INNSPUB

Journal of Biodiversity and Environmental Sciences (JBES)
ISSN: 2220-6663 (Print) 2222-3045 (Online)
Vol. 10, No. 6, p. 67-75, 2017
http://www.innspub.net

RESEARCH PAPER | OPEN ACCESS

Composition of tree species at the ebony forest in the watershed area of sausu, Central Sulawesi, Indonesia

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Article published on June 11, 2017

Key words: Makassar Ebony, *Diospyros celebica* Bakh., Composition, Sausu watershed area, Central sulawesi

Abstract

Diospyros celebica Bakh. (Makassar ebony) is one of endemic tree species to Sulawesi and prized of its luxuriant, multicolour wood grain. It has been used for long history of use even in Ancient Egyptian. Modern use of ebony are largely restricted to small items, such as crucifixes, musical instrumen parts including piano, viola, guitar, bass and for furnitures. The objectives of this research is to determine the composition of tree species and its condition in watershed area. It is expected that the result can be used as a references in the conservation of ebony species both in-situ or ex-situ. The structure and composition was studied in the watershed Sausu Central Sulawesi, Indonesia which is largely natural dispersal area of ebony stripes by using vegetation analyses methods. Geographically located between 120 ° 13'45,33 "-120 ° 32'10,22" E and 1 ° 5'3,94 "-1 ° 59'29,50" S. 3 (three) lines transects were established at the altitude 100 - < 250 m asl, 150-400 m asl and 400-550 m asl respectively. Each altitutude was sampled in 10 subplots with 2 (two) replicates, so in total there are 18 lines. The result showed that the riparian vegetation composition Sausu classified as poor types. It was dominated by *Koodersiodendron pinnatum* Merr, *Canarium littorale. Homalium foetidum* Benth, *Diospyros celebica* Bakh and *Pometia pinnata* Bl. (except on slopes with an altitude of 100 to <250 m asl). The species of *Diospyros celebica* Bakh. in the studied area have abundant of seedlings, but the trees that has Diameter Breats High (D.B.H) > 50 cm is very less. Conservation activities should be done species *Diospyros celebica* Bakh to maintain its sustainability.

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Introduction

Ebony forest is a forest where ebony becomes the dominant most species in that forest (Sagala, 1994). Ebony is luxurious wood that is classified as a high-demand timber class in timber trade, both local and international. Heartwood is a part of wood having a distinctive pattern of shiny black interspersed with a combination of red brown lines that make it have lavish peculiarity, hence, it is suitable as the material of luxury wooden veneers. In addition, the silky and fine characteristics of heartwood support its utilization as carving, pretentious furniture and others with high decorative value and selling price. Nevertheless, ebony's features were the cause of the declining number of ebony in the nature.

In order to prevent the extinction of ebony, various efforts had been made by the government, both the central and local governments, by issuing a variety of regulations to conserve the species, such as the decree of Minister of Agriculture No. 54/Kpts/Um/2/1972 that stipulated the permission of cutting ebony trees with diameter of 60 cm or more, while trees with diameter less than 60 cm were classified as protected trees and should not be cut down. The prohibition of ebony logging was also issued in the decree of the Minister of Forestry No. 950/IV-PPHH/1990 that basically banned the cutting of ebony trees unless there was a special permission. However, the high price and demand on ebony caused prevailing illegal logging, therefore, conservation attempts were urgently required.

The conservation of natural resources was expected to realize the sustainability of natural resources and the balance of the ecosystem in order to support optimally the improvement of people prosperity and human life quality (Widodo *et al.*, 2006). Environmental sustainability would not be actualized with the absence of local communities' livelihoods. Conservation included the establishment of Ebony Conservation Strategic Plans which should be accompanied by the implementations and disseminated at the level of the Central Government and Local Government (Samedi and Kurniawati, 2001).

Subsequently, there should be an explanation related to the strategic plans that contained various measures, therefore, ebony could be conserved and developed, including through a variety of studies.

Studies of the types of ebony had been carried out, nevertheless, the changes due to encroachment and vegetation dynamics in the ebony ecosystems, had affected the composition of vegetation diversity in the ecosystem. In addition, this study was conducted in Sausu Watershed to an altitude of 550 m asl and had not been done previously.

Study of vegetation composition at the ebony forest in Sausu Watershed aimed to find out the composition of tree species and condition of ebony (*Diospyros celebica* Bakh.) in the forest. This study was expected to be useful as a reference in the management of ebony, both in-situ and ex-situ.

Materials and methods

Research Site and Time

This study was conducted in Sausu Watershed, Central Sulawesi. It is one of watershed in the Province of Central Sulawesi. Geographically, it is situated in 120°13'45,33”-120°32'10,22” EL and 1°5'3,94”-1°59'29,50” SL(Fig. 1) Based on the division of forest management area, Sausu Watershed is included in KPH Dolago Tanggunung, Forestry Office of Central Sulawesi Province. The Sausu Watershed was considered having largely dispersion of very beautiful stripped ebony with high price in compared with other (Fig. 2). This study was carried out in February to May, 2015.

Materials and Tools

Materials and tools used in this study were: Global Positioning System (GPS), compass, machete, clinometers, micro caliper, measuring tape, shears, tape measure, camera, Sausu watershed maps, working maps, tree determination key book (Samingan, 1982), species identification reference book (Martawijaya *et al.*, 1989; Lemmens, 1995; Takahata, 1996; Lemmens *et al.*, 1998; or Pitopang *et al.*, 2011), tally sheet and stationery.

Meanwhile, the materials used in this study were: alcohol 70%, newsprint, cardboard, plastic bags, tag label, adhesive label, plastic rope, plot boundary markers, nylon rope, paint and brushes.

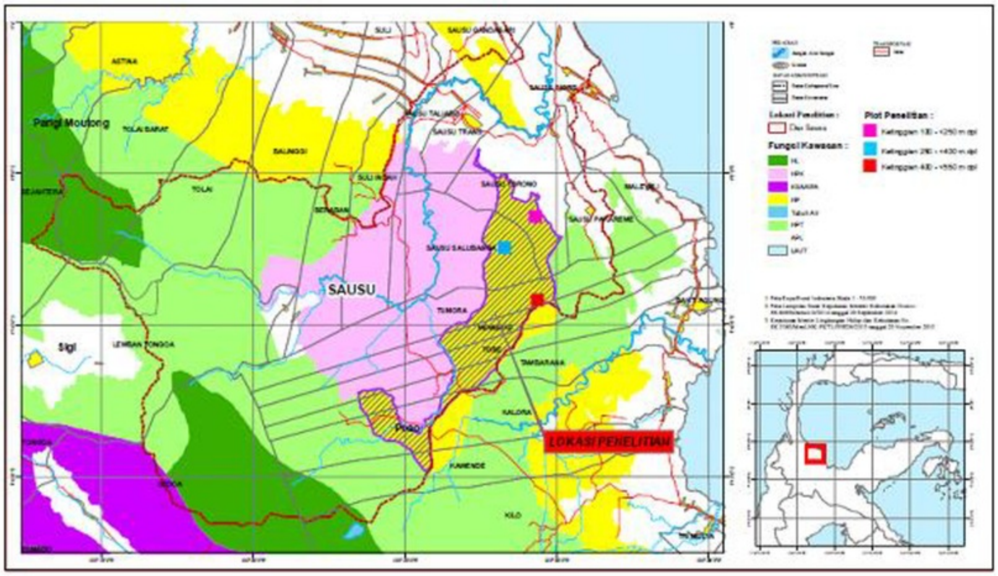

Fig. 1. Map of the study site.

Research Procedures

In accordance to the study area orientation, the research was conducted on Production Forest at an altitude of 100-550 m asl. Subsequently, zonation was determined based on the altitudes, namely: 100 to <250 m asl; 250 to <400 m asl; and 400 to 550 m asl in altitude. Plot was established in each altitude level at the mountain slope and ridge, each of them consisted of 3 lines and there was a total of 18 lines. Line transect method was applied in the research plots. In each line, a length of 200 m was divided into plots with 20x20 m in size and positioned systematically on the line, each line had 10 plots and totally, there were 180 plots.

Subsequently, tree species was identified per sub-plot with an assistance of the expert and recorded in tally sheet. Unknown species found out in the site were taken as samples including their leafstalks, flowers, and fruits, then identified by using literatures as the reference. The species could not be identified by the researchers, furthermore, was dipped in alcohol 70%, naturally dried, and tag labeled and clipped on newsprint and cardboard, to be identified on Celebence Herbarium of Tadulako University.

Data collection

Data included in this study was the data of tree with ≥20 cm in diameter, namely: the name of species, the number of individual, and tree diameter. Particularly for *Diospyros celebica*, the observations of total individual at the level of seedlings, sapling, pole, and tree, were carried out.

Data analysis

The dominance of the plant species was determined using the Importance Value Index (IVI) of these species. Vegetation composition was evaluated by analyzing the frequency, density, abundance, and IVI, using the following formula given by Mandal and Shambhu (2014), Naharuddin (2009), Mishra (1968) and Curtis and McIntosh (1951):

$$\text{Frequency} = \frac{\text{Total no : of quadrats in which the species occured}}{\text{Total no : of quadrats studied}}$$

$$\text{Relative frequency (\%)} = \frac{\text{Frequency of a species}}{\text{Frequency of all species}} \times 100\%$$

$$\text{Density} = \frac{\text{Total no : of individuals of a species}}{\text{Total no : of quadrats studied}}$$

$$\text{Relative density (\%)} = \frac{\text{Number of individuals of a species}}{\text{Number of individuals of all species}} \times 100\%$$

$$\text{Abundance} = \frac{\text{Total no : of individuals of a species}}{\text{Total No : of quadrats in which the species occured}}$$

$$\text{Relative Dominance (\%)} = \frac{\text{Basal area of a species}}{\text{Basal area of all the species}} \times 100\%$$

IVI = Relative frequency + Relative density + Relative dominance

Basal cover is considered as the portion of ground surface occupied by a species (Greig-Smith, 1983).

Basal area measurement was based on the following formula:

Total basal cover (TBC) = Mean basal area of a species x density of that species

Mean basal area (MBA) = πr^2(cm^2)

MBA = $C^2/4 \times \pi^2$ or (r = C/2 x 3,14)

where C is the average circumference of one individual of that species, and MBA is expressed as cm^{-2} plant^{-1} (Mishra, 1968; Wiryono, 2009; or Bratawinata, 2014)

Results and discussion

Forest is one of complex natural ecosystems that consists of a variety of flora. The flora composition of a habitat is totally different with others, particularly in their relations with diverse geographical situation including climate and latitude.

Table 1. Numbers of Species, Genus, and Family of Tree Vegetation Based on the Altitudes.

Altitude/Position	Family	Genus	Species	N/ha
100-<250 m asl/ Slope	39	62	77	394,17
250-<400 m asl/ Slope	30	45	54	282,50
400-550 m asl/ Slope	30	50	61	226.67
100-<250 m asl/ Ridge	31	52	60	315,83
250-<400 m asl/ Ridge	31	46	52	267,50
400-550 m asl/ Ridge	28	45	56	255.00

This study investigated the presence of species, genus, and family in Sausu Watershed as presented in Table 1.It showed the propensity of the decreased density per hectare in linear with the higher altitude from above sea level at each position (slope or ridge). It was due to at different of altitude, the adaptation level of the vegetation on each habitat was also diverse. Different habitat was affected by the environmental factors, in which the higher was the altitude, the lower was the temperature, and the higher was the moisture, the higher was the humidity. The vegetation of ebony forest in Sausu Watershed was intolerant to the tree height increment.

Even though the forest soil endured closed nutrient cycle where the trees would shed leaves and branches into the source of organic matters, and with the help of microorganisms become available nutrients to for the organism growth, therefore, the condition of the forest vegetation growth would be different from the outside of the forest. Likewise, Arief (1994) confirmed that the weathering process of organic matters—as the leftover of plants in forest ground that was assisted by the additional element of N and K from the air had enriched the forest soil with nutrients. Hardjowigeno (2010) explained that the accumulation of organic matters, nutrient cycle, and stable soil formation was simultaneously and strongly influenced by the organisms in the soil. Therefore, an area with vegetation would be more fertile which would eventually ensure the survival of flora in the area.

Table 2. Composition of Tree Species Diversity and Species Importance Value (SIV) from 10 Main Species based on Altitudes of Sausu Watershed.

Altitudes	Vegetations	SIV (%)
100 -<250 m dpl	*Pometia pinnata* Forb.	25.31
Slope	*Koodersiodendron pinnatum* Merr	16.64
	Canarium littorale BL.	16.13
	Pterospermum celebicum Miq.	12.86
	Calophyllum inophyllum L	12.82
	Ficus benjamina L.	10.33
	Diospyros celebica Bakh.	10.22
	Palaquium quercifolium Burck.	9.50
	Homalium foetidum Benth.	8.95
	Cananga odorata Hook F.	8.10
100 -<250 m dpl	*Koodersiodendron pinnatum* Merr	20.97
Ridge	*Homalium foetidum* Benth.	19.42
	Canarium littorale BL.	18.47
	Pometia pinnata Forb.	18.32
	Ficus benjamina L.	15.33
	Diospyros celebica Bakh.	15.14
	Litsea tomentosa BL.L	12.81
	Canarium hirsutum Willd.	10.37
	Palaquium quercifolium Burck.	9.86
	Calophyllum inophyllum L	8.86
250-<400 m dpl	*Koodersiodendron pinnatum* Merr	29.94
Slope	*Canarium littorale* BL.	24.89
	Homalium foetidum Benth.	16.35
	Litsea tomentosa BL.	12.64
	Palaquium quercifolium Burck.	12.11
	Pometia pinnata Forb.	11.70
	Octomeles sumatrana Miq.	11.58
	Diospyros celebica Bakh.	11.47
	Alstonia scholaris R.Br	10.75
	Calophyllum inophyllum L	9.58
250-<400 m dpl	*Koodersiodendron pinnatum* Merr	37.00
Ridge	*Homalium foetidum* Benth.	23.72
	Canarium littorale BL.	23.27
	Pterospermum celebicum Miq.	18.07
	Diospyros celebica Bakh.	17.89
	Pometia pinnata Forb.	16.82

	Canarium hirsutum Willd.	13.72
	Cananga odorata Hook F.	10.37
	Calophyllum inophyllum L	9.91
	Octomeles sumatrana Miq.	8.77
400-550 m dpl Slope	*Palaquium quercifolium* Burck.	18.71
	Pometia pinnata Forb.	18.18
	Dysoxylum macrocarpum BL.	18.11
	Koodersiodendron pinnatum Merr	16.45
	Canarium littorale BL.	16.37
	Octomeles sumatrana Miq.	15.88
	Diospyros celebica Bakh.	13.38
	Homalium foetidum Benth.	12.69
	Dracontomelon mangiferum BL.	9.34
	Heritiera littoralis Dryand.	8.41
400-550 m dpl Ridge	*Koodersiodendron pinnatum* Merr	27.96
	Octomeles sumatrana Miq.	26.85
	Palaquium quercifolium Burck.	15.18
	Homalium foetidum Benth.	13.75
	Pterospermum celebicum Miq.	13.57
	Heritiera littoralis Dryand.	12.36
	Diospyros celebica Bakh.	12.19
	Pometia pinnata Forb.	12.16
	Canarium littorale BL.	11.84
	Dracontomelon mangiferum BL.	11.05

Indicated the position of the slope had higher number of family, genus, as well as vegetation density per hectare in compared with the mountain ridge, in all levels of altitude (Table 1). It was allegedly caused by the ridge that had lower soil fertility in compared with the mountain slope, where tropical rainforest had relatively high precipitation. As the consequence, in the rain season, topsoil layer of soil eroded gradually whenever it rained, thus, topsoil contained by soil organic matter was leached. On one side, the role of organic matter on the soil friability was significant. On the other side, the granulator property of organic matter in mineral soils had caused soil friability was eroded easily, thus, the soil conditions of narrow mountain ridge were relatively less fertile. In addition to the factors of soil fertility, differences in the number of species and density/ha were also caused by the fall of the acorns on the mountain ridge (especially berry fruit) that would easily glide down into the slopes, grow and develop, hence, the ridges had higher density in compared to the slopes.

Vegetation diversity in Sausu Watershed could be classified as low in compared with other tropical rainforests. Study carried out by Bratawinata (1986) found out the tropical rainforest at an altitude of 700-770 m asl having 179 species that was dominated by Burceraceae, Fabaceae. Edwin (2009) reaffirmed the composition of species diversity in Wehea Forest, East Kutai district was 238 species from 105 genus, 53 family; the dominant species were the family of Dipterocarpaceae, Annonaceae, Myrtaceae, Euphorbiaceae, Lauraceae, Moraceae and Anacardiaceae. Nevertheless, in compared with other ebony forests, the species diversity in Sausu Watershed was relatively similar, as indicated by Sidiyasa (1989) who reported in Sausu and the adjacent area at an altitude of 45 to 90 m asl, the species diversity was 68 composed by 55 genus and 32 family. Kinho, Samedi and Kurniawati (2001), found out that in Tangkoko National Park, North Sulawesi, there were 86 species from 34 family dominated by *Cananga odorata*; in addition to eight types of ebony namely, *Diospyros cauliflora, D. ebenum, D. hebecarpa, D. cortalsiana, D. malarabica, D. maritime, D. minnahassae* and *D. pilosanthera*; with very limited regeneration.

Table 3. Species Dencity of Ebony (*Diospyros celebica*) at Mountain Slope and Ridge based on various altitudes of Sausu Watershed.

Diameter (cm)	Density (N/ha)					
	100 - < 250 m dpl		250 - <400 m dpl		400 - 550 m dpl	
	Slope	Ridge	Slope	Ridge	Slope	Ridge
Seedling	2.416,67	2.000,00	2.333,33	3.166,67	1.583,33	2.083,00
<10	360,00	213,33	280,00	360,00	199.99	293,33
10 - <20	43,33	56,67	50,00	66,67	46,67	66,67
20 - <30	10,00	5,83	5,80	7,50	8,33	6,67
30 - <40	4,17	8,33	2,50	9,17	6,67	3,33
40 - <50	0,83	5,83	3,33	3,33	0,83	2,50
50 -<60	0,83	0	1,67	0,83	2,50	0
60 – 70	0,83	0	0	0	0	0,83

Result of the vegetation analysis on 10 main species at the 3 (three) altitudes (slopes and ridges) is presented in Table 2.

Table 2 demonstrated the species that dominated the slopes and ridges at 3 (three) altitudes had dissimilar sequence of Species Diversity and Species Importance Value (SIV). The species dominating or controlling the area was *Koodersiodendron pinnatum* Merr which became the most dominant species in all altitudes at the first rank, except at the slope of 100 to <250 m asl in altitude, the second sequence and at the slope of 400-550 m asl in altitude were *Canarium littorale* BL, *Diospyros celebica* Bakh., *Homalium foetidum* Benth, *Pometia pinnata*. The domination of the species on all altitude indicated the species' toleranceagainst temperature and humidity which was higher in compared with others. In addition, these species had a capacity to compete including in obtaining range and adapting the position of slopes or ridge, or in other words, to overcome the ecological conditions. Similarly, Dombois and Ellenberg (1974) suggested that one species or one community of plant will be able to survive and grow up normally only if it is supported by particular environmental conditions as required by the species or the community. Furthermore, Lemmens *et al.*, (1995) and Soerianegara *et al.* (1994) emphasized that those species have a dispersion from an altitude of 800 m asl, even *Canarium littorale* reached an altitude of 1000 m asl, and *Homalium foetidum* Benth reached an altitude of 1,400 m asl, except for *Diospyros celebica* Bakh which has narrower dispersion of 700 m asl with a sequence of SIV (5-8) in all levels of altitude. Vegetation density analysis of *Diospyros celebica* at the slope and ridge based on various levels of altitudes in Sausu Watershed is presented in Table 3.

Table 3 demonstrated the species of *Diospyros celebica* in general had a high density at the level of seedlings, nevertheless the subsequent growths declined based on the growth level until at tree level. The abundant number of seedlings could not ensure the success of survival and growth up to the tree level. Species growth and development was highly associated with the intra-species and inter-species competition. In addition, the growth of ebony shoots and branches was rhythmic, hence, the growth range was inhibited by other species whose growths were continuous.

At the early stage of growth, semi-tolerant ebony required shade, despite the fact that it would also suffer and eventually die due to high level of shade.

Fig. 2. Style Wooden *Diospyros celebica* different areas of Sulawesi a. District Maros, b. District Sidrap, c. District Barru South Sulawesi; d. Sausu Watershed Central Sulawesi, e. West Coast of Sulawesi, f. Group of forest Uekuli.

Table 3 showed the tree growth at the level of sapling, pole, and tree was declining in number. It was obvious that the diameter increment increased in linear with the decline of vegetation density, even diameter of >60 cm could not be found at several altitudes.

Conclusion

Based on the study, the composition of tree vegetation in Sausu Watershed was categorized as low.

The most dominant species at various level of altitudes in Sausu Watershed were *Koodersiodendron pinnatum* Merr, *Canarium littorale*, *Homalium foetidum* Benth, *Diospyros celebica* Bakh, and *Pometia pinnata* BL. *Diospyros celebica* Bakh. was the most dominant species in Sausu Watershed at the level of seedlings, however, the numbers declined drastically at the level of tree with heartwood diameter of >50 cm.

References

Arief A. 1994. Forest of Nature and Its Effect on Environment. Yayasan Obor Indonesia. Jakarta.

Bratawinata. 1986. Classification of Mountain Forest Stands in East Kalimantan/Indonesia Based on Floristic Characteristics and Its Structure. Terjemahan Dissertation. Faculty of Forestry Universitas Georg-August Goettingen.

Bratawinata. 2014. Tropical Rain Forest Ecology. Laporatorium Ecology and Dendrology. Faculty of Forestry. Mulawarman University. Samarinda

Curtis JJ, McIntosh RP. 1951. An upland forest continuum in the prairie forest border region of Wisconsin. Ecology **32,** 476-496

Dombois MD, Ellenberg H. 1974. Aim and Method of Vegetation Ecologi. Willey International edition. John Wiley and Sons Chichester. New York.

Edwin M. 2009. Analisis Deskriptif Kondisi Vegetasi dan Sifat-Sifat Tanah Pada Sistem Lahan Maput (MPT) dan Pendereh (PDH) di Hutan Wehea Kabupaten Kutai Timur. Jurnal Kehutanan Tropika Humida **2(2)**, 181-191.

Greig-Smith P. 1983. Quantitative plant ecology. Berkeley, CA: University of California Press.

Hardjowigeno S. 2010. Soil science. Akademika Pressindo. Jakarta.

Lemmens RHMJ, Jansen PCM, Siemonsma JS, Stavast FM. 1989. Plant Recources of Sout-East Asia (Prosea). Basic List of Species and Commodity Grouping Version 1. Wageningen, The Nederland.

Lemmens RHMJ, Soerianegara I, Wong WC. 1995. Plant Recources of Sout-East Asia (Prosea) **5(2)** Timber Trees: Minor commercial timbers. Backhuys Publishers, Leiden.

Mandal G, Shambhu PJ. 2014. Analysis of Vegetation Dynamics and Phytodiversity From Three Dry Deciduous Forests of Doon Valley, Western Himalaya, India. Journal of Asia-Pacific Biodiversity **7,** 292-304

Martawijaya A, Iding Kartasujana YI Mandang Soewanda AP, Kosasi Kadir. 1989. Indonesian Wood Atlas Volume II.. Badan Penelitian dan Pengembangan Kehutanan Departemen Kehutanan. Bogor.

Mishra R. 1968. Ecology work book. Calcutta, New Delhi: Oxford and IBH Publishing Company

Naharuddin. 2009. Indeks Keanekaragaman dan Kemiripan Vegetasi di Hutan Sekunder Kawasan Sub DAS Powelua Kabupaten Donggala. J. Agroland **13 (3),** 260-264

Pitopang R, Iskandar LI, Burhanuddin F. 2011. Profile of Herbarium Celebence Tadulako University and Description 100 Species of Typical Sulawesi Trees. UNTAD PRESS.

Sagala P. 1994. Manage the Land Forestry Indonesia. Jakarta.

Samedi Kurniawati I. 2001. Kajian Konservasi Eboni. Makalah Lokakarya Manajemen Eboni (*Diospyros celebica* Bakh.) dalam Mendukung Keunggulan Industri Menuju Otonomisasi dan Era Pasar Bebas. Makassar.

Samingan T. 1982. Dendrologi. PT. Gramedia Jakarta.

Sidiyasa K. 1989. Beberapa Aspek Ekologi *Diospyros celebica* Bakh.di Sausu dan sekitarnya Sulawesi Tengah. Buletin Penelitian Hutan Bogor. **508,** 15-26

Soerianegara I, Lemmens RHMJ. 1994. Plant Resources of South-East Asia No. 5(1) Timber Trees: Mayor Commercial Timbers. Backhuys Publishers Leiden.

Takahata S. 1996. Illustrated Plant List of Pusrehut. East and West Corporation. Jakarta. Indonesia.

Widodo Sri Mulyati, Hiroshi Kobayashi. 2006. Overview of the Conservation of Biological Natural Resources and its Ecosystem.

Wiryono. 2012. Forest ecology. UNIB PRESS. Bengkulu.

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