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Floristic diversity and composition of Kuala Tambangan Heath Forest in Tanah Laut District, South Kalimantan, Indonesia

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Abstract. *Soendjoto MA, Riefani MK, Diana S. 2023. Floristic diversity and composition of Kuala Tambangan Heath Forest in Tanah Laut District, South Kalimantan, Indonesia. Biodiversitas 24: 5418-5427.* Heath forest *(kerangas*) is a unique ecosystem characterized with sandy soil with poor nutrients. This harsh condition makes heath forest has unique vegetation diversity as well as vulnerable to disturbances. In South Kalimantan, Indonesia there is a heath forest located in Kuala Tambangan and Tanjung Dewa villages of Tanah Laut District, hereinafter referred to as the Kuala Tambangan Heath Forest (KTHF), which has never been explored. The research aims to analyze the diversity and composition of vegetation community in heath forest in Kuala Tambangan and Tanjung Dewa villages and identify factors that have the potential to damage the forest. Data was collected using the transect method placed at three sites in the heath forest. Along each transect, 10 observation plots with size 20 m × 20 m were established to record woody plants at the tree level. Within this plot, nested plots with size of 10 m × 10 m was created to record plants at pole level, 5 m × 5 m for saplings and herbaceous plants and 2 m × 2 m for seedlings, ferns and grasses. In total, there were 85 plant species across all observation plots with 79 species were found in the heath soils. Some typical heath forest species were found such as *Melaleuca* sp., *Baeckea frutescens* L. and *Cratoxylum formosum* (Jack) Benth. & Hook.fil. ex Dyer. Important Value Index (IVI) as well as Shannon-Wiener diversity index (H') varied, both by plant group and by study site. For example, the highest IVI of the tree group belonged to *Acacia crassicarpa* A.Cunn. ex Benth. and *Acacia mangium* Willd., and for pole level was *Melaleuca* sp. The lowest diversity occurred at Site B, while the highest was at Site C. The results on vegetation diversity, structure and composition suggest that this forest is in degraded condition. Fires and land conversion are factors that threaten the existence of heath forest in Kuala Tambangan and Tanjung Dewa villages. Our findings recommend the needs of efforts to protect and restore this unique ecosystem.

Keywords: Conversion of functions, fire, heath, medicinal sources, plants

INTRODUCTION

Heath forest is a forest that grows on heath (*kerangas*) soil. Kerangas is a term originated from the language of Iban Dayak, one of the Dayak ethnic groups in Kalimantan, to indicate a type of soil that cannot be planted with rice. Heath (*kerangas*) can be found at the altitude of 0 to 1,500 m above sea level. The soils of heath forest are characterized by sand or sandstone (Lim 2006). These soils are sandy, acidic, and very poor in nutrients (Syuharni et al. 2014), making them categorized as unhealthy or infertile (Othman et al. 2023). Despite the marginal soil condition, heath forests contain unique flora and fauna diversity, and in several cases these forests serve as source of medicinal plants (Din et al. 2015; Kissinger 2022; Oktavia et al. 2022),

In Southeast Asia region, heath forests are primarily spread across the two major islands, namely Sumatra and Borneo. The distribution of heath forests in Sumatra includes the Bangka and Belitung Islands (Oktavia et al 2015, 2021). In Indonesian Borneo (Kalimantan), heath forests occur in the provinces of West Kalimantan (Navratil 2013; Utari et al. 2023), Central Kalimantan (Maimunah et al. 2019; Kissinger 2022), East Kalimantan (Kartawinata 1980; Navratil 2013; Setiawan et al. 2021), North Kalimantan (Agustiorini et al. 2022) and South Kalimantan (Nugroho et al. 2022b). Heath forests also occur in Brunei Darussalam (Din et al. 2015; Ikbal et al 2023; Zaini and Sukri 2014) and Malaysian Borneo (Sabah and Sarawak) (Lim 2006). Besides occurring on the two islands, heath forests can be found in Peninsular Malaysia, such as in Terengganu (Syuharni et al. 2014) and Pahang (Chua et al. 1995), although according to (Kamoona et al. 2023) in Pahang there is a high risk of disappearing or even in some locations it has not seen anymore.

In South Kalimantan Province, heath forests can be found in Liang Anggang Heath Forest (LAHF). This forest is easily accessible by two-wheeled vehicles and even four-wheeled vehicles. It is also relatively close to Banjarmasin as the former capital of South Kalimantan Province (about 25 km) and Banjarbaru as the new capital of the province (about 10 km). LAHF is usually used as a research site for various themes, both by universities and government agencies based in Banjarmasin or Banjarbaru, especially since parts of the LAHF area have the status of protected forest according to Minister of Forestry Decree Number

SK.435/Menhut-II/2009 dated 23 July 2009 concerning Designation of Forest Areas in South Kalimantan Province. The results of his research have also been published by, among others, Kissinger et al. (2022).

Besides the occurrence of heath forest in Liang Anggang, we explored references and sought information about the possibility of other heath forests in South Kalimantan Province. Anecdotal evidence suggested that there is an area in the southwestern part of the province which indicates the presence of heath forest. This forest is administratively located in Tanah Laut District with the distance of about 96.5 km from Banjarmasin or 82 km from Banjarbaru. The area is characterized by white sand with visually striking woody plants, namely galam (*Melaleuca* sp.), ujung atap (*Baeckea frutescens*), and *Syzygium* from the Myrtaceae family and *Cratoxylum formosum* (Jack) Benth. & Hook.fil. ex Dyer from the Hypericaceae family. To our knowledge, there are no publications regarding the presence of heath in the area. Therefore, this research aimed to analyze the diversity and composition of plant species in heath forest in Kuala Tambangan and Tanjung Dewa villages, Tanah Laut District, South Kalimantan Province, and also to identify factors might damage the existence of this forest. It is hoped that the results of this study might enrich the ecological information on heath forest, especially in the context of South Kalimantan, and to raise awareness to stakeholders in protecting and preserving the forest.

MATERIALS AND METHODS

Study area and period

The research was conducted in (i) Kuala Tambangan Village, Takisung Sub-district, and (ii) Tanjung Dewa Village, Panyipatan Sub-district of Tanah Laut District, South Kalimantan Province, Indonesia (Figure 1). The research area, hereinafter referred to as the Kuala Tambangan Heath Forest (KTHF), stretches from north to south and is separated by an asphalt road connecting Kuala Tambangan Village (Site A: 3°59'16.38"S 114°37'54.34"E) and Tanjung Dewa Village (Site B: 4°0'22.08"S 114°38'9.87"E; Site C: 4°1'6.60"S 114°38'14.82"E). There is no human settlement and cultivated land in the studied area. The presence of heath ecosystem is indicated by the soils which is white sand. There are also plants that appear to be typical of heath forests such as *B. frutescens* and *Melaleuca* sp.

We ascertained that the ecosystem in the studied area is heath forest, and not other types of vegetation communities commonly found in coastal areas (e.g. beach forests). Heath forests located on the coast are different from beach forests. Both types of forest are located on the coast, but coastal forests (as the name suggests) extend inland to a maximum of about 100 m from the coastline. Some plant species in both types of forest may be the same. However, several other species are only found (and can be dominant) in heath forests, such as *B. frutescens*, *Cratoxylum glaucum* Korth., *Melaleuca cajuputi* Powell, *Rhodomyrtus tomentosa* (Aiton) Hassk. (Purwaningsih and Kartawinata 2018; Othman et al. 2023; Utari et al. 2023). Meanwhile, other species are only found (and can also be dominant) in coastal forests, namely *Ipomoea pes-caprae* (L.) R.Br., *Casuarina equisetifolia* L. (Yakopi 2021; Nugroho et al. 2022b).

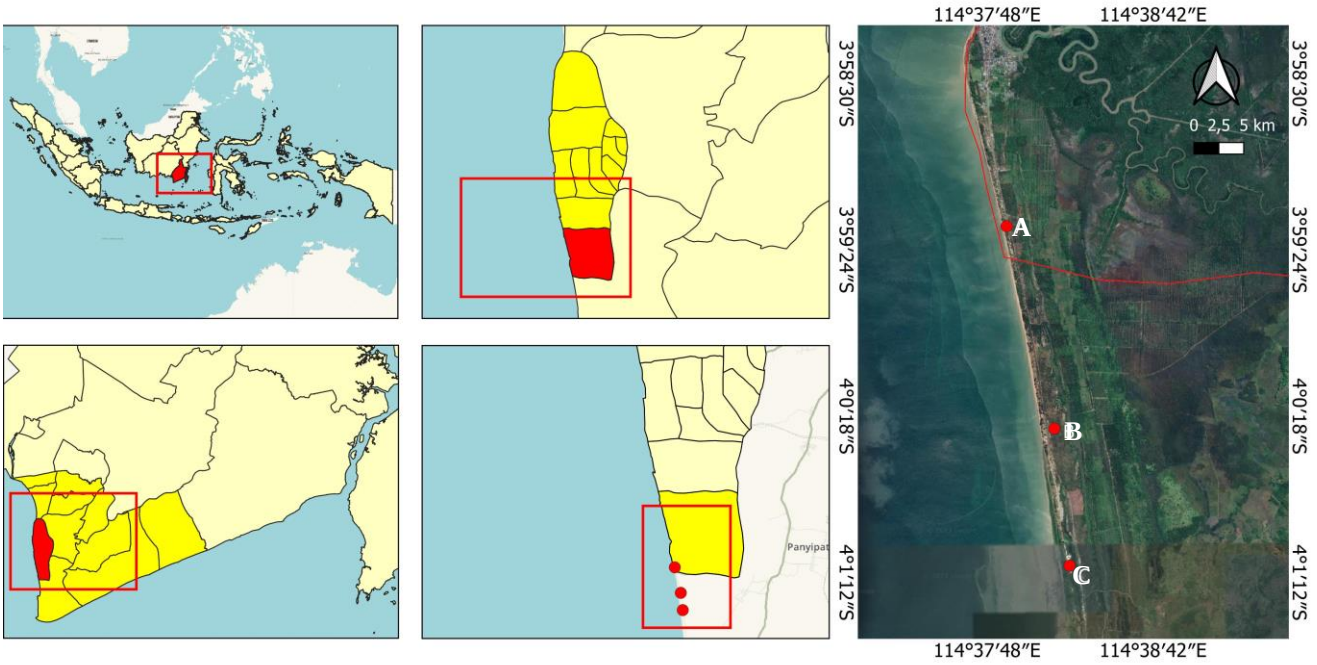

Figure 1. Map of study area showing Sites A at Kuala Tambangan Village, while, B and C at Tanjung Dewa Village of Tanah Laut District, South Kalimantan, Indonesia

Figure 2. A. Vegetation condition at Kuala Tambangan Heath Forest, Tanah Laut District, Indonesia. B. Identification, measurement and documentation of vegetation in the sampling plot

Vegetation conditions throughout the study area varied; some locations had plants with a height of ≥5 m or a stem diameter of ≥20 cm, while other locations had grass growing (Figure 2A). Therefore, vegetation samples were taken at three locations in June-July 2023. Site A is an area on the right side of the road from Kuala Tambangan Village and directly adjacent to the Java Sea. The starting point of the observation plot started about 100 m to the south of the former entrance gate of the Batulima Tourism Area. Site B is an area located on the left side of the road and is 2.16 km from the gate. On this site, 18 cottages are still standing, although they are in a neglected condition and unsuitable for use. The areas that contain Site A and Site B are actually the Batulima Tourism Area which has not been operating since 2010. Site C is an area with heath soil and located on the right side of the road and is 3.53 km from the gate of Batulima Tourism Area. Part of this area is a swamp. Site B and C are located in Tanjung Dewa villages. This research was carried out during the dry season and the soil in the swamp was just soft or contained water. In the rainy season this area is likely to be flooded.

At each site, a transect was established with length of 380 m. Along the transect line, 10 sampling plots (with size 20 × 20 m each) were placed and the distance between plots was 20 m. These large plots were used to record tree species, i.e. woody plants with diameter at breast height (DBH) of ≥20 cm (Figure 2B). Within the large plot, nested plots of three sizes were created, namely 10 × 10 m plot to document pole stage (i.e. young trees with 10 ≤ DBH < 20 cm); 5 × 5 m plot to record saplings (juvenile trees with ≥1.5 m high and <10 cm in diameter) and herbaceous plants species; and 2 × 2 m plot to record plant species at the seedling stage (woody plants <1.5 m high), grass and fern. The number of individuals of each species within the plots was counted.

Vegetation analysis was conducted to calculate frequency (F), relative frequency (RF), density (D), relative density (RD), dominance (Do), relative dominance (RDo), and Important Value Index (IVI) of each species of the four groups. The IVI of the tree group or pole group was the sum of RF + RD + RDo, while the IVI of the sapling and herbaceous groups as well as the seedling, grass and fern groups was the sum of RF + RD. The Shannon-Wiener diversity index (H') is also calculated and the basis for the calculation is the number of individuals of a particular species (n) and the number of individuals of all species (N). The formula for calculating each parameter is detailed as follows.

$$F_i = \frac{(\text{Number of plots where i-species were found})}{(\text{Number of all plots created})}$$

$$RF_i = \frac{(\text{Frequency of species-i})}{(\text{Sum of frequencies of all species})} \text{ x } 100\%$$

$$D_i = \frac{(\text{Number of individual i-species in all plots})}{(\text{Total area of all plots made})}$$

$$RD_i = \frac{(\text{Species density-i})}{(\text{Sum of all species densities})} \text{ x } 100\%$$

$$Do_i = \frac{(\text{Sum of basal area of species-i in all plots})}{(\text{Total area of all plots made})}$$

$$RDo_i = \frac{(\text{Dominance of species-i})}{(\text{Sum of dominance of all species})} \text{ x } 100\%$$

$$H' = -\Sigma\left(\frac{n}{N}\right)\ln\left(\frac{n}{N}\right)$$

RESULTS AND DISCUSSION

Plant species diversity

In total, 85 species from 43 families of plants were recorded across the three study sites and the four plant groups (Tables 1, 2, 3 and 4). The value of IVI may change at any time, depending on the ability and resilience of each plant species in adapting to environmental changes. The high IVI does not only indicate the dominance or high competitiveness of a species in an area, but also indicates the adaptability or high level of adaptation of the species to the environment (Soendjoto et al. 2023).

The number of species and diversity index varies, both based on plant group and based on the research location (Figures 3A and 3B). This also shows that many species are able to live and then develop in forests that are poor in nutrients. These plants certainly develop strategies. From conditions like this, we propose that there are two groups of plants that can be used as characteristics of heath forests. The first is a group of plant that able to adapt with nutrient deficiencies in unusual ways. For example, the pitcher plants, such as *Nepenthes*, which are commonly found in heath forest overcome nitrogen deficiency through acting as a carnivorous plant (Mansur et al. 2022). Various mistletoes fulfil their nutrient needs by acting as hemiparasites which might be detrimental to other plants. The second group is cosmopolitan species that may occur in a wide range of ecosystem types, but become prominent or unusual in heath forests. They adapt through physiological changes. The impact that usually arises from these changes is secondary metabolites which in turn can be used by humans, among other things, as a source of medicine. The examples of plant species include Clusiaceae (*Calophyllum, Garcinia*), Hypericaceae (*Cratoxylum*) and Myrtaceae (*B. frutescens*, *Melaleuca* sp., *Syzygium*) (Kartawinata 1980; Oktavia et al. 2021; Kissinger 2022).

Oktavia et al. (2021) divided heath forests of Belitung Island, Indonesia into three vegetation condition, namely grassland or *padang* (with 31 plant species), secondary heath forest or *bebak* (135 species), and primary heath forest or *rimba* (157 species). Referring to Oktavia et al (2021), the vegetation in KTHF (which consisted of 85 species) can be considered between *padang* and *bebak* or slightly towards *bebak*. Visual conditions in the field did show that there were other species, both in the form of ferns, herbs, and woody plants from the seedling level to trees (Figures 3A and 3B).

The direction towards *bebak* will be even greater if the 33 plant species growing outside the observation plot (Table 5) are taken into account. As noted, the 85 plant species in KTHF, which was previously known as the Batu Lima Tourism Area, were obtained from observation plots covering an area of 1.12 ha or only 0.98% of the total area of heath land in Kuala Tambangan with had a total extent of 114 ha. This area was identified starting from the white sand soils located near the Kuala Tambangan Village Office to the white sand appeared Site C.

Species characteristics

A cursory observation shows that certain morphological characters are inherent in plant species that are adapted to the environmental conditions of heath forests on the coast. For example, the leaves size of *Melaleuca* sp. that occur in the studied area is larger than the size of the leaves of *Melaleuca* sp. occurring in swamp. This is a plant strategy to increase the number of chloroplasts to increase the rate of photosynthesis. Increasing the rate of photosynthesis is an effort by plants to overcome poor nutrients and stress from other external factors. Dhami et al. (2018) stated that mature leaves have a larger size than the young ones to increase the number of cells, chloroplasts, pigment content, and the ability of leaves to photosynthesize or the rate of assimilation.

Other notes related to plant species in the observation plots are as follows. Six species usually living in wetlands and swamps were found, namely *Hidrolea spinosa*, *Monochoria vaginalis* (eceng padi), *Pontederia crassipes* (eceng gondok), *Ludwigia adscendens*, *Ludwigia leptocarpa*, and *Stenochlaena palustris* (kelakai). The presence of such species in the heath forest is understandable because some parts of the observation plots were located on the edge of the swamp. At the time of data collection, visually the swamp conditions were relatively dry but the soil surface looked wet. Although there is no information on the ecology of *H. spinosa*, its distribution in the tidal area of South Kalimantan (Setyawati et al. 2015) indicates that this herbaceous plant has a habitat in water bodies or wetlands. Other herbaceous plants found in this study also occurred in wetlands, including *L. adscendens*, *M. vaginalis*, *P. crassipes* (Setyawati et al. 2015) and *S. palustris* (Darnaedi and Praptosuwiryo 2016).

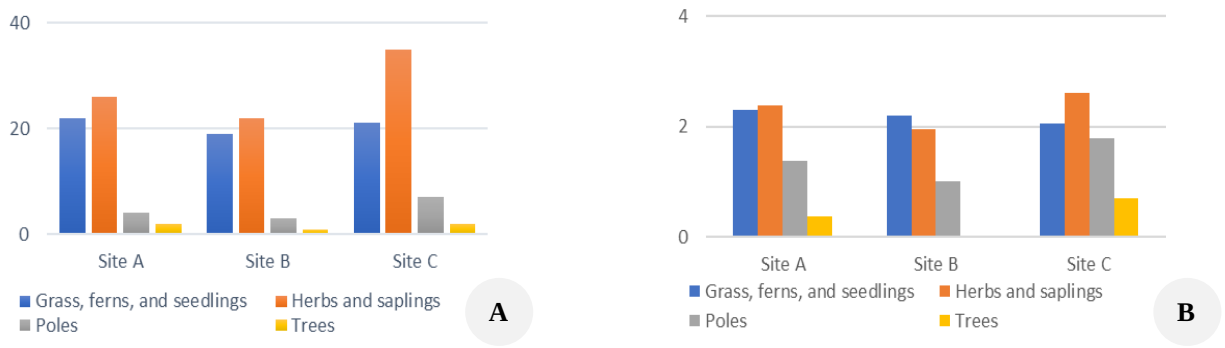

Figure 3. A. Number of species and B. Diversity index of plants in the Kuala Tambangan Heath Forest, Tanah Laut District, Indonesia according to plant groups and research sites

Table 1. The important value index (IVI) of species at seedling level, grasses, and ferns in the Kuala Tambangan Heath Forest, Tanah Laut District, Indonesia

Family and species name	Local name	Site A			Site B			Site C		
		RF	RD	IVI	RF	RD	IVI	RF	RD	IVI
Anacardiaceae										
Anacardium occidentale	*Jambu mete*	-	-	-	5.13	0.48	5.61	-	-	-
Blechnaceae										
Stenochlaena palustris	*Kelakai*	-	-	-	-	-	-	7.55	9.41	16.95
Clusiaceae										
Garcinia celebica	*Manggis pantai*	2.94	1.33	4.27	-	-	-	-	-	-
Cyperaceae										
Carex sp.	-	2.94	3.54	6.48	5.13	1.44	6.57	3.77	2.75	6.52
Cyperus flavescens	-	2.94	4.42	7.37	-	-	-	-	-	-
Cyperus iria	*Padi pipih*	-	-	-	2.56	0.24	2.80	-	-	-
Cyperus rotundus	*Teki ladang*	5.88	31.42	**37.30**	-	-	-	-	-	-
Cyperus sphacelatus	-	5.88	4.42	10.31	-	-	-	-	-	-
Eleocharis geniculata	*Rumput purun*	8.82	10.62	19.44	15.38	34.29	**49.68**	11.32	25.04	**36.36**
Eleocharis retroflexa	*Purun tikus*	5.88	1.77	7.65	7.69	6.24	13.93	-	-	-
Fimbristylis bisumbellata	*Kumpai padang*	2.94	0.44	3.38	-	-	-	1.89	0.43	2.32
Rhynchospora corymbosa	*Paruh emas*	-	-	-	-	-	-	3.77	0.87	4.64
Scleria bancana	*Kerisan*	-	-	-	-	-	-	1.89	0.29	2.18
Dilleniaceae										
Dillenia suffruticosa	*Sempur air*	-	-	-	-	-	-	1.89	0.14	2.03
Dryopteridaceae										
Cystopteris fragilis	*Pakis rapuh*	2.94	0.88	3.83	-	-	-	-	-	-
Tectaria semipinnata	-	2.94	1.33	4.27	-	-	-	-	-	-
Eriocaulaceae										
Eriocaulon heterolepis	-	-	-	-	2.56	2.64	5.20	-	-	-
Fabaceae										
Acacia crassicarpa	*Krasikarpa*	2.94	1.33	4.27	5.13	3.12	8.25	1.89	0.14	2.03
Acacia mangium	*Mangium*	2.94	0.88	3.83	-	-	-	-	-	-
Hypericaceae										
Cratoxylum formosum	*Mampat dadu*	5.88	2.21	8.09	-	-	-	-	-	-
Lecythidaceae										
Barringtonia asiatica	*Keben*	-	-	-	2.56	0.72	3.28	-	-	-
Lygodiaceae										
Lygodium microphyllum	*Akar kawat*	-	-	-	5.13	0.96	6.09	13.21	10.56	23.77
Lygodium salicifolium	-	-	-	-	-	-	-	1.89	0.29	2.18
Myrtaceae										
Baeckea frutescens	*Ujung atap*	-	-	-	2.56	4.08	6.64	1.89	0.14	2.03
Melaleuca sp.	*Galam*	2.94	0.44	3.38	10.26	3.36	13.61	-	-	-
Syzygium acuminatissimum	*Pitaruk*	5.88	1.33	7.21	5.13	10.79	15.92	3.77	0.43	4.21
Nephrolepidaceae										
Nephrolepis cordifolia	*Pakis umbi pedang*	2.94	0.44	3.38	-	-	-	1.89	0.14	2.03
Poaceae										
Acroceras munroanum	-	-	-	-	5.13	1.92	7.05	-	-	-
Axonopus compressus	*Papaitan*	-	-	-	5.13	0.96	6.09	3.77	0.58	4.35
Brachiaria mutica	*Rumput kalanjana*	8.82	18.58	27.41	-	-	-	3.77	1.16	4.93
Chrysopogon aciculatus	*Rumput jarum*	2.94	0.44	3.38	2.56	0.48	3.04	3.77	0.87	4.64
Digitaria didactyla	-	-	-	-	2.56	9.83	12.40	9.43	18.38	27.81
Eragrostis unioloides	*Rumput cinta*	2.94	1.77	4.71	2.56	0.24	2.80	5.66	10.85	16.51
Imperata cylindrica	*Alang-alang*	-	-	-	2.56	4.56	7.12	-	-	-
Polypodiaceae										
Drynaria quercifolia	*Paku kepala tupai*	2.94	1.33	4.27	-	-	-	-	-	-
Rubiaceae										
Psychotria viridiflora	*Engkrebang*	-	-	-	-	-	-	1.89	0.14	2.03
Sapindaceae										
Erioglossum rubiginosum	*Kilalayu*	8.82	2.65	11.48	-	-	-	1.89	0.14	2.03
Xyridaceae										
Xyris complanata	*Teki bunga kuning*	5.88	8.41	14.29	10.26	13.67	23.93	13.21	17.22	30.43
Total IVI (%)		100.00	100.00	200.00	100.00	100.00	200.00	100.00	100.00	200.00

Notes: IVI in bold indicates that the species has the highest IVI value or the species is dominant on that site

Table 2. The important value index (IVI) of plant species at saplings level and herbs in the Kuala Tambangan Heath Forest, Tanah Laut District, Indonesia

Family and species name	Local name	Site A			Site B			Site C		
		RF	RD	IVI	RF	RD	IVI	RF	RD	IVI
Acanthaceae										
Asystasia gangetica	*Ara sungsang*	-	-	-	-	-	-	1.33	0.17	1.50
Anacardiaceae										
Anacardium occidentale	*Jambu mete*	-	-	-	3.64	1.14	4.78	-	-	-
Arecaceae										
Elaeis guineensis	*Sawit*	1.89	0.27	2.16	-	-	-	2.67	0.99	3.66
Licuala spinosa	*Palem kipas*	-	-	-	1.82	2.73	4.55	1.33	0.17	1.50
Asphodelaceae										
Dianella ensifolia	*Menuntil*	9.43	19.78	29.22	5.45	2.05	7.50	2.67	1.65	4.32
Asteraceae										
Ageratum conyzoides	*Bandotan*	-	-	-	-	-	-	1.33	1.49	2.82
Chromolaena odorata	*Kirinyuh*	5.66	2.98	8.64	-	-	-	4.00	9.09	13.09
Mikania micrantha	*Sambung rambat*	-	-	-	-	-	-	1.33	0.50	1.83
Praxelis clematidea	*Minjangan*	7.55	4.61	12.15	-	-	-	2.67	1.16	3.82
Vernonia cinerea	*Sawi langit*	-	-	-	3.64	2.51	6.14	-	-	-
Clusiaceae										
Garcinia celebica	*Manggis pantai*	1.89	1.08	2.97	-	-	-	1.33	1.16	2.49
Convolvulaceae										
Cuscuta australis	*Taliputri*	5.66	3.52	9.18	3.64	1.82	5.46	-	-	-
Crassulaceae										
Kalanchoe pinnata	*Cocor bebek*	1.89	30.35	**32.24**	-	-	-	-	-	-
Dilleniaceae										
Dillenia suffruticosa	*Sempur air*	-	-	-	-	-	-	2.67	5.95	8.62
Dioscoreaceae										
Dioscorea bulbifera	*Gadung*	-	-	-	-	-	-	1.33	0.17	1.50
Tacca palmata	*Gadung tikus*	-	-	-	-	-	-	1.33	0.17	1.50
Fabaceae										
Acacia crassicarpa	*Krasikarpa*	5.66	1.90	7.56	1.82	0.23	2.05	-	-	-
Acacia mangium	*Mangium*	7.55	2.44	9.99	-	-	-	-	-	-
Desmodium triflorum	*Sisik betok*							2.67	1.32	3.99
Mimosa pudica	*Putri malu*	1.89	0.27	2.16	-	-	-	2.67	0.83	3.49
Flagellariaceae										
Flagellaria indica	*Rotan tikus*	-	-	-	-	-	-	2.67	3.14	5.81
Hydrophyllaceae										
Hydrolea_spinosa	*Daun dadangkak*	-	-	-	-	-	-	1.33	0.50	1.83
Hypericaceae										
Cratoxylum formosum	*Mampat dadu*	7.55	5.69	13.24	1.82	0.23	2.05	8.00	3.97	11.97
Lamiaceae										
Vitex trifolia	*Legundi*	-	-	-	3.64	0.46	4.09	-	-	-
Lecythidaceae										
Barringtonia asiatica	*Keben*	-	-	-	1.82	0.23	2.05	-	-	-
Linderniaceae										
Lindernia crustacea	*Kerak nasi*	-	-	-	-	-	-	2.67	0.99	3.66
Lindernia polygonoides	-	1.89	0.54	2.43	-	-	-	4.00	3.97	7.97
Yamazakia viscosa	-	3.77	1.63	5.40	-	-	-	-	-	-
Loganiaceae										
Mitrasacme pygmaea	-	1.89	1.90	3.78	-	-	-	-	-	-
Loranthaceae										
Amylotheca dictyophleba	*Benalu*	-	-	-	3.64	0.46	4.09	-	-	-
Lythraceae										
Lagerstroemia speciosa	*Bungur ratu*	-	-	-	-	-	-	1.33	0.17	1.50
Malvaceae										
Sida acuta	*Sapu gulma*	-	-	-	3.64	0.91	4.55	-	-	-
Melastomaceae										
Melastoma malabatrichum	*Senduduk*	-	-	-	14.55	36.45	**50.99**	13.33	31.07	**44.41**
Myrtaceae										
Baeckea frutescens	*Ujung atap*	-	-	-	5.45	25.51	30.97	1.33	0.17	1.50
Melalaeuca sp.	*Galam*	1.89	0.27	2.16	14.55	14.12	28.67	-	-	-
Rhodomyrtus tomentosa	*Karamunting*	9.43	6.23	15.67	5.45	1.59	7.05	2.67	1.32	3.99
Syzygium acuminatissimum	*Pitaruk*	1.89	0.27	2.16	1.82	0.23	2.05	10.67	10.91	21.58
Syzygium pycnanthum	*Jambu kopo*	-	-	-	-	-	-	1.33	0.66	1.99
Syzygium zeylanicum	*Nasi-nasi*	-	-	-	1.82	0.23	2.05	-	-	-

Onagraceae										
Ludwigia adscendens	-	-	-	-	-	-	-	2.67	2.98	5.64
Ludwigia leptocarpa	*Pacar banyu*	-	-	-	-	-	-	4.00	4.30	8.30
Phyllanthaceae										
Breynia coronata	*Lima*	1.89	0.27	2.16	-	-	-	1.33	0.17	1.50
Plantaginaceae										
Limnophila chinensis	-	-	-	-	1.82	0.91	2.73	1.33	6.78	8.11
Pontederiaceae										
Monochoria vaginalis	*Eceng padi*	-	-	-	-	-	-	1.33	0.17	1.50
Pontederia crassipes	*Eceng gondok*	-	-	-	-	-	-	1.33	0.83	2.16
Rubiaceae										
Psychotria viridiflora	*Engkrebang*	1.89	0.54	2.43	1.82	0.23	2.05	2.67	0.66	3.33
Richardia scabra	*Semanggi mexico*	1.89	7.86	9.75	-	-	-	-	-	-
Scleromitrion brachypodum	-	1.89	2.44	4.33	5.45	2.96	8.42	-	-	-
Santalaceae										
Dendrotrophe varians	*Kutunda*	3.77	1.90	5.67	-	-	-	-	-	-
Sapindaceae										
Dodonea viscosa	*Zaitun pasir*	1.89	0.54	2.43	-	-	-	-	-	-
Erioglossum rubiginosum	*Kilalayu*	3.77	1.63	5.40	-	-	-	2.67	1.16	3.82
Verbenaceae										
Lantana camara	*Tembelekan*	3.77	0.81	4.59	-	-	-	-	-	-
Vitaceae										
Cissus rostrata	-	1.89	0.27	2.16	10.91	4.33	15.24	1.33	0.66	1.99
Leea indica	*Mali-mali*	-	-	-	-	-	-	2.67	0.66	3.33
Zingiberaceae										
Alpinia galanga	*Laos*	-	-	-	1.82	0.68	2.50	-	-	-
Total IVI (%)		100.00	100.00	200.00	100.00	100.00	200.00	100.00	100.00	200.00

Notes: IVI in bold indicates that the IVI value of the species is the highest or the species is dominant at that site

Table 3. The important value index (IVI) of plant species at pole level in the Kuala Tambangan Heath Forest, Tanah Laut District, Indonesia

Family and species name	Local name	Site A				Site B				Site C			
		RF	**RD**	**RDo**	**IVI**	**RF**	**RD**	**RDo**	**IVI**	**RF**	**RD**	**RDo**	**IVI**
Anacardiaceae													
Anacardium occidentale	*Jambu mete*	-	-	-	-	20.00	16.67	24.31	60.97	-	-	-	-
Lannea coromandelica	*Kayu jawa*	12.50	21.74	21.34	55.58	-	-	-	-	-	-	-	-
Clusiaceae													
Garcinia celebica	*Manggis pantai*	-	-	-	-	-	-	-	-	20.00	8.33	4.70	33.03
Calophyllum inophyllum	*Nyamplung*	-	-	-	-	-	-	-	-	10.00	16.67	19.77	46.44
Fabaceae													
Acacia crassicarpa	*Krasikarpa*	37.50	26.09	27.25	90.83	40.00	33.33	25.26	98.59	20.00	33.33	33.16	**86.49**
Acacia mangium	*Mangium*	-	-	-	-	-	-	-	-	10.00	8.33	8.83	27.16
Hypericaceae													
Cratoxylum formosum	*Mampat dadu*	12.50	21.74	17.83	52.07	-	-	-	-	-	-	-	-
Lamiaceae													
Vitex pubescens	*Alaban*	-	-	-	-	-	-	-	-	10.00	8.33	7.37	25.70
Myrtaceae													
Melaleuca sp.	*Galam*	37.50	30.43	33.58	**101.51**	40.00	50.00	50.43	**140.43**	-	-	-	-
Syzygium acuminatissimum	*Pitaruk*	-	-	-	-	-	-	-	-	20.00	16.67	20.59	57.26
Syzygium pycnanthum	*Jambu kopo*	-	-	-	-	-	-	-	-	10.00	8.33	5.58	23.92
Total IVI (%)					300.00				300.00				300.00

Notes: IVI in bold indicates that the IVI value of the species is the highest or the species is dominant at that site

Table 4. The important value index (IVI) of plant species at tree level in the Kuala Tambangan Heath Forest, Tanah Laut District, Indonesia

Family and species name	Local name	Site A				Site B				Site C			
		RF	**RD**	**RDo**	**IVI**	**RF**	**RD**	**RDo**	**IVI**	**RF**	**RD**	**RDo**	**IVI**
Fabaceae													
Acacia crassicarpa	*Krasikarpa*	33.33	12.50	32.82	78.65	100.00	100.00	100.00	**300.00**	40.00	50.00	61.49	**151.49**
Acacia mangium	*Mangium*	66.67	87.50	67.18	**221.35**	-	-	-	-	60.00	50.00	38.51	148.51
Total IVI (%)					300.00				300.00				300.00

Notes: IVI in bold indicates that the IVI value of the species is the highest or the species is dominant at that site

Table 5. Plant species found outside the observation plots in the Kuala Tambangan Heath Forest, Tanah Laut District, Indonesia

Family and species name	Local name
Anacardiaceae	
Mangifera sp.	*Mangga*
Apocynaceae	
Cerbera manghas	*Bintaro*
Asteraceae	
Clibadium surinamense	*Japangan*
Elephantopus scaber	*Tapak liman*
Cannabaceae	
Trema cannabina	*Samabu*
Trema orientalis	*Mangkirai*
Combretaceae	
Terminalia catappa	*Ketapang*
Convolvulaceae	
Merremia peltata	*Bilaran tanah*
Merremia umbelata	*Mantangan*
Euphorbiaceae	
Claoxylon indicum	*Sitopu*
Fabaceae	
Acacia auriculiformis	*Auri*
Cassia siamea	*Johar*
Crotalaria juncea	*Orok-orok*
Leucaena leucocephala	*Lamtoro*
Gentiniaceae	
Utania volubilis	*Girang*
Loranthaceae	
Macrosolen cochinchinensis	*Benalu*
Malvaceae	
Hibiscus tiliaceus	*Waru*
Melastomaceae	
Melastoma affine	*Uduk-uduk*
Moraceae	
Ficus grossularioides	*Ara perak*
Myrtaceae	
Psidium guajava	*Jambu biji*
Pandanaceae	
Pandanus odorifer	*Pandan duri*
Phyllanthaceae	
Antidesma ghaesembilla	*Barunei*
Bridelia glauca	*Kanyere badak*
Glochidion littorale	*Obat-obat*
Glochidion obscurum	*Salai*
Phyllanthus buxifolius	*Seligi*
Rubiaceae	
Hypobathrum sp.	*Sapu tunggul*
Neolamarckia cadamba	*Jabon*
Morinda citrifolia	*Mengkudu*
Sapindaceae	
Dimocarpus longan	*Kelengkeng*
Sapotaceae	
Unidentified species	-
Vitaceae	
Cayratia trifolia	*Lambai-lambai*
Leea aequata	*Daun tetanus*

Second, there are hemiparasitic plants, namely *Amylotheca dictyophleba, Cuscuta australis,* and *Dendrotrophe varians*. Their haustorium attaches to plant organs, such as twigs, stems and roots of the host plants in the form of shrubs or trees. Hemiparasites obtain nutrition and water from their host to proceed photosynthesize and complete their life cycle. Plant seeds (including hemiparasites) can be dispersed by water and wind (Soendjoto et al. 2014) as well as by animal and human activities (Soendjoto et al. 2023). One of the animals that act as seed dispersers are birds from the Dicaedae family, such as the Scarlet-headed Flowerpecker (*Dicaeum trochileum*) and the Orange-Bellied Flowerpecker (*Diaceum trigonostigma*). After eating the hemiparasite fruit, the birds vomit the seeds or dispose of them through the feces which then stick to the twigs or branches of the perch (Riefani and Soendjoto 2021; Soendjoto et al. 2018).

In the observation plot, we also found oil palm (*Elaeis guineensis*). The presence of palm oil is suspected to have been brought in by people who graze cattle, animals or water from individual palms planted intentionally around the study site. Not a single *Nepenthes* individual was found in KTHF. This condition is clearly different with heath forests in other regions, such as in Sejahtera Village, West Kalimantan which contained 3 species of *Nepenthes* (Rantau et al. 2021), in Pematang Gadung, West Kalimantan with 4 species (Utari et al. 2023), in Barito Ulu, Central Kalimantan with 8 species (Mansur and Brearley 2008), Tanjung Selor, North Kalimantan with 6 species (Agustiorini et al. 2022), in Bangka Belitung Islands with 3 species (Rizqiani et al. 2018), and in Brunei Darussalam with 2 species (Latiff et al. 2014). *Nepenthes* has the adaptation ability to live in nutrient-poor and infertile areas such as in heath soils (Mansur et al. 2021, 2022). Thus, species from this genus are recognized as tropical carnivorous plants and used as a bioindicator for nutrient-poor soils, especially nitrogen (Marina et al 2018).

Potential factors damaging the forest

Because it is located by the beach, KTHF has a unique function. It can play a role in reducing the strength of tidal waves that rise and hit land, providing barrier for the nearby settlements and infrastructure especially during the western monsoon which usually occurs at the end of the year and the beginning of the following year. The strength of the wave is not certainly known because there is no data about it. However, physical damage as well as socio-economic problems after the waves hit can be used as a measure of how strong the tidal waves are, even though they don't happen every year. For example, in 1985, tidal waves destroyed part of the left embankment of the Tabanio River and the land around it, so that in the end a new estuary for the Tabanio River was formed (Soendjoto 2003). At the end of 2013 and early 2014 tidal waves reaching 3-4 m high obliterated 13 houses, eroded the beach, and uprooted trees in Kuala Tambangan Village (Mustika 2017).

Until this research was carried out, KTHF was in good condition. Visual observation showed that there was no damage in this area, except for branches and twigs that were broken and fell to the ground due to the wind and plants that looked wilted as a result of the dry season. However, approximately three weeks after data collection (third week of June 2023), some of the forest in the Site A showed burn marks (Figure 4A). On the other hand, the forest vegetation in the Site A (across the road) still looked fresh and had no signs of being burnt at all. From interviews with the community, the suspected cause of the fires in some KTHFs was triggered by cigarette butts that were thrown carelessly by road users.

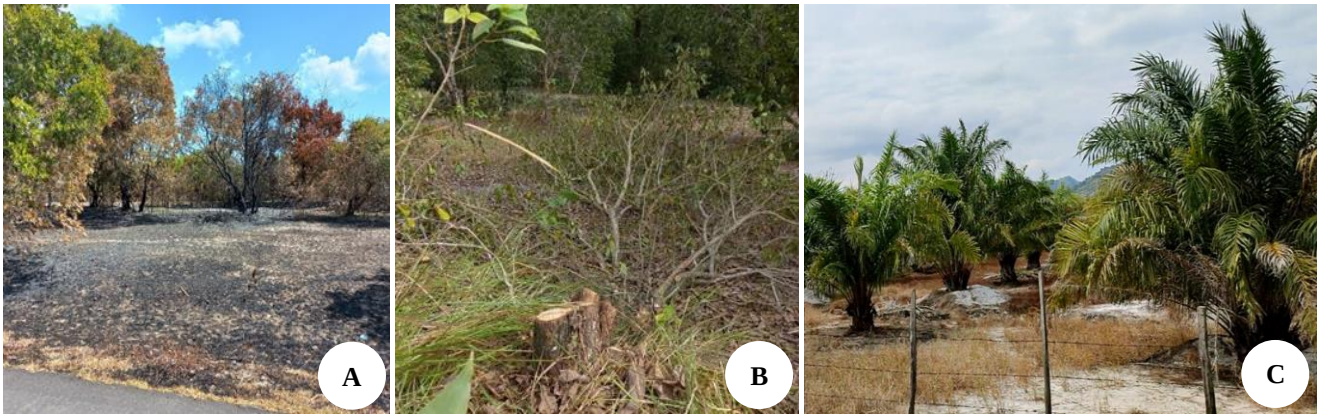

Figure 4. The threats to the heath forest in Kuala Tambangan Heath Forest, Tanah Laut District, Indonesia: A. Fires which burned the vegetation; B. Cut down of *Cratoxylum formosum* at sapling level; C. Land conversion from heath forest to oil palm plantations

The next fire occurred in the fourth week of July 2023. The remaining forest in the Site A, which is located just a few meters from the former tourist area entrance gate, caught fire, even though this forest was not burnt in the first fire in June 2023. Traces of fire can also be seen in the area across the road. In the opposite area, it can be seen some stakes, indicating that this area will be used as a cultivated land. Based on this condition, the provisional assumption is that the fire in the Site A was a side effect of burning for opening the land for cultivation. Burning vegetation and litter to clear the area occurred in the opposite KTHF area. Accordingly, such fires have the potential to spread into the KTHF because the vegetation in the form of grass is dry and woody plants are in a withered condition due to the dry season.

Fires, whether intentional or accidental due to negligence acts should be avoided. Heath forests usually occur on land with extreme, vulnerable and very sensitive to disturbances such as fire (Maimunah et al. 2019). If fire disturbance happens, various plant species that have the potential as a source of medicine, as informed by Din et al. (2015), Kissinger (2022), Nugroho et al. (2022a), and Oktavia et al. (2022) are likely to become rare or even locally extinct. Regenerating it is not easy. Repeated fires greatly slow plant regeneration as all organic matter is destroyed and nearly all nutrients and the limited water capacity of the ground surface are lost (Becker 2006).

Along with the observed impact of fire, 12 individuals of woody plants at sapling stage were found to be cut down, likely using a chainsaw (Figure 4B). This suggests an intentional cutting, although it is not clear the rationale of cutting such plants. This certainly disrupts forest condition. In the case of KTHF, plants are not only useful for maintaining the oxygen cycle, but also to shade paved roads and protect the coastline from abrasion or tidal waves.

Land tenure and conversion are the next factors that can impact the existence of KTHF (Figure 4C). However, we did not explore further because the problem is considered sensitive. It can be learned from several cases of land tenure that the community feels they have the rights to the land, for example using it for cultivation or other activities that have economic value.

In conclusion, there were 85 plant species found in the studied sites in Kuala Tambangan Heath Forest. Among them, six species are commonly found in wetlands. If these six species are excluded, the total number of species remains 79. This is the minimum number of species found to be able to adapt to heath soils and during the dry season. This number is considered minimal because there are other species that are not taken into account which occurred outside the observation plot. Fires and conversion of KTHF are the main factors that have the potential to damage the heath forest. Further research is needed, including the investigation of the condition of heath forest during the rainy season, measuring the nutrient content in the soil, or inventory of plant species that have the potential as a source of medicine.

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