



Tree Diversity on The Ultrabasic Soil in the Wallacea Region

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Abstract – We presented tree diversity on the ultramafic soils in Tojo Una-una district, Central Sulawesi, Indonesia. The research was carried out from March to July 2022. This study aims to determine the diversity of tree species at the study site using the single plot method with plot size 50 m X 50 m, which is divided into 25 subplots with 10 X 10 m in size. All recognized morphospecies of tree were collected for specimen herbarium.. In addition, fertile voucher specimens were also collected. Identification of vouchers and additional herbarium specimens was done in the field as well as at the Plant Biosystematics Laboratory, Department of Biology, Tadulako University. The results showed that there were 111 individual trees consisting of 16 families and 22 species. Some of them are endemic to Sulawesi, such as *Palaquium maliliense* P. Royen, *Sarcotheca celebica* Veldk., *Terminalia supitiana* Koord., *Canarium acutifolium* (DC.) Merr. var. *celebicum* Leenh., *Gymnacranthera maliliensis* R. T. A. Schouten., and *Chionanthus celebicus* Koord. Tree species *Canarium acutifolium* (DC.) Merr. var. *celebicum* Leenh has the highest Important Value Index of 32.94 % and the Shannon Whiener diversity index is 2.82 (medium category).

Keywords : Diversity, Tree, Central Sulawesi, Tojo Una-una, Ultramafic.Wallacea

1. INTRODUCTION

Sulawesi island or also known as Celebes, is fourth largest island in Indonesia [1]. It is comprised of about 182,870 km² of land surface and very important in the subregion of Wallacea [2]. Sulawesi Island has one of the fewer botanical specimen than on any other major island/region in Indonesia [3] ; [4], but has been highlighted

as a globally important biodiversity hotspot and conservation area [5], especially rich in species found nowhere else in the world [6] ; [7].

The natural vegetation of Sulawesi growing in a particular area is dependent on various factors such as soil chemistry, soil water, climate, altitude, distance from the sea , and distance from areas of similar conditions. Vegetation on ultrabasic soils is one of 14 types of vegetation in Sulawesi [3]. The soils that develop on ultrabasic rocks are notoriously infertile due to combinations some factor such as high levels of exchangeable magnesium and a skewed calcium: magnesium ratio. A deficiency of calcium, nitrogen, phosphorous, potassium, molybdenum and zinc, and toxic concentrations of heavy metals such as nickel, cobalt and chromium [8] ; [9]; [10] In the Sulawesi island, ultrabasic rocks occur in the east of Central and South Sulawesi and in Southeast Sulawesi where they cover about 8000 km². Map is presented in Figure 1 [3].

Various syntheses dealing with ultrabasic vegetation show that floristic diversity based on number of species has been fairly widely studied-on ultrabasic rocks in the temperate [11] ; [10] ;[12] but little in the tropical zone especially in Sulawesi. They show also that very few publication [13] ;[3] ; [14] ; [15]; [16]. Therefore, the research on tree diversity on the ultrabasic soil in the Wallacea region particularly Central Sulawesi is crucially investigated.

2. MATERIALS AND METHODS

a. Study site

The study was located at Podi village, Tojo Una-una Regency, Central Sulawesi Indonesia. In the the ultrabasic vegetation type, with an altitude of about 127 m above sea

level. Geographical position are 01° 3'35" S ;121° 20' 50"E. The research location is characterized by steep topography and rocky surface . The forest is lightly disturbed local community through logging activity (Figure 1). This region usually receives an annual rainfall of about 1500-2000 mm, with mean maximum temperature of 30-32°C, and average of relative humidity of about 80.71% , light intensity of about 1366.66 lux, soil humidity of 25.58 % , soil pH of 7.82 (Primary data, 2022). *Sampling protocol*

Plot size was determined by the minimum area curve [17] and was 50 x 50 m. Each plot was divided into 25 subplots of 10 x 10 m² each and all trees dbh ≥ 10 cm were recorded. In these subplots (recording units), individually all big trees (dbh ≥ 10 cm) was observed, crown base crown diameter and dbh measured, and trunk as well as total height estimated [18]. All recognized morphospecies were collected for the herbarium collection. Herbarium specimens were prepare as Bridson and Forman [19]. Additionally, fertile specimens were also collected. Processing of the specimens was done at the Laboratory of Plant Biosystematics, Department of Biology Tadulako University Palu.

Plant specimen were identified in the field, in CEB, and the Laboratory. Overall morphology was compared with other species in relevant literatures [20]; [21], [22]; [23]; <http://floramalesiana.org/> and with the help of specialist. Nomenclature of species followed IPNI [24], the plant list [25] (<http://www.theplantlist.org/>), the distribution followed Powo Science Kew [26] (<https://powo.science.kew.org/>). Preliminary conservation status was evaluated in accordance with the IUCN Standards and Petitions Subcommittee (2019) at the sites <https://www.iucnredlist.org/en>. [27]

b. Data analyses

The data collected were then tabulated and analyzed to determine the value of density, relative density, frequency, relative frequency, dominance, relative dominance, and important value index followed a formula from Mueller-Dombois and Ellenberg [28]. To analyze alpha diversity, Shannon-Wiener diversity index and species dominance index were used [29].

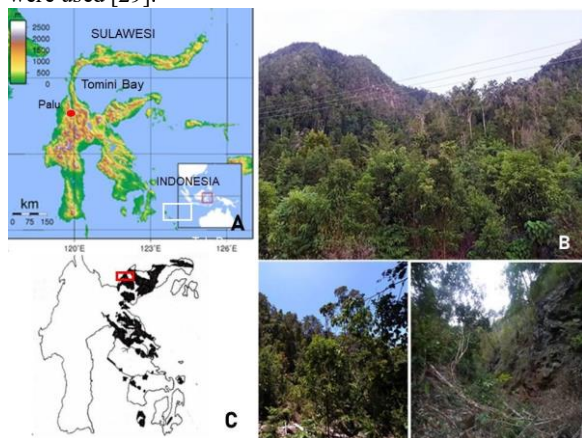


Figure 1 Research site. A. Sulawesi island. B. Forest on ultrabasic soil C. Distribution of Ultrabasic soil in Sulawesi island. Red rectangle is the research site in Tojo Una-una district, Central Sulawesi, Indonesia (modified from Whitten, et al., 1987 [3]).

3. RESULTS AND DISCUSSION

a. Species Diversity

Based on the results of the study, it was found that there were 111 individual trees consisting of 16 families and 22 species, including 6 endemic species to Sulawesi, 12 non-endemic species, 5 identical types of ultramafic soil, 8 low risk species, 2 near threatened species and 2 vulnerable species (Figure 2 and Table 1 at appendix 1).

Taxonomically, the investigated ultrabasic forest at the studied area mainly composed by *Canarium acutifolium* (Burseraceae), *Palaquium maliliensis* (Sapotaceae), *Sarcotheca celebica* (Oxalidaceae), *Buchanania arborescens* (Anacardiaceae), *Prunus clementis* (Rosaceae), *Syzygium acuminatissima* (Myrtaceae), *Terminalia supitana* (Combretaceae), *Cynometra cauliflora* (Fabaceae), *Deplancea bancana* (Bignoniaceae), *Gymnostoma rumphianum* (Casuarinaceae), *Gymnacranthera maliliensis* (Myristicaceae), *Diospyros maritima* (Ebenaceae), *Manilkara fasciculata* (Sapotaceae), *Actinodaphne macrophylla* (Lauraceae), *Chionanthus celebicus* (Oleaceae), *Knema* sp (Myristicaceae), *Palaquium obovatum* (Sapotaceae), *Gnetum* sp (Gnetaceae) and *Planchonella chartacea* (Sapotaceae).

The lowland forest with ultramafic soil in this study had a lower species richness compared to the non-ultramafic soil forest in various forest types in Central Sulawesi. In Table 2, We can see, tree species richness between this research site compared with some forest type in the Lore Lindu National Park.

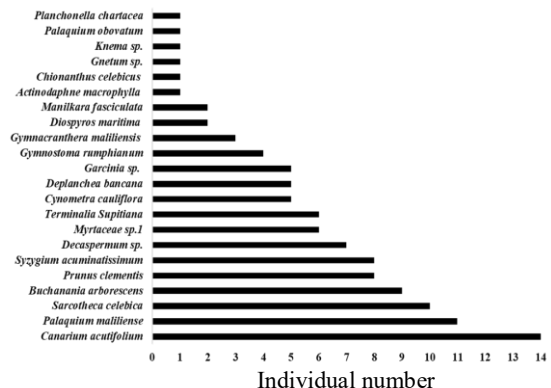


Fig.2. Tree species on the Ultrabasic soil at Tojo Una-una, Central Sulawesi, Indonesia and its abundance

In Table 2, We can see the ten most important tree species in the research site. Tree species (dbh ≥ 10 cm) that have the highest Importance Value Index (IVI) in the studied area was *Canarium acutifolium var celebicum* with IVI was 32.94% and than followed by *Palaquium maliliensis* (31.75%), *Syzigium acuminatissimum* (28.87%) *Sarchotecha celebica* (25.8), *Buchanania arborescence* (23.98), *Prunus clementis* (20.28), *Terminalia supitiana* (18.69), *Decaspermum* (17.44%), *Psychotria* (14.45%), and *Deplancea bancana* (13.98%).

Table 2. The comparison of tree species among forest types in central Sulawesi in 0,25 ha plot.

N	Sites	Alt.(m asl)	No.of Spec.	Referenc e
1	Desa Podi, Tojo Una-una, Central Sulawesi	127	22	This study
2	Lore Lindu National Park (Sub montane forest)	900	98	Mangopo, 2013 [30]
3	Lore Lindu National Park (Primary forest)	1100	76	Kessler <i>et al.</i> , 2005 [31]
4	Lore Lindu National Park (Secondary forest)	900	19-35	Kessler <i>et al.</i> , 2005 [31]
5	Lore Lindu National Park (sub montane forest)	1050	57	Gradstein <i>et al.</i> , 2007 [32]]

b. Forest Structure and Vegetation analyses

The analyses of forest structure revealed considerable in canopy height where tree species with height >30 m (emergent/top canopy species) of 22,52%, middle canopy (height 20.1-30 m) was 32,43% and Lower canopy (C) was 45.05% (Figure 3.1), Whereas the relative distribution of diameter class among tree is divided into 5 classes, namely class 1 (DBH=10-19,9 cm), class 2 (20-29.9 cm), class 3 (30-39.9 cm), class 4 (40-49.9 cm) and class 5 (50-59.9 cm) with the percentage as follow : 66.67%, 19.82%, 9.01%, 2.7% and 1.8% respectively (Figure 3.2)

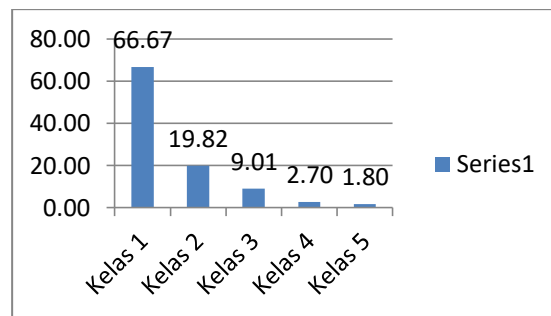
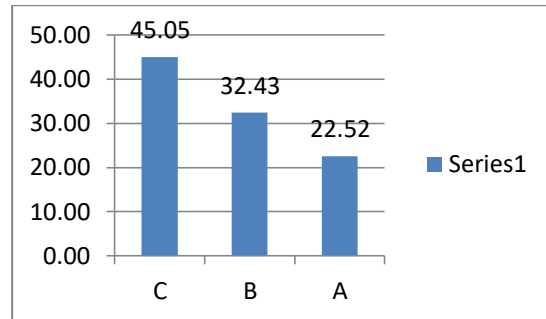


Figure 3.1 Relative distribution of height class among trees in the studied area. Notes: A = > 30 m = Top canopy species, B = 20.1-30 m = middle canopy species, and C= 0 - 20 m = lower canopy species. **Figure 3.2.** Relative distribution of diameter class among trees in the studied area, class 1 (10-19,9 cm), class 2 (20-29.9 cm), class 3 (30-39.9 cm), class 4 (40-49.9 cm) and class 5 (50-59.9 cm) .

Table 3. The ten most important tree species (≥ 10 cm) in the research site. Botanical name, Family, Relative Density (RD), Relative Frequency (RF), Relative Dominance (RDo), Important Value Index (IVI) and Shanon-Whiener Diversity Index (H')

N	Botanical name	Family	RD (%)	RF (%)	RDo (%)	IVI (%)	H'
1	<i>Canarium acutifolium</i> (DC.) Merr. var. <i>celebicum</i> Leenh	Burseraceae	12.6	11.39	8.93	32.94	0.26
2	<i>Palaquium maliliense</i> P. Royen	Sapotaceae	9.91	11.39	10.44	31.75	0.23
3	<i>Syzigium acuminatissimum</i> (Blume) DC	Myrtaceae	7.21	6.33	15.33	28.87	0.19

4	<i>Sarcotheca celebica</i> Veldk.	Oxalidaceae	9.01	8.86	7.94	25.8	0.22
5	<i>Buchanania arborescens</i> (Blume) Blume	Anacardiaceae	8.11	7.59	8.28	23.98	0.2
6	<i>Prunus clementis</i> (Merr.) Kalkman	Rosaceae	7.21	6.33	6.75	20.28	0.19
7	<i>Terminalia supitiana</i> Koord.	Combretaceae	5.41	7.59	5.69	18.69	0.16
8	<i>Decaspermum</i> sp.	Myrtaceae	6.31	5.06	6.07	17.44	0.17
9	<i>Psichotria</i> sp	Rubiaceae	5.41	5.06	3.98	14.45	0.16
10	<i>Deplanchea bancana</i> (Scheff.) Steenis	Bignoniaceae	4.5	5.06	4.41	13.98	0.14
	<i>Remaining species</i>		28.8	30.4	26.58	85.81	1.02
	Total		100	100	100	300	2.82

We recorded 111 individual trees consisted of 22 species, 16 families at the ultrabasic soil in the studied area. The tree species richness indicated lower than other places in central Sulawesi (See : [31]; [32] and [32]). The low species richness of trees in the studied habitats is due to the chemical elements contained in the soil, so that only a few plant species are able to adapt to these conditions. Ultrabasic soil is characterized by a deficiency of calcium, nitrogen, phosphorous, potassium, molybdenum and zinc, and toxic concentrations of heavy metals such as nickel, cobalt and chromium [10].

Tree species on ultrabasic soil in this habitat type were mainly composed by the family Sapotaceae, one of the pantropical angiosperm family which can live in all tropical areas. Additionally, this family is also known very common in the lowland forest area with sandy loam soil type [33].



Deplanchea bancana (Scheff) Steenis (Bignoniaceae)

There were 22 tree species recorded and 6 of them are endemic to Sulawesi namely *Gymnacranthera maliliensis*, *Canarium acutifolium* var. *celebicum*, *Terminalia supitiana*, *Chionanthus celebicus*, *Palaquium maliliense* and *Sarcotheca celebica*. [13] were also reported these species

Sapotaceae are recognized with its specific character that have milky sap, leaves simple, margin entire, flower actinomorphic, sympetalous, 1 ovule per cell. Some species such as; *Palaquium maliliensis*, *Palaquium obovatum*, *Manilkara fasciculata*, and *Planchonella chartacea* are recognized as good timber tree [13]. In addition, there were 14 individuals of *Canarium acutifolium* (Burseraceae) in area of 0.25 ha. *C. acutifolium* characterized by slightly rough to smooth bark with a dominant brown color, leaves compound in spirally arrangement and the leaflets are facing each other. *C. acutifolium* is widely used as a building material and resin is used in industry [22].



Sarcotheca celebica Veld. (Oxalidaceae)

from forest over ultrabasic soil around Soroako, Southern of Sulawesi. Other studies on ultrabasic soils in the lowland of Morowali Nature Reserve, central Sulawesi have also reported the same plant species [15]; [16]; [14].

Sulawesi is the largest island in the region of Wallacea, a biogeographical region with its unique flora and fauna [3]. Wallacea can thus be seen as a transitional area not only geologically speaking, between the Sunda and Sahul shelves, but biogeographically speaking, between the Asian biota to the west and the Australasian biota to the east [34]. Wallacea has had a complicated geological history [35],[36] which have resulted in the process of plant evolution becoming endemic species, which are only found in this area.

The trees found on the ultrabasic soils in the study area were small in size. This can be seen in figure 3.1 that trees with a DBH more than 30 cm which is less than 10%, and the top canopy layer (≥ 30 m in height) is only 22.52%. According to Whitten et al., 1987 [3] that Trees on ultramafic soils are relatively short with a height of 10-20 m and only a few trees have a total height of 25-40 m.

If we look at the aspect of the species Diversity Index (Shanon-Whiener Index/ H') that this habitat is categorized medium with $H' = 2.82$. Vegetation on ultramafic soils is characterized by low productivity and relatively low floristic diversity when compared to floristics in non-ultramafic areas [37]

4. CONCLUSIONS

It concluded that there were 111 individual trees consisting of 16 families and 22 species. Some of them are endemic to Sulawesi, such as *Palaquium maliliense* P. Royen, *Sarcotheca celebica* Veldk., *Terminalia supitiana* Koord., *Canarium acutifolium* (DC.) Merr. var. *celebicum* Leenh., *Gymnacranthera maliliensis* R. T. A. Schouten., and *Chionanthus celebicus* Koord. Tree species *Canarium acutifolium* (DC.) Merr. var. *celebicum* Leenh has the highest Important Value Index of 32.94 % and the Shanon Whiener diversity index is 2.82 (medium category).

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Appendix 1.

Table 2. Tree species in the research site, its distribution, conservation status and uses

No	Botanical name	Family	Distribution	Conservation Status	Uses
1	<i>Palaquium maliliense</i> P. Royen	Sapotaceae	C	E, UC	Major Timber
2	<i>Palaquium obovatum</i> (Griff.) Engl.		B, K, IN, LS, M, ML, MY, PH, C, SM, TH, V	LR	Major Timber
3	<i>Manilkara fasciculata</i> (Warb.) H. J. Lam & Maas Geest	Sapotaceae	B, SN, M, PNG, PH, C	V	Major timber
4	<i>Planchonella chartacea</i> (F.Muell. ex Benth.) H.J.Lam	Sapotaceae	B, J, SN, M, ML, PNG, PH, SL, C, SM,	LR	Major timber
5	<i>Syzigium acuminatissimum</i> (Blume) DC	Myrtaceae	IN, CH, PNG, C	LR	Minor timber
6	<i>Decaspermum</i> sp	Myrtaceae			
	<i>Gymnacranthera maliliensis</i> R. T. A. Schouten	Myristicaceae	C	E, UC	Major timber
7	<i>Knema</i> sp	Myristicaceae	-	-	Unknown
8	<i>Canarium acutifolium</i> (DC.) Merr. var, <i>celebicum</i> Leenh.	Bursaceae	C	E, UC	Minor Commercial timber
9	<i>Buchanania arborescens</i> (Blume) Blume	Anacardiaceae	PNG, B, K, L, SN, C, M, MY, A, PH, SL, I, T, TH, V	LR	Minor commercial timber
10	<i>Terminalia supitiana</i> Koord.	Combretaceae	C	E, UC	Major Timber
11	<i>Chionanthus celebicus</i> Koord	Oleaceae	C	E, UC	Minor timber
12	<i>Deplanchea bancana</i> (Scheff.) Steenis	Bignoniaceae	B, J, M, C, SM	LR	Lesser timber, Ornamental
13	<i>Sarcotheca celebica</i> Veldk.	Oxalidaceae	C	E, UC	Lesser commercial timber. Plant for Phytomining
14	<i>Prunus clementis</i> (Merr.) Kalkman	Rosaceae	F, C	ENDANG.	Minor Commercial timber
15	<i>Garcinia celebica</i> L.	Clusiaceae	B, K, J, L, SN, M, MY, PNG, PH, C, SM, TH, V		Lesser Commercial timber, Medicinal plant
16	<i>Gymnostoma rumphianum</i> (Miq.) L.A. S. Johnson	Casuarinaceae	ML, S		Lesser Commercial timber
17	<i>Cynometra cauliflora</i> L.	Fabaceae	B, J, M, PNG, A, C, SM	LR	Lesser Commercial timber, Ornamental tree
18	<i>Actinodaphne macrophylla</i> (Blume) Nees	Lauraceae	J, M, C, A	LR	Minor Commercial timber, Multipurpose
19	<i>Gnetum</i> sp.	Gnetaceae			
20	<i>Psychotria</i> sp	Rubiaceae			
21	<i>Diospyros maritima</i> Blume	Ebenaceae	B, K, C, J, L, SN, ML, PNG, PH, SL, C, SM, T, V, A	LR	Minor commercial timber

22	<i>Unidentified</i>	Myrtaceae	-	-	Unknown
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Notes : E = endemic, UC = ultramafic character, LR = Low risk, ENDANG = Endangered, V = Vulnerable, T = Taiwan, CH = China, IN = India, L = Laos, K = Kamboja, MY = Myanmar, TH = Thailand, V = Vietnam, M = Malaysia, Ph = Philipina, I = Indonesia, SM = Sumatera, J = Java., B = Borneo, C = Celebes, LS = Lesser Sunda, ML = Maluku, PNG = Papua Nugini, SL = Solomon, , A = Australia.

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