Vegetation structure of sapling plant at Bantimurung Bulusaraung National Park Balcoli Resort South Sulawesi

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Abstract: Tropical rainforests are dwindling so that the protected areas of the tropics are very important. Sapling plants as part of the undergrowth plants are an inseparable part of the forest ecosystem and play an important role in the sustainability of the forests, including forests in the tropics. We examine the structure and composition of sapling plants in Bantimurung Bulusaraung National Park, Balcoli resort, in two areas, which are Bukit Batu Putih and Gunung Bulusaraung. This national park is one of the protected areas in Province of South Sulawesi, Indonesia. Species with the highest importance value index in Bukit Batu Putih are Tabernaemontana sphaerocarpa, Homalium guianense, Micromelum minutum, Lepiniopsis ternatensis and Melicope lunu-ankenda with a total of 191.84%, while the lowest are Planchonella firma, Coffea sp., Matthaea sancta, Ficus pumila and Syzygium ingens with a total of 1.58%. Species in Gunung Bulusaraung with the highest important value index are Daemonorops longipes, Actephilla excelsa, Memecylon paniculatum, Galbulimina belgraveana and Ficus gil with a total of 126.31%, while the lowest are Arenga pinnata, Pterospermum celebicum, Ficus ampelas, Antidesma bunius and Cyathea contaminans with a total of 2.68%. The value of Shannon-wiener diversity, Simpson’s diversity index, species richness, Pielou’s evenness index, and Rarefaction in Bukit Batu Putih and Gunung Bulusaraung is lower than that of Gunung Bulusaraung and only Simpson’s dominance index is higher indicating of lower species diversity in Bukit Putih area. The value of similarity index between Bukit Batu Putih and Gunung Bulusaraung is 23.71% indicating that these two areas have a high difference in the structure and composition of sapling plant vegetation.

1. Introduction

Forests are very important for biodiversity [1]. Vegetation research in the tropics focuses more on vegetation structures with tree life forms, while studies that examine the undergrowth plants in which including tree saplings are still very rarely performed [2]. Sapling plants as part of the undergrowth plants are an inseparable part of the forest ecosystem and play an important role in the sustainability of the forests, including forests in the tropics [3].
Tropical rainforests are dwindling so that the protected areas of the tropics are very important [5]. Many areas of the tropics are likely to survive only in protected areas due to the high rate of deforestation [6]. The same is true for forests on the island of Sulawesi that has high biodiversity, as well as some, are endemic. However, at this time the forest is decreasing and remaining only in mountainous areas and protected areas [7].

The Bantimurung Bulusaraung national park (Babul NP) is one of the protected areas in Province of South Sulawesi. Given the importance of Babul NP as a natural resource area that has a unique biodiversity [8] and protected area, it needs protection and conservation. One approach that needs to be done is to understand the ecological conditions of vegetation plants that include plants at the level of the sapling. This study aims to determine the composition and structure of sapling plants in Balloci Resort, Babul NP, Maros District.

2. Experimental Details

2.1. Study Area
The research was conducted at the Tompobulu village, Resort of Balloci, Bantimurung Bulusaraung National Park, District of Maros Province South Sulawesi, Indonesia in March-April 2016. The sampling was conducted in two areas, that was: Bukit Batu Putih (GBP) and Gunung Bulusaraung (GBS). Bukit batu putih has an altitude up to 1,135 m asl while GBS up to an altitude of 1,353 m asl. According to [8] GBS is the highest peak in this national park.

Bantimurung Bulusaraung National Park is one of the national parks located in Province of South Sulawesi, Indonesia and appointed by Decree of the Minister of Forestry of the Republic of Indonesia No. 398/Menhut/II/2004. This national park is located in two areas of government administration, that is regency of Maros and regency of Pangkep [8]. People around Mallawa resort which is one of the resorts in Babul NP cultivate many orchids obtained from within Babul NP for conservation purposes [9].

2.2. Sampling and Data Analysis
We randomly placed 10 transects with the size of 100 x 5 m in each of the areas. In each transect we made 10 plots with the size of 5 x 5 m. The total number of transects in the study area was 20, composed of 200 observation plots. We counted every sapling in the plot. Each sapling in the plots was measured its crown diameter and then identified to the species level. We collected voucher specimens of each sapling plant. We made identification of scientific name of the species in the field. The sapling plant species that cannot be identified were identified through voucher specimens, using books by [10]. Consultation with local resident and official of Babul NP were also done on the identification activity.

We calculated the crown cover which is the value of dominance [11]. Important value indices (IVI) is calculated by the following formula:

\[ IVI = \text{relative density} + \text{relative frequency} + \text{relative dominancy} \]

where IVI is importanta value index [11].

We calculated Shanon-Wiener Diversity index (H’), Species richness (S) [12], Simpson dominance index (D), Simpson diversity index (λ) [13] Pielou’s evenness index (E) [14]. We also specify the rarefaction value [15] and make Rank abundance curve [16] of the vegetation in both regions. We assessed the similirarity between BBP and GBS using Sorensen index of similarity (SI) [11].

3. Results and Discussion
The total plant families found throughout the study sites were 29, with a total of 54 species. There were 15 families and 27 species found in BBP. In GBS, the number of families found as many as 25 with the number of species as many as 48, however, one species can not be identified in this area.
The dominant family in BBP in terms of the number of species is Rutaceae which has 4 species, while Lauraceae, Myrtaceae, Rubiaceae each has 3 species. The dominant family in GBS is Myrtaceae with 5 species, and Euphorbiaceae, Lauraceae, Myristicaceae each is having 4 species, while in this area Rubiaceae and Rutaceae each is having 3 species.

**Table 1.** Species that included in the 10 species with highest importance value in BBP and GBS, Babul NP.

| Species                        | Bukit Batu Putih (BBP) | Gunung Bulusaraung (GBS) |
|--------------------------------|------------------------|--------------------------|
|                               | Rde  | RFr  | RDo  | IVI   | Rde  | RFr  | RDo  | IVI   |
| Tabernaemontana sphaerocarpa   | 17.898 | 17.850 | 24.198 | 59.947 |
| Homalium guianense             | 17.118 | 9.789  | 12.560 | 39.467 |
| Micromelum minutum             | 12.438 | 13.436 | 13.108 | 38.982 |
| Lepinioopsis ternatensis       | 20.813 | 7.678  | 1.504  | 29.994 |
| Melicope lunu-ankenda          | 4.392  | 5.950  | 13.104 | 23.447 |
| Pavetta indica                 | 7.020  | 9.597  | 6.560  | 23.176 |
| Gastonia serratifolia          | 4.721  | 5.758  | 9.729  | 20.208 |
| Actinodaphne macrophylla       | 6.199  | 5.950  | 2.492  | 14.641 |
| Psidium guajava                | 5.758  | 5.182  | 2.612  | 10.668 |
| Actinodaphne sp.               | 7.020  | 5.182  | 2.612  | 10.668 |

Rde=Relative density, RFr = Relative frequency, RDo = Relative dominance, IVI = Important value index. Species in each area were ranked by their IVIs.

The plant families that only found in BBP are Araliaceae, Meliaceae and Salicaceae which make up 20% of families in BPP. The plant families that only found in GBS are Sapindaceae, Annonaceae, Arecaceae, Clusiaceae, Cyatheaceae, Anacardiaceae, Fagaceae, Himantandraceae, Malvaceae, Melastomataceae, Pandanaceae, Pentaphylacaceae, Phyllanthaceae. These families comprise 52% of sapling families in GBS.

The family of Myrtaceae can be found abundantly in Australia, Southeast Asia, South and Central America, and is also distributed in some area of Africa [17]. This family is found as the largest constituent of small trees in an old-growth coastal temperate rain forest of Chiloe’ Island, Chile [18], and forest with open canopy will greatly reduce its presence [19].
Table 1 shows 10 species that have the highest IVI in BBP and GBS. Tabernaemontana sphaerocarpa was a species with the highest IVI in BBP (59.947%), this species also has the highest frequency and largest canopy cover. The species with the highest density value was Lepiniopsis ternatensis, although its crown cover was the lowest compared to the other 9 species. The species with the highest IVI in GBS was Daemonorops longipes (40.947%) and was also a species with the largest crown cover. The total percentage of IVI of 5 species with the highest IVI in BBP was 191.84% and in GBS was 126.31%. Pavetta indica and Actinodaphne macrophylla were belonging to species that have IVI highest of 10 both in BBP and GBS, and there were no species belonging to species with IVI highest of 5 both in the study site.

The IVI value of *D. longipes* is the highest in the GBS area because the density, frequency, and dominance value of this species also have a high value. An altitude of 1200 m asl, environmental conditions affect the density of rattan rods and vertical structures. Species *D. longipes* has low tolerance to low temperatures. Cold environments may suppress high growth of rattan [20], therefore we didn't find this species that growth very hight at the study sites. The growth of rattan that tends to creeping causes the canopy cover to be large.

*Planchonella firma*, *Coffea sp.*, *Matthaea sancta*, *Ficus pumila* and *Syzygium ingens* are the 5 species with the lowest IVI in BBP with a total of 1.58%, while in GBS the lowest are *Arenga pinnata, Pterospermum celebicum, F. ampelas, Antidesma bunius* and *Cyathea contaminans* with a total of 2.68%.

The value of $H'$, $S$, $\lambda$, $E$, and Rarefaction in BBP is lower than that of GBS and only D is higher that is 0.10 in BBP and 0.05 in GBS indicating of lower species diversity in BBP area (Table 2). The lower value of species diversity in BBP can also be seen at the rank abundance curve (Fig. 1) where the curve or BBP is shorter than that of GBS. The rank abundance curve also indicates that there are species that are more dominant in BBP and the number of species in that location is less than that of in GBS.

Tabel 2. Value of $H'$, $D$, $S$, Rarefaction, $\lambda$, and $E$ in BBP and GBS.

|          | BBP   | GBS   |
|----------|-------|-------|
| $H'$     | 2.27  | 3.03  |
| $D$      | 0.10  | 0.05  |
| $S$      | 27    | 48    |
| Rarefaction | 26.70 | 49    |
| $\lambda$ | 0.89  | 0.94  |
| $E$      | 0.69  | 0.78  |

The BBP area has a lower species richness compared to the GBS area. The leastwise of the number of species found in the BBP area probably because this area was a secondary forest making it easier to get interference from humans. Much of BBP area was formerly an agricultural land that could be proved by *Coffea sp.*, and elephant grass (*Pennisetum purpureum*) which was found growing in this area where these plants were plantation crops of the residents. [21] aid that many people use natural resources around Babul NP for daily living needs.

The species diversity of BBP area is lower than that of GBP area because its species evenness is also low. This is relevant to [22] that the diversity of vegetation will be higher in an area with a relatively large number of species where the number of individuals is distributed evenly among the species of vegetation.

Sorenson’s SI value for sapling vegetation in BBP with GBS is 27.71%. The number of species present in the two regions is so small that it is suspected to cause the SI value to become low.
In the area of BBP it was found only 6 species (22.22%) while in GBS it was found as many as 27 species (56.25%) and this condition probably made the structure and composition of sapling vegetation in these two areas relatively different.

4. Conclusion
There is a difference of vegetation composition and structure at the sapling level between the BBP area and the GBS area. In the GBS area there are many species that are only found in that area, whereas in the BBP area, the biodiversity of sapling vegetation is relatively low. As part of Babul NP which is a protected area, sapling vegetation is part of the regeneration within the forest in these two areas, so it needs to be managed with better management in order to preserve the natural resources within the park.

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References
[1] Morales-Hidalgo, D., N.O. Sonja, and E. Somanathan. Status and trends in global primary forest, protected areas, and areas designated for conservation of biodiversity from the Global Forest Resources Assessment 2015. Forest Ecology and Management. 352 (2015) 68–77.
[2] Lü, T. X., J. Xia Yin & J. Wei Tang. Diversity and composition of understory vegetation in the tropical seasonal rain forest of Xishuangbanna, SW China. Rev. Biol. Trop. (Int. J. Trop. Biol. ISSN-0034-7744). 59 (2011) 455-463.
[3] Denslow, J.L. Tropical rainforest gap and tree species diversity. Annual Review of Ecology and
Systematic. 18 (1987) 431-451.

[4] Clark, D.A., and B.A. Clark. Assessing the growth of tropical rain forest trees: Issues for forest modeling and management. *Ecological Applications*. 9 (1999) 981–997.

[5] Corlett, R. T., and R. B. Primack. Tropical rainforest conservation: A global perspective in Tropical forest community ecology. Editors: Carson, W.P., and S.A. Schnitzer. Wiley-Blackwell, Singapore (2008).

[6] Dietz J., D. Holscher, C. Leuschner, A. Malik, A. M. Amir. Forest structure as influenced by different types of community forestry in a lower montane rainforest of Central Sulawesi, Indonesia. In: Tscharntke T., Leuschner C., Zeller M., Gohardja E., Bidin A. (eds) Stability of Tropical Rainforest Margins. Environmental Science and Engineering (Environmental Science). Springer, Berlin, Heidelberg (2007) https://doi.org/10.1007/978-3-540-30290-2_7

[7] Whitten, J. A., M. Mustafa., & G.S. Henderson. The Ecology of Sulawesi. Gadjah Mada University Press, Jogjakarta.

[8] Lubis, M.I., W. Endarwin, S. D. Riendriasari, Suwardiansah, A. U. Ul-Hasanah, F. Irawan, H.K. Aziz, and A. Malawi. 2008. *Conservation of herpetofauna in Bantimurung Bulusaraung National Park, South Sulawesi, Indonesia*. Departemen Konservasi Sumberdaya Hutan, Fakultas Kehutanan Institut Pertanian Bogor, Indonesia 16000. (1988).

[9] Hiola, S.F., G.D. Dirawan,and M. Wiharto. Orchids conservation by community in round Mallawa resort areas atau Bantimurung Bulusaraung National Park, South Sulawesi, Indonesia. International Journal of Science and Research. 6 (2017) 328-330.

[10] Sidiyasa, K., T. C. Whitmore, I. G. M. Tantra, and U. Sutisna. Tree flora of Indonesia: check list for Sulawesi. Ministry of Forestry, Agency for Forestry Research and Development, Forest Research and Development Centre, Bogor. (1989).

[11] Mueller-Dombois, D., and H. Ellenberg. Aims and Method of Vegetation Ecology. John Willey and Sons, New York. (1974)

[12] Omoro, L.M.A and O. Luukkanen. Native Tree Species Regeneration and Diversity in the Mountain Cloud Forests of East Africa, Biodiversity Loss in a Changing Planet, PhD. Oscar Grillo (Ed.), InTech, DOI: 10.5772/23108. (2011). Available from: https://www.intechopen.com/books/biodiversity-loss-in-a-changing-planet/native-tree-species-regeneration-and-diversity-in-the-mountain-cloud-forests-of-east-africa

[13] Oksanen, J., F. G. Blanchet, M. Friendly, R. Kindt, P. Legendre, D. McGlinn, P. R. Minchin, R. B. O’Hara, G. L. Simpson, P. Solymos, M. H. H. Stevens, E. Szoecs and H. Wagner. vegan: Community Ecology Package. R package version 2.4-3. (2017) https://CRAN.R-project.org/package=vegan

[14] Ken M. Vegetation Description and Data Analysis: a Practical Approach 2nd Edition. Wiley-Blackwell, USA (2012).

[15] Krebs, C.J. *Ecological Methodology*. Harper & Row Publishers, New York. (1989).

[16] Smith, T.M., and R.L. Smith. *Element of Ecology*. 7 th. Eds. Benjamin Cummings, San Francisco (2008).

[17] Wilson P.G., M.M. O’Brien, P.A. Gadek, C.J. Quinn. Myrtaceae revisited: a reassessment of infrafamilial groups. *American Journal of Botany*. 88 (2001) 2013–2015

[18] Gutíe’rez, A.G., J. C. Aravena, N. V. Carrasco-Fari´as, D. A. Christie, M. Fuentes and J. J. Armesto. Gap-phase dynamics and coexistence of a long-lived pioneer and shade-tolerant tree species in the canopy of an old-growth coastal temperate rain forest of Chiloe´ Island, Chile. *Journal of Biogeography*. 35 (2008) 1674-1687

[19] Rocha-Santos, L., M. Benchimol, M. M. Mayfield, D. Faria, M.S. Pessoa, D.C. Talora, E. Mariano-Neto, and E. Cazetta. Functional decay in tree community within tropical fragmented landscapes: Effects of landscape-scale forest cover. *PLoS ONE*. 12, 1-18. (2017). e0175545.https://doi.org/10.1371/journal.pone.0175545

[20] Watanabe, N. M. & E. Suzuki. Spesies diversity, abundande, and vertical size structure of rattans in Borneo and Java. *Biodiversitas and Conservation*. 17 (2008) 523-538.
[21] Busaeri, S.H., D. Salman, I.M. Fahmid., Yusran. Household livelihood strategies in Bantimurung Bulusaraung National Park Maros District, South Sulawesi Province, Indonesia. *International Journal of Humanities and Social Science*. 5 (2015) 278-283.

[22] Barbour M. G., J. H. Burk & W. D. Pitts. Terrestrial Plant ecology. The Benjamin Cummings Publishing Co. Inc., Menlo Park (1987).