Characteristics of forage garden vegetation of the Sumatran elephant (*Elephas maximus sumatranus*) in Medan Zoo

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Abstract. Medan Zoo is an ex situ conservation area for several wildlife species, covering an area of approximately 30 hectares, most of which are green open space and provide a forage garden for Sumatran elephants. This study aims to determine the characteristics of vegetation and the diversity of natural food types for elephants available in the Medan Zoo. Data collection using purposive sampling method, carried out in the forage garden which located in several points of elephant free-range. Based on the calculation of the Shannon-Wiener index, the overall diversity of plant species at the research location is 3.7 which can be categorized as high. The dominant understory plants in the elephant forage garden are species from the family of Poaceae, namely Paspalum conjugatum, Eragrostis amabilis, and Otcholeanodosa. Meanwhile, for species of trees habitus, the dominance for each level of vegetation starting from the tree, poles and saplings were: Melia azedarach, Hibiscus tiliaceus and Cassia sp. There are types of elephant feed plants, classified into 8 families. The dominant type of natural feed is from the family of Poaceae.

1. Introduction

The Sumatran elephant (*Elephas maximus sumatranus*) is a large mammal endemic of Sumatra island whose population has decreased along with the narrowing of its habitat, due to the conversion of forest land for agricultural land, plantations and other development interests. Due to habitat fragmentation, elephants often cause conflicts with humans. This condition makes the Sumatran elephants listed as endangered and listed in the IUCN Red List of Threatened Species [1], and included in Appendix I of the Convention on International Trade in Endangered Species of Wild Fauna and Flora [2]. In addition, Sumatran elephants are also protected according to Ministerial Regulation Number P.106/MENLHK/SETJEN/KUM.1/12/2018. The endangered category in question is that wild Sumatran elephants (in nature) are only found in a small population due to their narrow / limited geographical distribution and low population density [3].

To reduce conflict with humans, part of the elephant population were conditioned to go into captivity. Elephants are kept in captivity as an attraction or to be exhibited as trained animals, such as in zoos or in safari parks.

The Medan Zoo as an ex situ conservation area has an area of approximately 30 hectares, most of which are green open spaces, including a forage garden for the Sumatran elephant. This study aims to determine the characteristics of vegetation and the diversity of natural feed types for elephants available in Medan Zoo.
2. Methodology

The research was conducted from July to September 2020 at forage garden in the Medan Zoo, with the object of research being vegetation and natural food for elephants in the garden. The tools used in this research are: GPS, machete, roll meter, camera, raffia rope, notebook and pen/pencil. This research is an explorative research, which data collection using purposive sampling method, carried out in the elephant forage garden which spreads in several locations of elephant free-range as well as other forage garden locations that provide elephant feed to be given drop in. Vegetation analysis for the growth rate species of trees habitus was carried out in 5 (five) sample plots of elephant free-range locations, while for understorey vegetation the samples were taken on 6 (six) transects, each of which contained 5 (five) plots. Furthermore, the plant samples found were identified to know the type and its scientific name.

3. Results and discussion

3.1. Characteristics of feed garden vegetation

Forage garden in Medan Zoo are dominated by grassy vegetation types. In addition to understorey plants, there are also plant species of trees habitus at the growth rate of saplings, poles and trees; but no seedling growth rate was found. The possibility that happened is the growing seedlings are always stepped on by an elephant's foot, at the beginning of their growth. There were only 4 species of plants at tree level and pole level in the sample plot, with 13 individuals for each vegetation level; while saplings have 11 species and the total number is 67 individuals. The dominant plant species at each vegetation level starting from the tree, pole and sapling level are: *Melia azedarach*, *Hibiscus tiliaceus* and *Cassia* sp. The density of each species at each growth rate can be seen in Figures 1, 2 and 3.

![Figure 1. Tree level species densities per hectare](image1)

![Figure 2. Pole level species densities per hectare](image2)

Based on the calculation of the Shannon-Wiener index, the overall diversity of plant species with trees habitus at the study location was 3.7 which can be categorized as high according to [4]. But if you look at the diversity of species at each level of vegetation, the index of species diversity at the sapling growth rate of 3.49 is high; meanwhile, the levels of poles and trees were low [4], namely 1.76 and 1.35, respectively. This illustrates that the presence of plants at the level of poles and trees were very rare and the species dominance was not evenly distributed [5].
The results of the analysis of understorey vegetation on 6 transects showed that 3 dominant plant species with the highest of Important Value Index (IVI) were recorded: Paspalum conjugatum, Eragrotis amabilis, Ottochioanodosa. The dominant species on transects I, II and VI were Paspalum conjugatum, while Ottochioanodosa was the dominant species for transects IV and V; and the dominant species on transect III is Eragrotis amabilis, as shown in Table 1. All dominant species are from the Poaceae family. According to [6] the plant species in the family of Poaceae are the pioneer species that have the ability to spread quickly because the seeds are light and easily carried away by the wind. In addition, the root system of rhizomes (in soil) and stolons (above ground) causes high expansion capacity and can reach far areas; so that the types are easy to invade empty lands. Species from the family of Poaceae require full sun exposure without shade.

**Table 1. The Dominant understorey species on each transect**

| Number of Transect | Understorey species     | Family     | IVI    |
|--------------------|-------------------------|------------|--------|
| I                  | *Paspalum conjugatum*   | Poaceae    | 124.75 |
| II                 | *Paspalum conjugatum*   | Poaceae    | 82.30  |
| III                | *Eragrotis amabilis*    | Poaceae    | 89.53  |
| IV                 | *Ottochioanodosa*       | Poaceae    | 67.6   |
| V                  | *Ottochioanodosa*       | Poaceae    | 72.6   |
| VI                 | *Paspalum conjugatum*   | Poaceae    | 47.74  |

The diversity of understorey species on all transects was in the very low to moderate category [4], with an Shannon-Wiener index value of 0.604 to 2.443. Transect I has a very low level of diversity, transects II and III have a low level of species diversity; whereas transects IV, V and VI are categorized as moderate species diversity, as shown in Table 2. The equitability index of understorey, calculated using the Pielou formula in [7], shows that only transects IV and VI have an even distribution index that is classified as evenly distributed (index value is more than 0.75), while other transects have a value less than 0.75. This shows that the equitability of understorey species in the forage garden is generally low, or in other words the distribution of species is uneven.
Table 2. The Diversity Index of Shannon-Wiener and Equitability Index of Pielou of understorey species on each transect

| Number of Transek | Shannon-Wiener Index (H’) | Hmax | Equitability Index (E) |
|-------------------|---------------------------|------|-----------------------|
| I                 | 0.604                     | 2    | 0.302                 |
| II                | 1.949                     | 3.322| 0.587                 |
| III               | 1.657                     | 3.807| 0.435                 |
| IV                | 2.387                     | 3.17 | 0.753                 |
| V                 | 2.211                     | 3.17 | 0.697                 |
| VI                | 2.443                     | 3.17 | 0.771                 |

Table 3 shows that the distribution of species, Paspalum conjugatum and Centrosema pubescens were understorey species that are evenly distributed in the study location, while Isachne sp. and Brachiaria mutica has the smallest distribution frequency, because there are only one transect, namely transect VI. The Paspalum conjugatum had the highest of importance value index (IVI) on the 3 transects observed from the 6 transects (Table 1); so that this type was the dominant species on the three transects. The reason is this plant is easy to grow, the main distribution is with seeds and stolon roots and has the property of being easily attached to objects that pass around it [8]. In contrast to the Paspalum conjugatum which dominates in several transects, although Centrosema pubescens is evenly distributed, this species is not the dominant type. However, C. pubescens is a type of legume which is an important food plant for elephants, when viewed from its nutritional content because of its efficiency in N absorption [9].

Some of the understorey species listed in Table 3 are elephant food. These species are members of the Poaceae and Fabaceae families. The types are Paspalum conjugatum, Centrosema pubescens, Desmodium sp., Mimosa pudica, Saccharum spontaneum, Pennisetum purpureum, Panicum muticum, Isachne sp., and Brachiaria mutica. Tall grasses such as Saccharum spontaneum and Pennisetum purpureum are the types of grasses favored by elephants, due to they contain carbohydrates that are easily broken, protein, silica and fiber. [10]. Furthermore, Sukumar said that elephants like leaves in the dry season because their protein content is higher than grasses, which can reach 10 to 20 percent. One type of leaves favored by elephants is the leaves from family of Fabaceae, which is evenly distributed in the Medan Zoo’s feed garden.
Table 3. Distribution of understorey species in the free-range area of elephant

| Species                | Family           | I   | II  | III | IV  | V   | VI  |
|------------------------|------------------|-----|-----|-----|-----|-----|-----|
| *Paspalum conjugatum*  | Poaceae          | √   |     |     |     |     |     |
| *Eleutheranthera ruderalis* | Heliantheae     |     |     | √   |     |     |     |
| *Centrosema pubescens* | Fabaceae         | √   |     |     |     |     |     |
| *Andrographis paniculata* | Achanthaceae    |     |     |     |     |     |     |
| *Nephrrolepis biserrata* | Polypodiaceae   |     |     |     | √   |     |     |
| *Agreatum conyzoides*  | Asteraceae       |     |     |     |     |     | √   |
| *Desmodium sp*         | Fabaceae         |     |     |     |     |     |     |
| *Eragrostis amabilis*   | Poaceae          |     |     |     |     | √   |     |
| *Asystasia intrusa*    | Acanthaceae      |     |     |     |     |     |     |
| *Mucuna sp.*           | Fabaceae         |     | √   |     |     |     |     |
| *Ipomea sp.*           | Convolvulaceae   |     |     |     |     |     |     |
| *Mikania micrantha*    | Asteraceae       |     |     |     |     | √   |     |
| *Passiflora foetida*   | Passifloraceae   |     |     |     |     |     |     |
| *Oxalis barrelieri*    | Oxalidaceae      |     |     |     |     |     |     |
| *Cissus sp*            | Vitaceae         |     |     |     |     |     |     |
| *Mimosa pudica*        | Fabaceae         |     |     |     |     |     |     |
| *Sonchus arvensis*     | Asteraceae       |     |     |     |     |     |     |
| *Saccharum spontaneum* | Poaceae          |     |     |     | √   |     |     |
| *Ottochloa nodosa*     | Poaceae          |     |     |     |     |     |     |
| *Cyperus sp*           | Poaceae          |     |     |     |     |     |     |
| *Impatiens sp*         | Balsaminaceae    |     |     |     |     |     |     |
| *Pennisetum purpureum* | Poaceae          |     |     |     |     |     |     |
| *Panicum muticum*      | Poaceae          |     |     |     |     |     |     |
| *Isachne sp*           | Poaceae          |     |     |     |     |     |     |
| *Brachiaria mutica*    | Poaceae          |     |     |     |     |     |     |

*elephant feed

3.2. Diversity of feed plants

Sumatran elephants are herbivores whose food comes from plants which include: leaves, stems, bark, tubers, roots and fruit. In Medan Zoo, at least 19 types of elephant feed were found scattered in several locations, including into 8 families, namely: Poaceae, Euphorbiaceae, Musaceae, Mimosaceae, Fabaceae, Bambusaceae, Combretaceae and Ulmaceae. The dominance of the species growing on the forage land is from the Family of Poaceae, which is 11 species or 58 percent of the types of feed available in the Medan Zoo.

Even though they are not in their natural habitat, the Sumatran elephants that are held captive in this Zoo, still get their natural food, especially from grasses from the family of Poaceae both tall grasses and short grasses. Other types available are from the family of Euphorbiaceae and Fabaceae. It turns out that these three families are the most important families that provide types of food for elephants according to previous research [11-14]. Furthermore [15] reported that the food favored by elephants in Mane Pidie, was dominated by the Moraceae, Arecaceae and Euphorbiaceae tribes. Euphorbiaceae
Table 4. Types of elephant natural food plants that available in the feed garden

| No. | Feed plants species | Family       | Part consumed                      |
|-----|---------------------|--------------|-----------------------------------|
| 1   | *Isachne* sp.       | Poaceae      | All parts                         |
| 2   | *Manihot esculenta* | Euphorbiaceae| All parts                         |
| 3   | *Brachiaria decumbens* | Poaceae   | All parts                         |
| 4   | *Pennisetum purpureum cv. Mott* | Poaceae | All parts                         |
| 5   | *Saccharum spontaneum* | Poaceae   | All parts                         |
| 6   | *Saccharum officinarum* | Poaceae   | All parts                         |
| 7   | *Imperata cylindrica* | Poaceae      | All parts                         |
| 8   | *Leersia hexandra*  | Poaceae      | All parts                         |
| 9   | *Panicum auritum*   | Poaceae      | All parts                         |
| 10  | *Eragrotis amabilis* | Poaceae      | All parts                         |
| 11  | *Panicum maximum*   | Poaceae      | All parts                         |
| 12  | *Brachiaria mutica* | Poaceae      | All parts                         |
| 13  | *Bambusa* sp.       | Bambusaceae  | Leaves, shoots, young stems       |
|     |                     | Musaceae     | Fruits, the inside of the midrib and leaves |
| 14  | *Musa* sp           | Musaceae     | Fruits, the inside of the midrib and leaves |
| 15  | *Terminalia catappa* | Combretaceae | Bark, roots                       |
| 16  | *Pterocarpus indicus* | Fabaceae   | Bark, roots                       |
| 17  | *Mimosa pudica*     | Mimosaceae   | All parts                         |
| 18  | *Centrosema* sp.    | Fabaceae     | All parts                         |
| 19  | *Trema orientalis*  | Ulmaceae     | Leaves                           |

Elephants choose certain parts of the plant to eat, such as: leaves, fruit, stems, bark, tubers [16,14], tubers [14] and roots [16]. At the study site, several times elephants were seen eating the bark and roots of the *Pterocarpus indicus*; according to Mahout who cares for elephants, this is done by elephants to treat stomach aches. Referring to some of the results of previous studies, *Pterocarpus indicus* contains antibacterial properties which can act as anti-diarrhea, as reported by [17].

4. Conclusion

The vegetation of the elephants' forage garden in the Medan Zoo is dominated by grasses species from the Poaceae family. There are only 4 species at the growth rate of poles and trees, and 11 species at the sapling growth rate, but no seedling was found. Most types of understorey are the food for Sumatran elephants. At least 19 types of elephant feed were found scattered in free-range area.

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References

[1] IUCN International Union for Conservation of Nature and Natural Resources 2012 *IUCN Red List Categories and Criteria: Version 3.1.Second edition* (Gland, Switzerland and Cambridge UK) 32

[2] CITES Convention on International Trade in Endangered Species of Wild Fauna and Fauna 2017 *New CITES trade rules come into effect as 2017 starts*
[3] Mackenzie A, Ball A S and Virdee S R 2001 *Instant Notes Ecology Second Edition* (Oxford, UK: Bios Scientific Publishers Limited)

[4] Odum P E 1996 *Fundamentals of Ecology* (Philadelphia, US: WB Sounders)

[5] Deshmukh I, Danimiharja S, Kartawinata K and Soeriatmaja R E 1992 *Ekologi dan Biologi Tropika* (Jakarta: Yayasen Obor Indonesia)

[6] Griscom H P, Griscom B W and Ashton M S 2006 *Pattern and process of forest succession within experimental treatments of a pasture in a dry tropical region, Azuero Peninsula, Panama* (New Haven, CT: School of Forestry and Environmental Studies, Yale University)

[7] Pielou E C 1975 *Ecological Diversity* (New York: John Wiley and Sons)

[8] Rostini T, Djaya S and Adawiyah R 2020 *Jurnal Sain Peternakan Indonesia* 15 2

[9] Darmawati A, Anwar S and Hermanan I 2015 *Agripet* 15 1 7

[10] Sukumar R 1989 *The Asian Elephant: Ecology and Management* (Cambridge, UK: Cambridge University Press)

[11] Campoz-Arceiz A, Lin Z T, Htun W, Takatsuki S and Leimgruber P 2008 *Ecological Research* 23 1057

[12] Chen J, Deng X B, Zhang L and Bai Z L 2006 *Acta Ecologica Sinica* 26 309

[13] White L J T, Tutin C E G and Fernandez M 1993 *African Journal of Ecology* 31 181

[14] Zahrah M 2016 *Journal Natural* 16 1 7

[15] Abdullah, Rushkhanidar and Martolis J 2015 *Prosiding Seminar Nasional Biotik 2015*

[16] Santoso Y, Supartono and Thohari M 2011 *Media Konservasi* 16 3 149

[17] Hargono D, Widowati L and Herlinda H 1998 *Media Litbangkes* VIII 01