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Research Article

Identification of the Type of Feed for the Sumatran Elephant (*Elephas maximus sumatranus*) at the Elephant Response Unit (ERU) Camp Bukit Barisan Selatan National Park

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Abstract

The conservation of the Sumatran elephant (*Elephas maximus sumatranus*), an endangered and endemic subspecies in Indonesia, requires detailed understanding of its ecological needs, particularly regarding forage availability. This study investigates the composition of food plants consumed by Sumatran elephants within the Elephant Response Unit (ERU) Camp, Bukit Barisan Selatan National Park. The research specifically aimed to identify plant species consumed, determine the plant parts most frequently eaten, and assess foraging frequency to inform sustainable habitat management. A total of five individual elephants (three males and two females) were observed using focal animal sampling over a period of three days, with six-hour daily sessions conducted from 09:00 to 15:00 WIB. Grazing locations were selected through purposive sampling across five habitat types. Collected data were analyzed using the Sorensen species similarity index and foraging frequency formula. Results indicated that elephants consumed 30 plant species, with the highest diversity (19 species) found in open land habitats. The most frequently consumed species included *Brachiaria mutica*, *Cyperus kyllingia*, *Fimbristylis* sp., and *Imperata cylindrica*. The highest similarity index between individuals (80%) occurred in elephants that grazed in similar areas, while habitat-based similarity reached 63.15% in mixed swamp-canopy zones. Notably, several species were foraged for purposes other than feeding. These findings underline the importance of maintaining abundant forage species in conservation areas to support elephant well-being and enhance the ecological resilience of in-situ management strategies.

Keywords: *Sumatran elephant; habitat; identification; foraging frequency; food plants*

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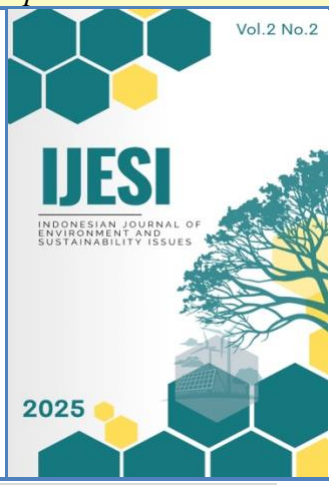

INTRODUCTION

The Sumatran elephant (Elephas maximus sumatranus), a subspecies of the Asian elephant, is native exclusively to the island of Sumatra, Indonesia. This species plays a significant ecological role as a megaherbivore, contributing to forest dynamics through seed dispersal and vegetation management. However, its population has experienced a steep decline in recent decades, leading to its classification as Endangered on the International Union for Conservation of Nature (IUCN) Red List. The main drivers of this decline include habitat destruction from large-scale deforestation, agricultural expansion, and illegal poaching. Such anthropogenic disturbances result in habitat fragmentation and loss of critical ecological resources, ultimately threatening the survival of remaining wild populations.

Among the various ecological factors essential to the survival of large herbivores, food availability stands out as particularly vital. Elephants, due to their large body size and high metabolic demands, require a substantial amount of food daily—estimated at 5–10% of their body weight [1], [2]. In natural conditions, they consume a wide variety of plant materials, including grasses, leaves, stems, bark, roots, fruits, and aquatic plants [3]. Prior studies have documented more than 400 plant species potentially consumed by Sumatran elephants, particularly from families such as Poaceae, Cyperaceae, Fabaceae, and Moraceae [4], [5]. However, food selection by elephants is not random and often depends on plant availability, habitat type, seasonal fluctuations, and regional vegetation composition [6]. Understanding this variation is essential for managing elephant habitats, especially in conservation settings where human intervention supports wildlife preservation.

The Elephant Response Unit (ERU), located in the Bukit Barisan Selatan landscape, represents an in-situ conservation initiative designed to integrate habitat protection with direct elephant monitoring and conflict mitigation strategies. The area surrounding the ERU is ecologically diverse, consisting of mixed vegetation types such as open grasslands, swamps, young secondary forests, and mature secondary forests. These habitat types are expected to harbor a wide range of plant species suitable for elephant foraging. Despite the ecological importance of the ERU as a managed habitat, current knowledge on the specific plant species consumed by elephants within this area remains limited. Most available dietary data are derived from broader regional studies and may not reflect the localized foraging patterns within the ERU context. This lack of site-specific dietary information presents a significant gap in developing tailored habitat management plans and sustainable feeding strategies within conservation zones. Effective conservation strategies, particularly for large herbivores, require an integrative approach to natural resource management that supports habitat sustainability and aligns with local ecological wisdom [7].

Given the pivotal role of food resource availability in maintaining the health and ecological function of elephant populations, accurate identification of preferred forage species is critical. Information on consumed plant parts and frequency of consumption also provides insight into habitat carrying capacity and can inform enrichment planting or supplemental feeding efforts. Furthermore, understanding elephant feeding behavior within the ERU can assist in reducing human–elephant conflict by

preventing elephants from leaving conservation areas in search of food. Although elephant diet studies exist in natural forest settings, there is a clear need for research focused on managed conservation areas to ensure site-specific management interventions are evidence-based. In response to this research gap, the present study aims to: (1) identify the plant species consumed by Sumatran elephants within the Camp Elephant Response Unit (ERU) of Bukit Barisan Selatan; (2) determine which plant parts are preferred and consumed; and (3) assess the frequency of plant species consumption. The results are expected to contribute valuable ecological data to inform conservation planning and enhance the effectiveness of habitat management strategies within ERU conservation frameworks.

METHODS

Determining grazing locations was carried out using the purposive sampling method, which involves randomly and intentionally selecting grazing sites [8]. The research location at the Camp Elephant Response Unit (ERU) includes open land, swamps, covered areas, and a mixed habitat of swamp openings and swamp cover. The selection of grazing locations was based on the availability of food sources sufficient to meet the elephants daily feeding needs. The subjects of observation in this study were five individual Sumatran elephants (*Elephas maximus sumatranus*), consisting of three males and two females. Observations for each elephant were conducted over 18 hours, divided into 6 hours/day for 3 consecutive days—the observation period aligned with the grazing time at Camp ERU, from 09:00 to 15:00 WIB. Data collection on the most frequently consumed plants species performed using the focal animal sampling methods, which involves directly following the elephants for a specific period.

Types of Food Plants Consumed by Sumatran Elephants

Data on food plant types were obtained through direct observation by following and recording all plant species consumed by elephants while grazing in their habitat [9] The plant species were identified by collecting plant samples from the grazing area and creating a simple herbarium. Plant sample collection was conducted on the same day as the data collection on food plant types and the parts consumed. The simple herbarium was only created for plant species that were difficult to identify directly at the observation site. The identification process was based on plant morphology using plant identification books, namely The Kew: Tropical Plant Families Handbook Second Edition [10] and Collection of Illustrated Tropical Plants. The data on food plant species consumed by Sumatran elephants, obtained through direct field observations, were processed into a list of food plant species. To analyze the similarity of plant species consumed by each observed elephants and across different habitat types, the Sorensen species similarity index was used as follows:

$$IS = \frac{2c}{a+b} \times 100\%$$

Description:

IS = Species similarity index

c = Number of species consumed by both elephants

a = Number of species consumed only by elephants A
b = Number of species consumed only by elephant B

A similarity index value of Sorensen species approaching 100% indicates that the compared elephant individuals consume relatively the same plant species. In contrast, a value approaching 0% suggests that the plant species consumed are relatively different [11]. The Sorensen species similarity index is also used to determine the similarity of food plant species across different habitat types.

Most Frequently Consumed Plant Species

The most frequently consumed plant species were determined by calculating the foraging frequency of each plant species when eaten by elephants [8], [12]. The frequency of a plant species being consumed by elephants can be calculated using the following formula [13] :

$$F = \frac{X}{Y} \text{ x } 100\%$$

Description:
F = Frequency of plant species consumed
X = Number of times a specific plant species is foraged
Y = Total number of foraging instances

The foraged plant species were then categorized into three groups: foraged only, foraged and eaten, and foraged, eaten, and the regurgitated.

Parts Consumed

Data on the plant parts consumed by elephants were obtained through direct observation and by recording the parts eaten while the elephants were grazing [14]. The consumed plant parts were categorized into five groups: stem, flower, leaf, bark, and the entire plant [15], [16]. To ensure data accuracy and consistency, all observers received prior training in plant identification and behavioral recording techniques. When uncertainties in plant identification occurred, specimens were reviewed by botanical experts from the local university herbarium to validate identification.

RESULT AND DISCUSSIONS

Types of Plants for Sumatran Elephants Food

A total of 30 plant species were identifies as food sources for Sumatran elephants, distributed across five habitat types (Table 1).

Table 1. Types of Food Plants Consumed by Sumatran Elephants in Each Grazing Habitat Type

No	Family	Types of Food Plants	Habitat				
			OL	S	CC	CcS	CS

1	Arecaceae	*Calamus* sp.				√	
2	Asteraceae	*Clibadium surinamense*				√	
3		*Mikania micrantha*	√				
4	Costaceae	*Costus spicatus*			√		
5	Cyperaceae	*Cyperus killing*	√			√	√
6		*Cyperus rotundus*	√				
7		*Cyperus* sp. 1				√	
8		*Cyperus* sp. 2				√	
9		*Fimbristylis* sp.	√			√	
10		*Rynchospora corymbosa*		√		√	√
11		*Scleria* sp.	√			√	√
12	Fabaceae	*Bauhinia* sp.	√				
13		*Crotalaria pallida*	√				
14		*Mimosa pudica*	√				
15	Melastomataceae	*Melastoma malabathricum*	√				
16	Nephrolepidaceae	*Nephrolepis biseriate*				√	
17	Phyllanthaceae	*Bridelia tomentose*	√				
18		*Glochidion* sp.	√				
19	Poaceae	*Axonopus compressus*			√		
20		*Brachiaria mutica*	√		√	√	√
21		*Brachiaria* sp.	√				

22		*Gigantochloa apus*	√				
23		*Imperata cylindrica*	√		√	√	√
24		*Oplismenus compositus*	√				
25		*Panicum repens*		√		√	√
26		*Paspalum conjugatum*	√				√
27		*Paspalum* sp.	√				
28		Sp 4			√		
29	Selaginellaceae	*Selaginella* sp.			√		
30	Solanaceae	*Solanum* sp.	√				
		Total	19	2	6	12	7

Description: Open land (OL); Swamp (S); Canopy Cover (CC); Canopy cover and swamp (CcS); and Clearing and swamp (CS)

The selection of grazing habitats was based on the availability of food sources to meet the elephants daily dietary needs. As megaherbivores, Sumatran elephants require a large amount of food each day, making them unable to be highly selective in their feeding habits [17]. Elephant consume 400 plant species across various habitats and regions [5]. Research conducted in Kerinci Seblat National Park found that Sumatran elephants consumed 273 plant species. Meanwhile, a study in the Flying Squad of Tesso Nilo National Park recorded 110 plant species food plant species, primarily from the families Euphorbiaceae, Fabaceae, Moraceae, and Poaceae [18], [19]. Based on the findings, the food plant species consumed by Sumatran elephants in Camp ERU primarily belong to Cyperaceae, Fabaceae, and Poaceae.

The results of this study indicate that the highest number of food plant species was found in open land, with 19 plant species recorded. This finding aligns with research conducted by [8] at the Aek Nauli Elephant Conservation Camp (ANECC) in North Sumatra, which reported that out of 31 food plant species, 17 species were found in open land. Extensive open areas in tropical rainforests contribute to increased food plant species for elephants, such as grasses and bamboo[20], [21]. Most plants thrive in sunlight, essential for their growth and development through photosynthesis [22], [23]. Sunlight reaching open land stimulates plants, rhizomes, and seeds to germinate and grow rapidly [24]. Environmental factors. Such as temperature, soil conditions, and air humidity, influence plant growth in a given habitat.

Swamp habitat had the fewest food plants species recorded. Swamp are permanently or seasonally saturated with water and have limited oxygen availability [25]. In this study, *Rynchospora corymbo*sa and *Panicum repens* were the only two plant species found exclusively in swamp habitats. This may be due to their anatomical adaptations, particularly the presence of aerenchyma tissue [26]. Aerenchyma tissue has large intercellular spaces, facilitating air diffusion throughout the plant body and enabling survival in low-oxygen conditions such as swamps [27], [28]. These findings align with previous studies: [29] reported that *Rynchospora corymbosa* is commonly found in wetland areas, including swamps and [30] recorded *Panicum repens* as a swamp-dwelling plant species. This research confirms that *Rynchospora corymbosa* and *Panicum repens* are food plants for Sumatran elephants. This finding is consistent with previous studies, which found these species being consumed by Sumatran elephants in Tesso Nilo National Park and Pangkalan Gondai Village, Langgam District [12], [19].

Similarity Index of Food Plant Species for Sumatran Elephants

The composition of food plant species for Sumatran elephants at Camp ERU varies in each grazing habitat. Based on the food plants similarity index analysis, the highest IS value was found in the mixed habitat with swamp clearing and cover types, at 63.15% (Table 2).

Table 2. Similarity Index of Food Plant Species for Sumatran Elephants in Each Grazing Habitat

Habitat Type	Similarity Index (IS)				
	Open land	Swamp	Canopy cover	Canopy cover and swamp	Clearing and swamp
Open land		0%	16%	32,25%	38,46%
Swamp			0%	28,57%	44,44%
Canopy Cover				22,22%	30,76%
Canopy cover and swamp					63,15%
Clearing and swamp					

This indicates that the plant species in these two habitats are relatively similar. Several plant species, including *Brachiaria mutica, Cyperus kyllingia, Imperata cylindrica, Panicum repens, Rynchospora corymbosa,* and *Scleria* sp., were found in both habitats. The high similarity in plant species between these habitats is likely due to their proximity and overlapping areas. Adjacent habitats share similar plant species because they have similar environmental factors such as air and soil humidity, pH levels, wind speed and direction, all of which influence plant growth and

seed dispersal [31]. Meanwhile, the open land and swamp habitats, as well as the cover and swamp habitats, had low IS values (0%). The adaptation level of plant species in each habitat type influences the low similarity index in this study. Plant species found in swamp habitats are not present in open land and cover habitats, as these species possess unique characteristics that allow them to survive exclusively in swamp environments.

The food plant species consumed by Sumatran elephants at Camp ERU are similar. Among the five individual elephants, the highest similarity index (IS) of 80% was observed between Haryono and Renold (Table 3). This is because both elephants were grazed in the exact location but on different days. The availability of the same plant species in the study area resulted in similar feeding patterns. The plant species commonly consumed by both individuals include *Brachiaria mutica, Fimbristylis sp., Imperata cylindrica, Nephrolepis bisserata, Panicum repens, Rynchospora corymbosa, Scleria* sp., and *Solanum* sp.

Table 3. Similarity Index of Food Plant Species for Each Sumatran Elephant Individual

Sumatran Elephant Individuals	Similarity Index (IS)				
	Haryono	Rahmi	Agam	Mela	Renold
Haryono		34,48%	52,17%	44,44%	80%
Rahmi			43,75%	37,03%	27,58%
Agam				47,61%	52,17%
Mela					44,44%
Renold					

The lowest similarity index (IS) was observed between the elephants, Rahmi and Renold. This is due to the different grazing locations, which resulted in variations in plant composition. Different grazing locations allow plant species to grow, influenced by environmental factors such as soil conditions, light intensity, temperature, and air humidity [31]. Additionally, the similarity in plant species consumed by the five Sumatran elephant is influenced by plant diversity in grazing areas, which is also related to the mahout's decision in selecting grazing locations. Based on the similarity index analysis, there is a high similarity between the plants found in the habitat and those consumed by the elephants. The most commonly eaten plant species include *Brachiaria mutica, Fimbristylis* sp., *Imperata cylindrica, Rynchospora corymbosa, Panicum repens, Scleria* sp.

Composition of Forage Plant Species and Grazing Frequency

Eight plant species were found to be most frequently consumed by Sumatran elephants, based on the highest grazing frequency (Figure 1). The most commonly plant species varied across different habitat types, with *Brachiaria mutica* and *Imperata cylindrica* dominating four habitat types. The types of plants consumed by Sumatran elephants can be influenced by 3 factors: the availability of forage in their habitat, the elephant's health, and weather conditions [32], [33]. According to [32], elephants tend to consume more plant species believed to have medicinal properties when they are in poor health. Additionally, elephants reduce their feeding activity when environmental temperatures rise and seek shade [15], [34].

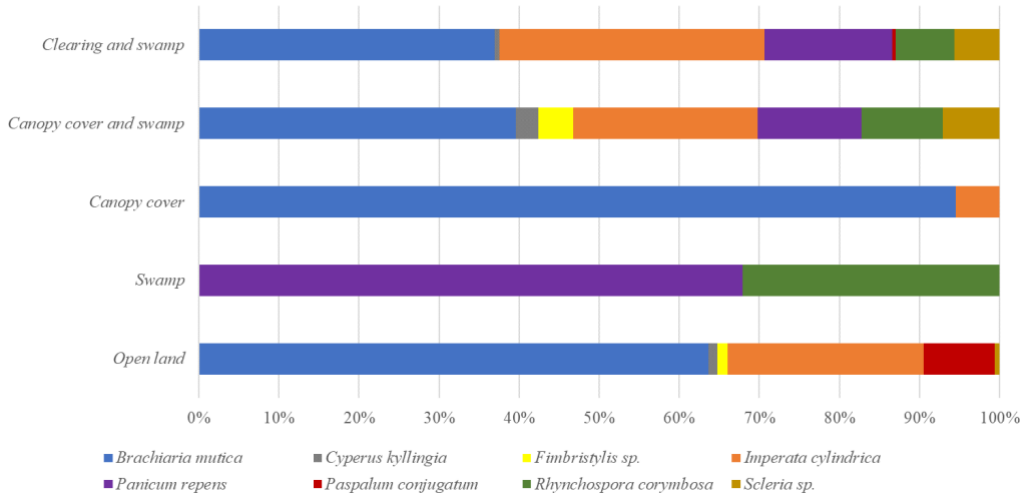

Figure 1. Composition of Forage Plant Species and the Highest Frequency in Each Habitat Type

This study found that Sumatran elephants primarily consumed plant species that were abundantly available in their habitat, particularly *Brachiaria mutica* and *Imperata cylindrica*, as indicated by their high grazing frequency. Both species belong to the Poaceae family, known for their cosmopolitan nature and ability to thrive in various habitats [30]. *Brachiaria mutica* has lightweight seeds that can be easily dispersed by wind or animals, leading to widespread distribution. Additionally, it can propagate through vegetative though rhizomes and stolons, allowing it to dominate specific habitats [35]. Similarly, *Imperata cylindrica* spreads widely due to its wind-dispersed seeds and vigorous rhizomes [36]. These findings align with studies by [14] and [19] conducted in Tesso Nilo National Park, which concluded that the Poaceae family is the most frequently consumed by Sumatran elephants.

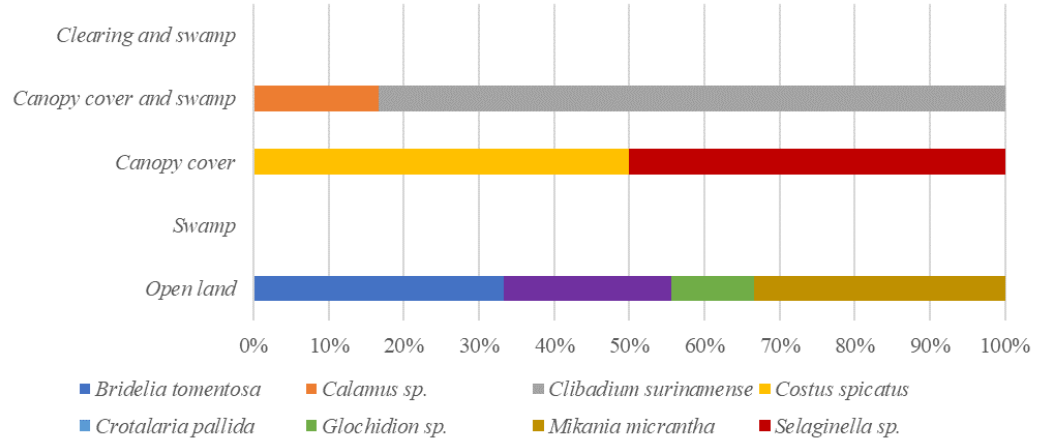

Figure 2. Composition of Forage Plant Species and the Lowest Grazing Freuqency in Each Habitat Type

Additionally, forage plant species with the lowest grazing frequency are those with limited availability in the habitat. These plant species belong to the families Arecaceae, Asteraceae Costaceae, Fabaceae, Phyllanthaceae, and Selaginellaceae (Figure 2). The low availability of these plant species may be due to competition among plants for nutrients and resources necessary for growth.

Parts Consumed

The parts consumed by Sumatran elephants vary depending on the plant species and their nutritional needs. Based on research findings, elephants most frequently consume the entire plant (12 species), followed by leaves (10 species) (Table 4). This is because the entire structure of ground-level plants tends to be soft and more accessible to elephants than tall trees leaves[37]. Most plants consumed belong to the Poaceae family, particularly short grasses. Additionally, Sumatran elephants eat entire plants while in the juvenile phase [5], such as *Glochidion* sp., and climbing plants like *Mikania micrantha* and *Selaginella* sp. In this study, leaves and a combination of stems, flowers, and leaves were mainly consumed from shrub or herbaceous plants.

Table 4. Parts Consumed by Sumatran Elephants

No	Family	Types of Elephant Feed Plants	Parts Consumed				
			S	F	L	B	AP
1	Arecaceae	*Calamus* sp.			√		
2	Asteraceae	*Clibadium surinamense*			√		
3		*Mikania micrantha*					√
4	Costaceae	*Costus spicatus*			√		
5	Cyperaceae	*Cyperus killingia*	√	√	√		
6		*Cyperus rotundus*			√		
7		*Cyperus* sp. 1	√	√	√		
8		*Cyperus* sp. 2	√	√	√		
9		*Fimbristylis* sp.	√	√	√		
10		*Rynchospora corymbosa*	√	√	√		
11		*Scleria* sp.	√	√	√		
12	Fabaceae	*Bauhinia* sp.	√		√		
13		*Crotalaria pallida*		√	√		

14		*Mimosa pudica*						√
15	Melastomataceae	*Melastoma malabathricum*			√			
16	Nephrolepidaceae	*Nephrolepis biseriate*	√		√			
17	Phyllanthaceae	*Bridelia tomentose*				√		
18		*Glochidion* sp.						√
19	Poaceae	*Axonopus compressus*						√
20		*Brachiaria mutica*						√
21		*Brachiaria* sp.						√
22		*Gigantochloa apus*			√			
23		*Imperata cylindrica*			√			
24		*Oplismenus compositus*						√
25		*Panicum repens*			√			
26		*Paspalum conjugatum*						√
27		*Paspalum* sp.						√
28		Sp 4						√
29	Selaginellaceae	*Selaginella* sp.						√
30	Solanaceae	*Solanum* sp.			√			
		Total	8	7	18	1		11

Description: S (stem); F (flower); L (leaf); B (bark); AP (all parts)

Additionally, Sumatran elephants have a denser molar surface pattern than African elephants, making them more adapted to consuming grasses [38]. This study only observed bark consumption in *Bridelia tomentosa*, eaten exclusively by an elephant named Mela. Elephants consume bark because it contains essential minerals such as magnesium, calcium, and potassium, which help strengthen teeth, tusks, and bones while supporting protein and carbohydrate metabolism [39]. In addition to uprooting plants for consumption, Sumatran elephants also pull-out plants for other purposes. A total of eight plant species were uprooted without being eaten, most of which were tree-like species. The leaves of *Flacourtia inermis, Lantana camara, Syzygium polyanthus, and Vitex pinnata* were pulled by Sumatran elephants to protect themselves from bites of ectoparasitic insects. Locally known as *pitak*, these insects resemble flies and feed on elephant blood [40].

Meanwhile, *Callicarpa tomentosa, Ficus hispida, and Selaginella plana* were used by elephants to shield their backs from intense sunlight. Sumatran elephants use plants for protection when water or mud is unavailable during hot weather. Additionally, *Alstonia scholaris* was uprooted only by the Agam elephant, as it obstructed access to other edible plants. *Alstonia scholaris* belongs to the Apocynaceae family and is not a primary food source for Sumatran elephants. Furthermore, this species has a tree-like growth habit, whereas the elephants in this study primarily consumed herbaceous and shrub-like plants.

CONCLUSION

Based on the research findings, a total of 30 plant species were identified as food sources for Sumatran elephants (Elephas maximus sumatranus), distributed across five distinct habitat types. The majority of these species 19 in total were recorded in open land habitats, indicating the ecological importance of these areas for foraging activity. The eight most frequently consumed plant species included *Brachiaria mutica*, *Cyperus kyllingia*, *Fimbristylis sp*., *Imperata cylindrica*, *Panicum repens*, *Paspalum conjugatum*, *Rynchospora corymbosa*, and *Scleria sp*. Observations revealed that elephants consumed various parts of these plants, including stems, flowers, leaves, bark, and whole plants. The presence of these forage species highlights the need for active preservation and management of native vegetation to ensure a sustainable food supply for Sumatran elephants within the *Elephant Response Unit* (ERU) area. Nonetheless, further research is recommended to evaluate the palatability, seasonal availability, and habitat carrying capacity associated with these plant species. Such information is critical for refining habitat management strategies and supporting long-term conservation planning. These efforts will enhance the ecological function of the ERU Camp as a viable in-situ conservation site, contributing to the continued survival of this endangered subspecies.

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AUTHORS CONTIBUTIONS

Agustina Marhaeni was primarily responsible for the conceptualization of the research, including the formulation of objectives and field study design. She conducted the main field investigation, performed direct observations, and led the initial drafting of the manuscript. Andy Darmawan contributed to the development of the methodological framework, ensured data validation and analytical accuracy, and provided substantial input in the critical revision and refinement of the manuscript. Gres Maretta supported the validation of plant identification, assisted in data interpretation, and contributed significantly to the graphical presentation of results and manuscript editing. Subki, as the field coordinator from Bukit Barisan Selatan National Park, played a crucial role in supervising field activities, facilitating access to the research site, and ensuring adherence to conservation protocols. All authors reviewed and approved the final version of the manuscript and collectively agreed to take responsibility for the integrity and accuracy of the research.

CONFLICT OF INTEREST

The authors declare that there are no conflicts of interest related to the design, implementation, analysis, or publication of this research. All procedures were conducted independently, and no financial or personal relationships have influenced the outcomes presented in this article.

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