Park, Ethiopia. PhD Thesis, Addis Ababa University, Addis Ababa.

[15]. Mwambola1 S, Ijumba J, Kibasa W, Masenga E, Eblate E, Kayombo, C (2014) Feeding preference of the African elephant (*Loxodanta africana*) on woody plant species in Rubondo Island National Park (RINP), Tanzania. Amer J Res Commun 2 : 102-113.

[16]. Owen-Smith RN (1988) Mega herbivores: The influence of very large body size on ecology. Cambridge University Press. 363 pp.

[17]. Roux C (2006) Feeding Ecology, Space Use and Habitat Selection of Elephants in Two Enclosed Game Reserves in the Eastern Cape Province, South Africa. M.Sc. Thesis. Rhodes University, Grahams.

[18]. Santra AK., Pan S, Halder S (2008) Nutritional status of forage plants and their use by wild elephants in southwest Bengal, India. Trop Ecol 49: 251-257.

[19]. Shannon G, Page B, Slotow R, Duffy K. (2006) African elephant home range and habitat selection in Pongola Game Reserve, South Africa. J Afri Zool 41: 37–44.

[20]. Sinclair ARE (1977) The African Buffalo: A study Resource Limitation of Population.

ChicagoUniversity Press, Chicago.

[21]. Sitati NW, Walpole MJ, Smith RJ, Williams N (2003) Predicting spatial aspects of human–elephant conflict. J Appl Ecol 40: 667–677.

[22]. Smithers RHN (1990) The mammals of the southern African sub region. University of Pretoria, Pretoria.

[23]. Stephenson PJ (2007) WWF Species Action Plan: African elephants, 2007-2011, WWF, Gland, Switzerland.

[24]. Sukumar R (2003) The Living Elephants: Evolutionary Ecology, Behaviour, and Conservation. New York.

[25]. Timer G (2005) Diversity, Abundance, Distribution and Habitat Association of Large Mammals in the Chebera Churchura National Park, Ethiopia. MSc. thesis, Addis Ababa University, Addis Ababa, pp. 127.

[26]. Tsegaye A, Bekele A, Balakrishnan M (2016) Population Status, Disribution and Habitat Association of Waterbuck (Kobusellipsiprymnus) in CheberaChurchuraNational Park, Ethiopia. Eth J Biol Sci 14 (1): 31–43, 2015.

[27]. White LJT, Tutin CEG, Fernandez M (1993) Group composition and diet of forest elephants, *Loxodonta africana cyclotis* Matschie 1900, in the Lope Reserve. Gabon. Afr J Ecol 31: 181-199. 28.

[28]. Williamson B R(1975). The condition and nutrition of elephants in Wankie National Park. Arnoldia (Rhodesia) 7: 1-20.

[29]. Woldeyonhans, D. (2006). Diversity, distribution and relative abundance of Avian species of Chebera Churcura National Park, Ethiopia. M. Sc. Thesis. Addis Ababa University.