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Natural Feed Options for Sumatran Elephants at the Seblat Elephant Training Center North Bengkulu Regency, Indonesia

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

The health and welfare of Sumatran elephants at the Seblat Elephant Training Center (SETC), North Bengkulu Regency, depend on many environmental factors in their habitat, one of which is the availability of a variety of plant species (diet) in the Seblat Nature Tourism Park (SNTP) forest area. Research on this matter was conducted in May-June 2022 within the SNTP forest area, where the Seblat SETC facility is located. This study aimed to evaluate the dietary preferences of Sumatran elephants at SETC towards natural plant species in the SNTP forest. The "Focal Animal Sampling" method was used to measure the duration of feeding activity of each elephant on specific plant species while they were foraging in the forest. The elephants' preferences for plant

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species were analyzed quantitatively, while the types of plants consumed by the elephants were described qualitatively. The research found that 15 families with 33 species were identified as the natural food plants for the SETC elephants in Bengkulu. The Poaceae family was most preferred by the elephants with the highest preference value (35.07%), followed by Fabaceae (31.73%), Malvaceae (9.87%), and Cyperaceae (7.83%), while the least preferred were Costaceae, and Myrtaceae (0.33% respectively), Convolvulaceae (0.41%), and Selaginellaceae (0.73%). Based on sex, adult male elephants preferred Fabaceae plants such as *Mimosa pudica* (35.99%), *Desmodium triflorum* (11.66%), *Mimosa invisa* (7.36%), *Cynodon dactylon* (6.54%) over other families. Conversely, adult female elephants preferred Poaceae such as *Leersia virginica* Willd., *Cyrtococcum patens* (L.) A., *Centhotheca lappacea* Desvaux., *Digitaria sanguinalis* (L.) Scop., and *Imperata cylindrica* L. patients. These predictors, however, need further work to validate reliability.

Keywords: Sumatran elephants; food preference; focal animal sampling; Seblat Elephant Training Center (SETC).

1. INTRODUCTION

The Sumatran elephant is a critically endangered species protected due to concerns over its potential extinction. The loss of lowland tropical rainforests as its habitat, ivory poaching, and human-elephant conflicts are the greatest threats to the elephant's future (Van der Meer and Campos-Arceiz, 2019, Sukumar 2003). The Seblat Elephant Training Center (SETC), established within the Seblat Nature Tourism Park (SNTP) area in North Bengkulu Regency, aims to conserve and develop the elephant population through semi in-situ methods. Wild elephants involved in conflicts with humans are brought to Seblat Elephant Training Center (SETC), tamed, cared for, trained, and bred to increase the number of young individuals, which are then released back into their natural habitat (Suhartono et al., 2007).

The Seblat Nature Tourism Park (SNTP) area is the natural habitat of wild elephants, but over the past two decades, it has suffered from degradation, destruction, and fragmentation due to illegal logging, firewood collection, and poaching (Yulianto et al., 2020, Gao et al., 2019). Outside the SNTP area, there is production forest, much of which has been converted into palm oil, rubber, and coffee plantations, both by large foreign companies and by local communities. This extensive forest conversion has led to a drastic decline in the wild elephant population within the SETC forest area. In 2009, the number of wild elephants inside and outside the SETC area was recorded at 700-800 individuals, but this number has steadily decreased to 60-80 individuals (Rizwar et al., 2001). Recent information from the authorities of Natural Conservation Center in Bengkulu Province indicates that wild elephants are no longer found within the SNTP forest, as they have migrated to the remaining production forest outside the SNTP and to the protected forest of Kerinci Seblat National Park (KSNP).

Understanding the preferences of Sumatran elephants for certain plant species is crucial for their health and well-being in captivity and/or in the wild. This knowledge can assist in designing appropriate diets for captive elephants, as well as implementing effective habitat management strategies to conserve wild populations. As large-bodied mammals, elephants have a habit of consuming grass, leaves, branches, fruits, bark, and young stems. Elephants prefer grass because it contains easily digestible carbohydrates and has low fiber content (Ramanankirahina et al., 2019). Santosa and Thohari (Santosa and Thohari 2011) identified 42 plant species from 24 families that serve as elephant fodder, with the most preferred and consumed species belonging to the grass family Poaceae. A study by Borah & Deka (Borah and Deka, 2008) in India noted that the plant species most preferred by elephants were *Ficus glomerata* (15.80%), *Leersia hexandra* (15.08%), and Mussa (12.3%), with *Imperata cylindrica* at 8.45%. Meanwhile, Anwar et al. (2015) found that the plants most preferred by Sumatran elephants were grasses from the genera Imperata and Saccharum, as well as several woody plant species such as *Asplenium nidus*, *Ficus* sp., and Garcinia sp.

Generally, the descriptions from these studies focus on elephants in their natural habitats, while research or publications on the dietary preferences of Sumatran elephants kept in semi in-situ conditions are relatively scarce. This study aims to identify the plant species preferred by Sumatran elephants at the Seblat Elephant

Training Center (SETC) and is expected to contribute to the conservation efforts and population development of these elephants at this place.

2. MATERIALS AND METHODS

2.1 Location of Study

The study on the dietary preferences of Sumatran elephants at the Seblat Elephant Training Center (SETC) within the Seblat Natural Tourism Park (SNTP) area, North Bengkulu Regency, was conducted from May to June 2023 using the "focal animal sampling" method [Martin and Bateson 1993). This method was employed to observe and analyze the feeding duration of individual elephant at SETC directly. The estimated area for foraging by elephants of SETC within the SNTP is approximately 1,659 hectares.

2.2 Sampling Method

Observations on the natural dietary preferences of elephants were conducted on five (5) ETC-tamed elephants, consisting of two (2) adult males (Names: Nelson & Robi) and three (3) adult females (Names: Desi, Sari, and Fatma). Data for each elephant were recorded, including name, gender, weight, and age. Observations were carried out from 09:00 to 12:00 West Indonesian Time (WIT) when the elephants were herded within the SETC area.

The data collected in this study includes information on the plant species consumed by each individual elephant under observation, as well as the amount of time spent consuming each plant species during grazing.

2.3 Data Analysis

The analysis of the elephants' preferences for natural plant species was calculated using a modified formula from Martin and Bateson (Martin and Bateson 1993):

$$N_o = \left(\frac{ni}{N}\right) \times 100\%$$

Explanation:
No: Elephant preference or Option
ni: The amount of time spent by the elephant consuming a specific plant species.
N: The total time allocated by the elephant for consuming all plant species

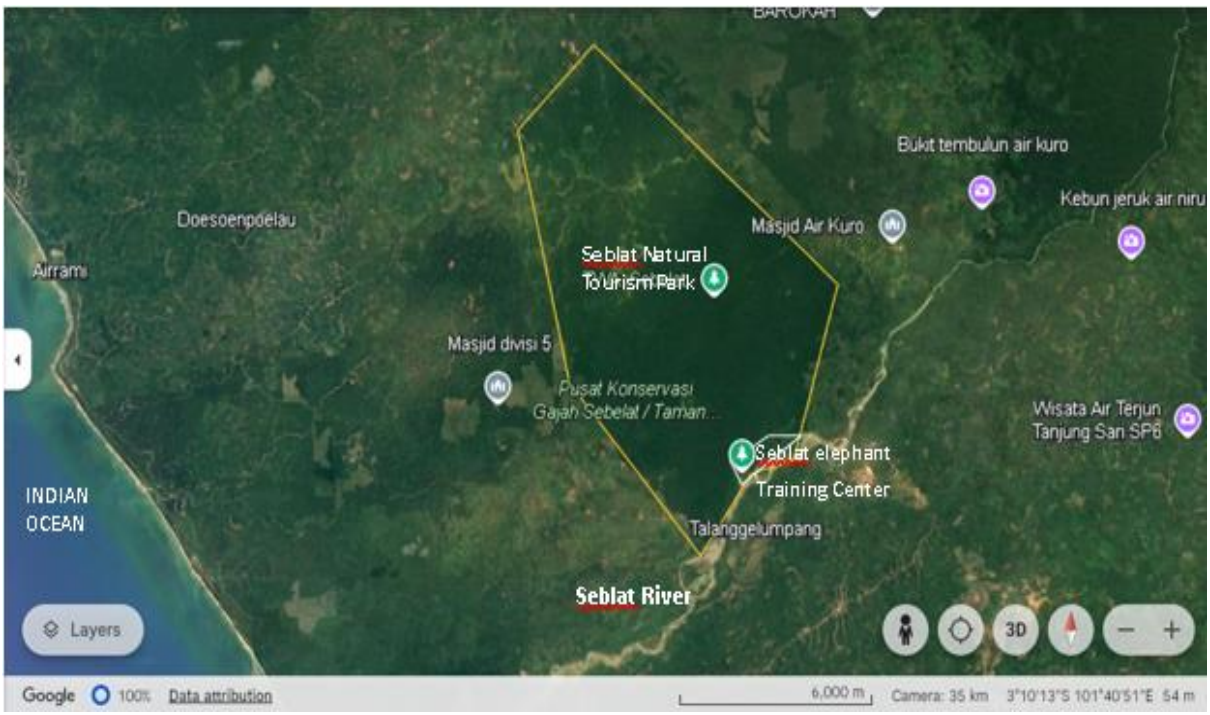

Fig. 1. Map of Seblat Natural Tourism Park Area and Seblat Elephant Training Center at Seblat District, Bengkulu Province-Southern Sumatra, Indonesia (From Google Earth 2024)

3. RESULTS AND DISCUSSION

The results of this study revealed that 33 species from 15 plant families were identified as the forage species consumed by the tame elephants at the Seblat Elephant Training Center (SETC) within the SNTP area.

The plant group most preferred, favored, and frequently consumed by the SETC elephants consisted of grasses from the Poaceae family (12 species), followed by the Fabaceae family (6 species). Research by Kaspari et al., (2021) suggests that the nutritional content within the Poaceae family (grasses) is likely the main factor determining the preference of elephants and/or herbivorous mammals for these forage plants. Some of the key nutrients commonly found in grasses include:

1. Carbohydrates: Grasses generally contain complex carbohydrates in the form of cellulose, amylose, and amylopectin. These carbohydrates are the primary energy source for herbivores, including elephants, helping to meet their energy requirements.
2. Fiber: Fiber is an essential component of herbivores' diets as it aids in digestion and the movement of food through the digestive tract. Grasses are rich in fiber, particularly soluble and insoluble fiber, which supports the digestive health of herbivores.
3. Protein: Although the protein content in grasses is typically lower than in other plants like legumes, they still provide an important source of protein for herbivores. Protein is necessary for growth, tissue repair, and other bodily functions.
4. Minerals: The Poaceae family often contains essential minerals such as calcium, phosphorus, magnesium, and potassium. These minerals are crucial for maintaining the bone health, nervous system, and other physiological functions of herbivores
5. Vitamins: Although the vitamin content in grasses may not be as high as in some other plants, certain grasses still contain important vitamins such as vitamin A, vitamin E, and vitamin K, which are vital components of a herbivore's diet.

A previous study by Syarifudin, (2008) within the SNTP primary and secondary forest area identified 58 species of elephant forage plants, which is significantly more than the findings of this study. The families Poaceae, Asteraceae, and Fabaceae constituted the bulk of the plant species consumed and preferred by the elephants. Santosa and Thohari (2011) discovered 245 plant species consumed by elephants, with 65 species having the potential as forage sources, belonging to 77 families within the SNTP forest area.

The differences in study results among researchers are likely due to variations in the size of the forest area observed and the sampling locations. Afriani et al., (2014) microscopically examined the forage plants contained in the feces of tame elephants at SETC. Seventeen species from 11 families were identified as elephant forage plants, with the Fabaceae and Asteraceae families being the most consumed compared to other families. The combination of these nutritional components makes the Poaceae family an important food choice for many herbivorous mammals, including elephants. However, food preferences can also be influenced by other factors such as availability, feeding habits, and habitat environment.

The elephants' preferences for plant species at SETC were analyzed based on the amount of time spent consuming specific plant species, compared to the total time spent consuming all recorded forage species. The preference values (in percentages) are presented in Table 2.

Overall, the Poaceae family was the most preferred and favored by the PLG elephants, showing the highest preference value (35.07%), followed by Fabaceae (31.73%), Malvaceae (9.87%), and Cyperaceae (7.83%), while the least preferred were Costaceae and Myrtaceae (0.33%), Convolvulaceae (0.41%), and Selaginellaceae (0.73%). Sukumar, (2003) stated that elephants tend to favor Fabaceae grasses due to their high content of easily digestible carbohydrates. The protein content in these grasses' ranges from 6-8%, with protein and crude fat being essential chemical components required by rumen microbes in mammals (Kushartono and Iriani, 2004). The characteristics of the Fabaceae and Poaceae families include self-sustaining growth and high productivity, leading to their abundant availability in the wild, making them a favored food source for elephant.

Elephants require food plants that contain mineral salts such as calcium. The calcium needs of elephants are met through the consumption of twigs, roots, and mud, as they

exhibit salt-licking behavior (He et al., 2022). In terms of food types, Cyperaceae grasses were more preferred by elephants compared to non-grass groups. *Cyperus rotundus* L. and *Cyperus brevifolius* Rottb. were frequently consumed due to their relative abundance in the study area. The root morphology of these plants is fibrous, with numerous roots forming a multiplant growth structure capable of obtaining water and nutrients from the surrounding environment (Djufri, 2003).

Malvaceae, specifically *Pterospermum javanicum* Jungh., was also favored by the SETC elephants (9.87%). Observations indicated that elephants only consumed the twigs of this plant. Santosa and Thohari (2011) reported that, in addition to leaves, bark, and fruits, the twigs of forage plants are also preferred by elephants.

The preferences or choices of the SETC Elephants for forage plants based on sex show clear differences. The preference of male elephants for forage plants is displayed in Fig. 2. The most commonly consumed plants by male elephants belong to the Fabaceae family, specifically *Mimosa pudica* (35.99%), *Desmodium triflorum* (11.66%), Mimosa invisa (7.36%), and *Cynodon dactylon* (6.54%). The Fabaceae family, such as legumes, are rich in protein and nitrogen. Robbins (1993) suggested that protein is an important component in the diet of large herbivores as it supports muscle growth and the maintenance of other bodily functions. Male elephants, which require significant muscle mass and optimal physical condition for intrasexual competition and intense activities, may prefer Fabaceae to meet their protein needs. Protein requirement might be more pronounced in males during the mating season when energy and stamina are highly needed (Sukumar, 2003). Owen-Smith (1988) added that male elephants may prioritize plants that provide quick energy and high protein content to support intensive physical activities, including long-distance movement besides competition for mates.

Table 1. Forage Plant Species Consumed by Sumatran Elephants at SETC within The Seblat Natural Tourism Park (SNTP) Area

No	Species	Family	Local Name
1	*Homalomena occulta* L.	Araceae	Nampu
2	*Calamus axillaris* Becc.	Arecaceae	Rotan
3	*Mikania micrantha* Kunth.	Asteraceae	Sembung Rambat
4	*Elephantopus scaber* L	Asteraceae	Tapak Liman
5	*Ipomea purpurea* L. Roth.	Convolvulaceae	Ipomea
6	*Cheilocostus speciosus* J. Koenig.	Costaceae	Pacing Tawar
7	*Cyperus rotundus* L.	Cyperaceae	Rumput Teki
8	*Cyperus brevifolius* Rottb.	Cyperaceae	Jukut Pendul
9	*Dryopteris filix-mas* LSchott.	Drypteridaceae	Pakis Jantan
10	*Spatholobus littoralis* Hassk.	Fabaceae	Bajakah Tampala
11	*Mimosa pudica* L	Fabaceae	Putri Malu Kecil
12	*Senna obtusifolia* L.	Fabaceae	Senna
13	*Calopogonium mucunoides*Desv.	Fabaceae	Kacang Asu
14	*Desmodium triflorum* (L.) DC.	Fabaceae	Sisik Betok
15	*Mimosa invisa* Mart.	Fabaceae	Putri Malu Besar
16	*Pterospermum javanicum* Jungh.	Malvaceae	Bayur
17	*Psidium guajava* L	Myrtaceae	Jambu Biji
18	*Piper sarmentosum* Roxb.	Piperaceae	Karok
19	*Leersia virginica* Willd.	Poaceae	Rumput Lulangan
20	*Cyrtococcum patens* (L.) A.	Poaceae	Rumput Mentebong
21	*Centhotheca lappacea* Desvaux.	Poaceae	Rumput Suket
22	*Digitaria sanguinalis* (L.) Scop.	Poaceae	Jampang Piit
23	*Imperatacylindrica (*L.) P. Beauv.	Poaceae	Ilalang
24	*Pennisetum clandestinum* Hochst.	Poaceae	Rumput Kikuyu
25	*Chrysopogon aciculatus* (Retz.)	Poaceae	Rumput Jarum
26	*Themeda arguens* (L.) Hack.	Poaceae	Rumput Merakan
27	*Cynodon dactylon* (L.) Pers.	Poaceae	Rumput Bahama
28	*Microstegium vimineum* (Trin.) A.	Poaceae	Rumput Kemasan
29	*Leersia oryzoides* (L.) Sw.	Poaceae	Rumput Potong
30	*Echinochloa cruss-galli* L.P.	Poaceae	Gulma Jawan
31	*Selaginella wiildenowii* Desv.	Selaginellaceae	Paku Rene
32	*Cyclosorus interruptus* Willd.	Thelypteridaceae	Pakis Perisai Rawa
33	*Leea indica* (Burm.F.) Merr.	Vitaceae	Malai

Table 2. Sumatran Elephants' Preferences for dietary plants in the Seblat Elephant Training Center

No	Species	Family	Local Name	No Species (%)	No Family (%)
1	*Homalomena occulta* L.	Araceae	Nampu	1.22	1.22
2	*Calamus axillaris* Becc.	Arecaceae	Rotan	2.77	2.77
3	*Mikania micrantha* Kunth.	Asteraceae	Sembung Rambat	0.57	2.04
4	*Elephantopus scaber L*	Asteraceae	Tapak Liman	1.47	
5	*Ipomea purpurea* L. Roth.	Convolvulaceae	Sri Pagi Ungu	0.41	0.41
6	*Cheilocostus speciosus* J.Koenig.	Costaceae	Pacing Tawar	0.33	0.33
7	*Cyperus rotundus* L.	Cyperaceae	Rumput Teki	4,00	**7.83**
8	*Cyperus brevifolius* Rottb.	Cyperaceae	Jukut Pendul	3.83	
9	*Dryopteris filix-mas* L.Schott.	Drypteridaceae	Pakis Jantan	1.96	1.96
10	*Spatholobus littoralis* Hassk.	Fabaceae	Bajakah Tampala	2.37	**31.7**
11	*Mimosa pudica* L	Fabaceae	Putri Malu Kecil	16.23	
12	*Senna obtusifolia* L.	Fabaceae	Senna	2.28	
13	*Calopogonium mucunoides*	Fabaceae	Kacang Asu	3.26	
14	*Desmodium triflorum* (L.) DC.	Fabaceae	Sisik Betok	4.65	
15	*Mimosa invisa* Mart.	Fabaceae	Putri Malu Besar	2.94	
16	*Pterospermum javanicum* Jungh.	Malvaceae	Bayur	9.87	**9.87**
17	*Psidium guajava* L	Myrtaceae	Jambu Biji	0.33	0.33
18	*Piper sarmentosum* Roxb.	Piperaceae	Karok	0.98	0.98
19	*Leersia virginica* Willd.	Poaceae	Rumput Lulangan	5.63	**35.1**
20	*Cyrtococcum patens* (L.) A.	Poaceae	Rumput Mentebong	1.06	
21	*Centhotheca lappacea* Desvaux.	Poaceae	Rumput Suket	2.20	
22	*Digitaria sanguinalis* (L.) Scop.	Poaceae	Jampang Piit	3.02	
23	*Imperatacylindrica (*L.) P.Beauv.	Poaceae	Ilalang	7.01	
24	*Pennisetum clandestinum* Hochst.	Poaceae	Rumput Kikuyu	2.53	
25	*Chrysopogon aciculatus* (Retz.)	Poaceae	Rumput Jarum	1.55	
26	*Themeda arguens* (L.) Hack.	Poaceae	Rumput Merakan	0.49	
27	*Cynodon dactylon* (L.) Pers.	Poaceae	Rumput Bahama	2.61	
28	*Microstegium vimineum* (Trin.) A.	Poaceae	Rumput Kemasan	1.06	
29	*Leersia oryzoides* (L.) Sw.	Poaceae	Rumput Potong	4.73	
30	*Echinochloa cruss-galli* L.P.	Poaceae	Rumput Jawan	3.18	
31	*Selaginella wiildenowii* Desv.	Selaginellaceae	Paku Rene	0.73	0.73
32	*Cyclosorus interruptus* Willd.	Thelypteridaceae	Pakis Rawa	0.98	0.98
33	*Leea indica* (Burm.F.) Merr.	Vitaceae	Malai	3.75	3.75
Total				100	100

Explanation: No= Preference to dietary plants

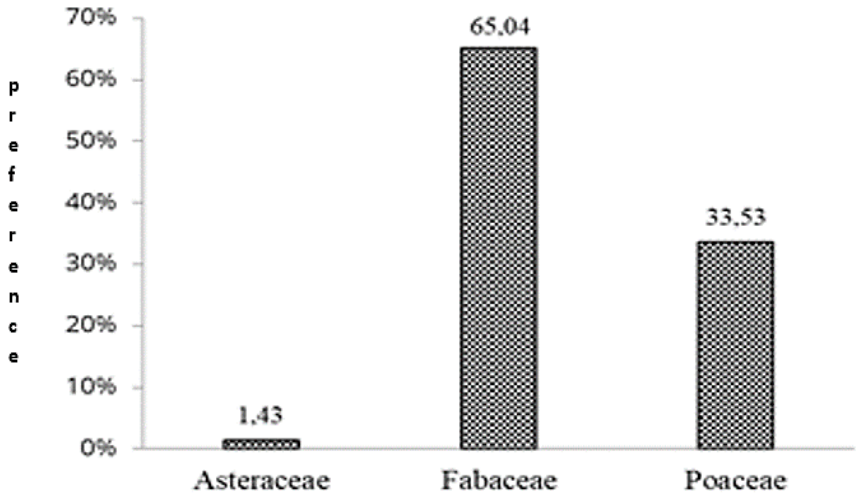

Fig. 2. Preferences of adult male elephants to forage plants in the SETC

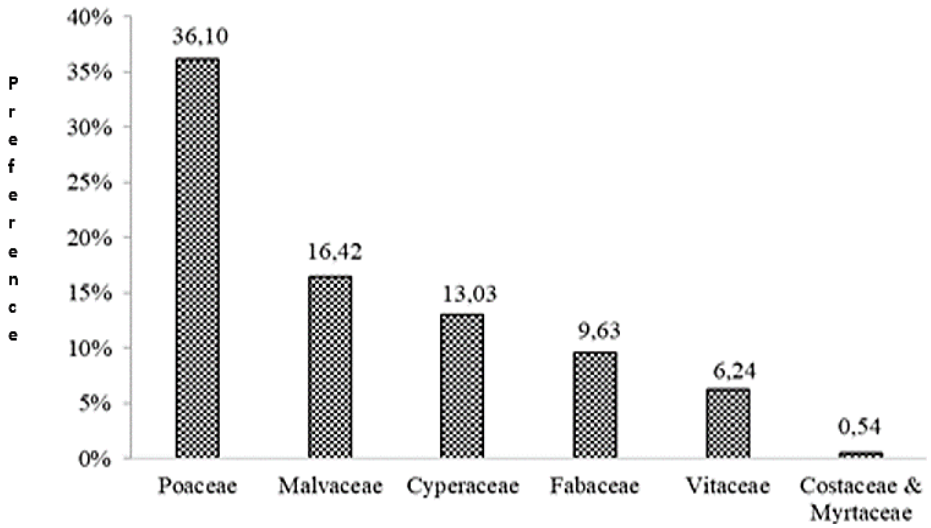

Fig. 3. Preferences of adult female elephants to forage plants in the SETC

Sunil (2012) stated that *Mimosa pudica* contains flavonoid compounds, which are known for their anti-inflammatory, antiviral, antifungal, antibacterial, and antihypertensive properties that help maintain and enhance the function of capillaries. Hou et al., (1996) stated that in addition to flavonoids, Fabaceae also contains beneficial substances such as saponins, tannins, flavonoids, proteins, stilbenoids, xanthones, terpenes, balsams, phytoalexins, and organic acids. Fabaceae is highly effective in treating intestinal worms, bloating, and improving digestion. Elephants are large mammals with poor digestion, capable of processing only 50% of the plant matter they consume (Samansiri and Weekaroon, 2007).

The preferences or choices of female elephants at the SETC for various forage plants are shown in Fig. 3.

Female elephants choose the Poaceae family because they are often higher in fiber but lower in protein. Johnson et al., (1997) noted that females who are pregnant or lactating have stable and constant energy needs, which can be supported by a fiber-rich diet that aids in fermentation and long-term energy production. Fiber is also crucial for digestive health, which becomes critical during gestation and lactation. Van Soest, (1994) added that the fiber content in Poaceae supports the fermentation process in the large intestine, producing volatile fatty acids as an energy source.

Umar, (2015) stated that Poaceae contains 29.03% crude fiber and 6.99% crude protein. Elephants require forage with a high fiber content to aid digestion. The fiber in the Poaceae group is due to the sufficient lignin content that complements cellulose and hemicellulose. As a plant matures, its crude fiber content increases, making it easier for elephants to digest (Parakkasi, 1999)

4. CONCLUSION

Based on the research results, it can be concluded that there are 15 families with 33 species of natural forage plants for the SETC elephants. In general, the Poaceae family is the most preferred and favored by the SETC elephants, with the highest preference value (35.07%), followed by Fabaceae (31.73%), Malvaceae (9.87%), and Cyperaceae (7.83%). The least favored are Costaceae and Myrtaceae (0.33%), Convolvulaceae (0.41%), and Selaginellaceae (0.73%). In terms of sex, adult male elephants prefer and favor Fabaceae such as *Mimosa pudica* (35.99%), *Desmodium triflorum* (11.66%), Mimosa invisa (7.36%), and *Cynodon dactylon* (6.54%) over other families. Conversely, adult female elephants prefer and favor Poaceae such as *Leersia virginica* Willd., *Cyrtococcum patens* (L.) A., *Centhotheca lappacea* Desvaux., *Digitaria sanguinalis* (L.) Scop., and *Imperata cylindrica* L.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image

generators have been used during writing or editing of this manuscript.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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