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PHYTOSOCIOLOGY OF A LOWER MONTANE FOREST ON MT. BATULANTEH, SUMBAWA, INDONESIA

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ABSTRACT
MANSUR, M. & KARTAWINATA, K. 2017. Phytosociology of a lower montane forest on Mt. Batulanteh, Sumbawa, Indonesia. *Reinwardtia* 16 (2): 77–92. — While Indonesia's forests are globally known for their high species diversity but many regions remain little known. The objective of the study was to investigate the tree community in a lower montane forest at Mt. Batulanteh in Sumbawa. We subjectively laid out plots of 1.800 m^2 each, two in secondary forests and one in a disturbed primary forest. All stems over 5 cm diameters were measured and identified. In the plot of 0.54 hectare, we recorded 723 individuals, representing 78 species, 60 genera and 33 families. Estimated volume of boles was 183.2 m^3/0.54 ha. The forest at Mt. Batulanteh was classified as *Garcinia-Cryptocarya* association consisting of *Micromelum-Cinnamomum* subassociation. *Dipterocarpus-Calophyllum* subassociation and *Garcinia-Syzygium* subassociation. Dominant species were *Micromelum minutum* (IV=27.24), *Mallotus philippensis* (IV=26.2), *Cryptocarya ferrea* (IV=24.71) and *Cinnamomum burmanni* (IV=23.81) in Plot 1, *Dipterocarpus retusus* (IV=77.4) and *Calophyllum soulattri* (IV=24.21) in Plot 2, and *Garcinia celebica* (IV=34.86) and *Syzygium sp. 1* (IV=34.76) in Plot 3. *Dipterocarpus retusus* was unique of having restricted distribution. Fagaceae, typical family in montane forests, was absent. Shannon's diversity index was low (H^{-1} = 1.61). It can be concluded that the plots do not constitute a representative of Mt. Batulanteh and the surrounding forests, but they were sufficient to provide an illustration of the forests locally. The diameter class distribution indicated that the forests were regenerating. They were developing secondary forest and regenerating disturbed primary forest; slow successions were in the process and could be enhanced by ecological restoration. Further botanical explorations in poorly known regions of Sumbawa should be intensified further.

Key words: biomass, carbon stock, CO_2 sequestration, *Dipterocarpus retusus*, floristic association, Mt. Batulanteh, Montane forest, regeneration, structure, Sumbawa.

ABSTRAK
MANSUR, M. & KARTAWINATA, K. 2017. Fitososiologi hutan pegunungan bawah, G. Batulanteh, Sumbawa, Indonesia. *Reinwardtia* 16 (2): 77–92. — Hutan Indonesia dikenal mempunyai keanekaragaman jenis tinggi, tetapi masih banyak wilayah yang belum diketahui keanekaragaman jenisnya. Tujuan dari penelitian ini adalah untuk menelaah komunitas pepohonan di hutan pegunungan bawah G. Batulanteh, Sumbawa. Petak seluas 1,800 m^2 dibuat secara terpilih, dua buah di hutan sekunder dan sebuah di hutan primer terganggu. Hasil menunjukkan bahwa dalam petak seluas 0,54 ha tercatat 723 pohon, 78 jenis, 60 marga dan 33 suku. Estimasi volume batang bebas cabang sebesar 183,2 m^3/0,54 ha, biomassa 220,1 ton/0,54 ha, stok karbon 110,0 ton/0,54 ha dan sekuestrasi CO_2 403,1 ton/0,54 ha. Hutan di G. Batulanteh dapat diklasifikasikan sebagai asosiasi *Garcinia-Cryptocarya* yang terdiri atas subassosiasi *Micromelum-Cinnamomum,* subasosiasi *Dipterocarpus-Calophyllum* dan subasosiasi *Garcinia-Syzygium*. Jenis dominan adalah *Micromelum minutum* (IV=27,24), *Mallotus philippensis* (IV=26,2), *Cryptocarya ferrea* (IV=24,71) dan *Cinnamomum burmanni* (IV=23,81) dalam Plot 1, *Dipterocarpus retusus* (IV=77,4) dan *Calophyllum soulattri* (IV=24,21) dalam Plot 2, *Garcinia celebica* (IV=34,86) dan *Syzygium sp. 1* (IV=34,76) dalam Plot 3. *Dipterocarpus retusus* adalah jenis yang unik karena sebarannya terbatas. Fagaceae merupakan suku khas hutan pegunungan, namun tidak terdapat di hutan G. Batulanteh. Keanekaragaman indeks Shannon rendah (H^{-1} = 1,61). Tegakan dalam petak-petak penelitian tidak cukup mewakili tipe hutan pegunungan G. Batulanteh dan sekitarnya, tetapi dapat memberikan gambaran hutan setempat. Sebaran kelas diameter menunjukkan bahwa hutan sedang beregenerasi. Mereka merupakan hutan sekunder yang sedang berkembang dan hutan primer terganggu yang sedang beregenerasi. Proses suksesi yang lambat sedang berlangsung dan dapat dipercepat dengan restorasi ekologi. Ekplorasi botani selanjutnya di daerah Sumbawa yang belum banyak dikenal masih harus ditingkatkan.

Kata kunci: asosiasi floristik, biomassa, *Dipoterocarpus retusus*, G. Batulanteh, Hutan pegunungan, regenerasi, sekuestrasi CO_2 , stok karbon, struktur, Sumbawa.

INTRODUCTION

Sumbawa, where the Batulanteh montane area lies, is the largest island in West Nusa Tenggara Province. It is located in the humid to seasonally dry rainfall region of Schmidt & Ferguson (1951). Therefore, the pattern of vegetation occurring there is in line with the rainfall distribution (Monk *et al*., 1997; Steenis, 1935; Steenis & Schippers-Lammertse, 1965; Whitmore, 1984). Similarly, its flora which is relatively poor and fall within the South Malesian phytogeographic realm (Steenis, 1950), is in harmony with the above rainfall distribution (Steenis & Schippers-Lammertse, 1965).

Botanical studies, especially the aspect of exploration, have been initiated since the last two centuries (Steenis-Kruseman & Steenis, 1950). Such prominent biologists including Beccari, Bloembergen, de Voogd, Ernst, Pijl, Posthumus, Reinwardt, Rensch, Straelen, Warburg Weber, Weber-van Bosse, Zollinger, *etc*. had explored the island (Steenis-Kruseman & Steenis, 1950; Kostermans & Kartawinata, 1961; Wiriadinata *et al*., 2013). More recent botanical exploration was carried out by Keim & Rahayu (2010) specially focusing on collecting Pandanaceae in the Batulanteh montane forest area and floristic survey by Wiriadinata *et al*. (2013) in the lowland and montane forests, in West Sumbawa, outside the Mt. Batulanteh area. Qualitative notes on vegetation are usually attached to the reports of these floristic surveys.

Based on phytosociological assessment using the Braun-Blanquet method, Meijer Drees (1951) developed a scheme on distribution, ecology and silvicutural possibilities of the trees and shrubs from the savanna-forest region in eastern Sumbawa and Timor. He identified 20 communities that were grouped into four alliances.

Long before, Rensch (Steenis-Kruseman & Steenis, 1950) also explored the Batu Dulang and Batulanteh areas. Kostermans (1963) paper on vegetation of West Sumbawa was based on 1961 expedition to Mt. Batulanteh, Batu Dulang and their surrounding areas (Kostermans & Kartawinata, 1961). Kostermans (1963) identified two types of vegetation in the area: (1) a dry, deciduous forest type, extending from sea level to the altitude of ± 800 m, and (2) an evergreen submontane and montane forest types occurring above 800 m alt. Yusuf (1996) studied the forests along an altitudinal gradient from 50 m to 900 m in the north-west section of West Sumbawa and noted relatively poor species richness of 170 species of trees and shrubs in 0.64 ha. It should be noted that all available information on vegetation for East and West Nusa Tenggara was synthesized by Monk *et al*. (1997). The above account reveals that the montane forest at Batulanteh has been assessed only qualitatively and to date no quantitative measurements have been exercised.

The forests on Mt. Batulanteh have been heavily disturbed by tree poaching and conversion into agricultural lands. However, remnants of relatively good track of least disturbed natural forests and those that have developed after heavy disturbances are available. They have been selected as sites for the present study. The objective of the present study is to do quantitative measurements of floristic composition and structure of and to estimate the carbon storage in the lower montane forest at Mt. Batulanteh. To date no such initiative has been undertaken. The main section of the paper focused on the description of the forest in terms of the main structural parameters, species richness, pattern of relative abundance and family composition. The data and information secured may be useful for planning a park establishment and eventual park and protected forest management. Such data are important for measuring the suitability and the priority of conservation (Keel *et al.,* 1993), for maintaining the carbon balance (Istomo *et al*., 2009) and for ecological restoration of disturbed forests. More studies on floristic composition and structure of various plant communities in both protected and non-protected areas are needed to test scientific theory explaining the cause of patterns of species richness but also for utilization, management and conservation of biodiversity (Whitmore, 1978).

STUDY SITE

The forests on Mt. Batulanteh (1,730 m alt.) and its surrounding areas in the Sumbawa Besar District, West Nusa Tenggara Province, constitute a forest region, and is managed by the Batulanteh Production Forest Management Unit (*Kesatuan Pengelolaan Hutan Produksi*) as prescribed in the Minister of Forestry Decree (*SK. 342/Menhut-II/2011*) (Julmansyah, 2014). It extends from the coast to the summit of Mt. Batu Pasak (1,776 m alt.), including the Mt. Batulanteh forest area. It covers a total area of 32.776 ha, consisting of protection forest (14.303 ha), production forest (14.842 ha) and limited production forest (3.631 ha). It is recorded that the 56 % of the Batulanteh forest area has been assigned primarily for production purposes. The presence and maintenance of these forests are important in the hydrological system of the Sumbawa watershed, which provides water for the low-lying areas of northern west Sumbawa, including the City of Sumbawa Besar (Anonymous, 2015). Protection and conservation of these forest help also the sustainability of the highly productive honey industry in the area that depends a great deal on a diversity of tree species as providers of feeds to honey-bees *Apis dorsata.*

Climatically, the study site was located in the seasonally dry region belonging to the rainfall type C (Schmidt & Ferguson, 1951). Fig. 1. shows the climate diagram of Walter (1973) of the nearest rainfall station at Batu Dulang (1,162 m alt.), with the mean annual rainfall of 3,131 mm, the mean annual temperature of 19^0 C . The climate diagram indicated a five-month dry period from June (93 mm) to October (100 mm) and a seven-month wet period from November to May, where the mean monthly rainfall was greater than 100 mm, with the highest mean in January (701 mm). The diagram was constructed on the basis of data available at Climate Data.org (2017).

The forests comprised secondary forests and disturbed primary forests. The secondary forests have developed from abandoned lands. The lowland and lower montane forests have been much disturbed and converted into agricultural lands in 1961 when Kosterman and Kartawinata (1961) undertook botanical exploration in the Batulanteh area.

MATERIALS AND METHODS

The study was undertaken on 11-20 May 2016 in the protection forest of the Batulanteh Forest Unit (*Kelompok Hutan*) covering 12.703 ha within the Regional Land Register (*Register Tanah Kawasan*) no. 61. Administratively, it was located at the Batudulang Subdistrict (*Desa*), Batulanteh District (*Kecamatan*) and Sumbawa Regency (*Kabupaten*) (Fig. 1.). In general the topography of the study site was undulating to hilly with slopes of 25^0-40^0. The soils were dominated by lithosols and brown Mediteranian, less fertile, thin solum (< 90cm) and sensitive to erosion (Julmansyah, 2014).

Three plots of 1.800 m^2 each was established, covering a total sample area of 0.54 ha. Each plot was further divided into 18 quadrats of 100 m^2 (10m × 10m) each. Plot 1 on clay soil and Plot 3 on friable black lathosol soil were located in secondary forests, while Plot 2 on friable black latosol soil in a disturbed primary forest. Each plot was laid out on a more or less flat to gently sloping area. Plot 1 was established in the Palempatable protection forest at 1,092 m alt. and geographically located at 08^0 36' 25.5" South and 117^0 16' 20.5" East. In the Keban Atas protection forest, Plot 2 was laid out at 1,039 m alt. and is geographically located at 08^0 36' 31.5" South and 117^0 15' 54.5" East, while Plot 3 at 1, 010 m alt. on coordinates of 08^0 36' 17.7" South and 117^0 16' 11.3" East.

Within each quadrat all trees with DBH (Diameter at Breast Height) ≥ 5 cm were identified, their diameters were measured and bole heights and total tree heights were estimated by comparing with the heights of measured selected trees which were used as references. A simulated forest profile diagram for each plot was constructed using the method of Kartawinata *et al*. (2004) by plotting in a linear row the data on tree heights and tree numbers reflecting the sequence of field recording.

We defined and calculated density, frequency and dominance and their relative values according to the standard method (Cox, 1967; Mueller-Dombois & Ellenberg, 1974). Density was defined as the number of individuals per unit area. The number of individuals per species was later calculated for the total area of the plot, which was 1,800 m^2. The density in the plot was the sum of the individuals of all species and was expressed in terms of the number of individuals per hectare. The Relative Density (RD) for each species was

$$RD = \frac{\textbf{number of individuals of a species}}{\textbf{total number of individuals}}\ x100\ \%$$

calculated as follows:

Frequency referred to the number of occurrences of a species in quadrats within the plot and was expressed as a percentage of the total number of quadrats. The following formula calculated the Relative Frequency (RF):

$$RF = \frac{\textbf{frequency of a species}}{\textbf{sum frequency of all species}}\ x100\ \%$$

Stem cover, which was the same as basal area, was used to define tree dominance. The basal area (BA) was computed as follows:

$$BA = (½d)^2\pi$$

where *d* referred to diameter. The dominance of a species was measured by summation of the basal area (BA) values for all stems in the species. The Relative Dominance (RDo) was computed with the following formula:

$$RDo = \frac{\textbf{dominance of a species}}{\textbf{dominance of all species}}\ x100\ \%$$

The sum of RD, RF and RDo denotes the importance of a species in the plot and is designated as the Importance Value (IV):

$$IV = RD + RF + RDo$$

The sum of Importance Values of all species in a family entailed the Family Important Value (FIV) (Kartawinata *et al*.,2004). Shannon's index of diversity was calculated using the formula:

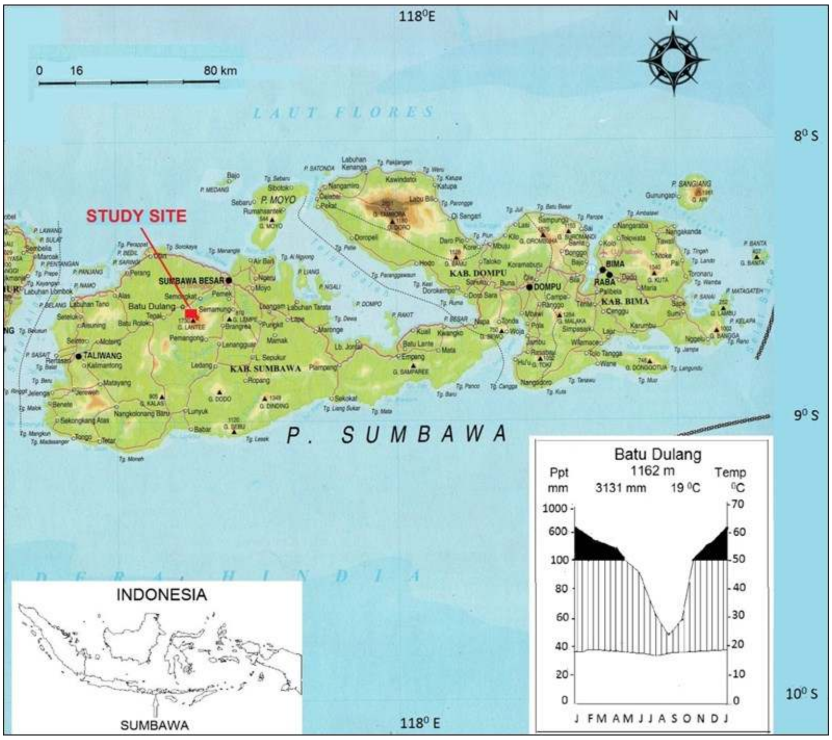

Fig. 1. Map of Sumbawa Island indicating the study site at Mt. Batulanteh, supplemented with a Walter's climate diagram for Batu Dulang, the nearest site having rainfall and temperature data. It shows that the area has seasonally dry climate from June to October (Source of basic map: Chaldun, 2006).

$$(H') = -\sum_{i=0}^{n} \left(\frac{ni}{N}\right) \log\left(\frac{ni}{N}\right)$$

Where *ni* is the Important Value (IV) of species *i* and *N* are IV of all species.

We also estimated the tree (bole) volume (m^3) by calculating BA x Bole Height × 0.57, where 0.57 was the constant for Tropical Asia (Reyes *et al*., 1992).

In each quadrat we noted the topography and soil types. We collected herbarium specimens for each species within the plot and identified them at the Herbarium Bogoriense, Research Center for Biology-LIPI, Cibinong Science Center. The identity and nomenclature of each tree species follow *Flora Malesiana* (Steenis *et al.,* 1948-2013) if species were not listed in The Plant List.

RESULTS

Species composition

In the plot of 0.54 hectare we recorded 723 individuals, representing 78 species, 60 genera and 33 families. Out of 78 species we identified 15 secondary forest species, with following distribution: one (*Garcinia celebica*) was recorded in all plots, two (*Ficus fistulosa* and *Mallotus dispar*) in Plot 1, four (*Elaeocarpus ganitrus, Ficus pubinervis, F. variegata, Prunus arborea*) in Plot 2, three (*Erythrina subumbrans, Pterospermum javanicum, Tetrameles nudiflora*) in Plot 1 & Plot 2, one (*Erythrina lithosperma*) in Plot 2 & Plot 3 and four (*Aglaia odoratissima, Mallotus philippensis, Neonauclea parviflora, Prunus arborea*) in Plot 1 and Plot 3 (Table 2).

Table 1 shows the summarized parameters in the plots. Plot 2 (disturbed primary forets) contained lesser number of species than those of Plot 1 and Plot 3 (which were both secondary forests), but it had higher BA, stem volume, biomass and CO_2 sequestration than Plot 1 and Plot 3. The biomass and carbon stock in these forests were higher than those in the Halimun-Salak National Park (Mansur *et al*., 2011). It was due to the fact that it contained bigger trees including *Dipterocarpus retusus*. The highest number of individuals occurred in the diameter class of 5-9.9 cm for Plot-1 and Plot-2, while for Plot 3 in diameter class of 10-19.9 cm. In general the number of individuals decreased as the diameter increased. The biggest stem diameters in secondary forest was 80 cm while in the primary forest reached as high as 100 cm. Applying critera of Barbour *et al.* (1987), the Shannon's diversity index in each plot was considered low.

Table 2 shows all species present in the three plots along with their vegetation parameters and were clustered into groups based on their distributions. Group 1 consisted of 12 species that were present with different BA, D, F and IV in the three plots. Several species had IV > 10: five species in Plot 1 and Plot 3 and four species in Plot 2. They floristically characterized, thus formed character species of the lower montane

Table 1. Summarized measured parameters and results in each plot in a lowermontane forest at Mt. Batulanteh, Sumbawa

Parameter	Plot 1	Plot 2	Plot 3	Total
Plot area (ha)	0.18	0.18	0.18	0.54
Altitude (m)	1092	1039	1010	
Number of stems	271	245	207	723
Number of species	44	37	38	78
Number of genera	34	29	31	60
Number of families	18	23	21	35
Diversity indeks (H')	1.39	1.27	1.39	1.06
Basal Area (m^2)	6.71	10.18	6.77	23.66
Volume (m^3)	32.34	107.9	42.97	183.21
Biomass (ton)	58.35	103.37	58.34	220.06
Carbon (ton)	29.17	51.68	29.17	110.02
CO2 Sequestration (ton)	107.06	189.68	107.06	403.08

forest at Mt. Batulanteh. Applying the criteria of Mueller-Dombois & Ellenberg (1974) using species ditribution, complemented with highest IV of two species, the lower montane forest at Mt. Batulanteh can be designated as the ***Garcinia celebica-Cryptocarya ferrea* association** or for short the ***Garcinia-Cryptocarya* association**.

The similarity of floristic composition among the three plots was only 36.3% to 36.5% as indicated in the cluster dendrogram (Fig. 2). The dissimilarity was likely contributed mainly by species that were restricted and characterized the community in each plot (Group 2, Group 3 and Group 4)

On the basis of species distribution as used in defining association (Mueller-Dombois & Ellenberg, 1974), Plot 1 constituted a sub-association, which on the basis of dominance, can be designated the ***Micromelum minutum-Cinnamomum burmanii* subassociation**, or for short it was called as the ***Micromelum-Cinnamomum* subassociation**. It was characterized by 24 species in Group 2, whose distribution were restricted to this community, of which six were prevalent species (IV > 10). They made up the character species of the *Micromelum-Cinnamomum* subassociation. Other component species were listed as Group 1, Group 5 and Group 7. The prevalent species (with IV >10), including the two dominant species, were not restricted to Group 2 (character species) but were also present in Group 1, including *Acronychia trifoliolata* (19.06), *Cinnamomum burmanni* (23.81), *Cryptocarya ferrea* (24.71), *Dysoxylum caulostachyum* (10.27), *Elaeocarpus ganitrus* (14.83), *Grewia eriocarpa* (19.41), *Mallotus philippensis* (26.02), *Micromelum minutum* (27.24), *Syzygium racemosum* (15.11), *Syzygium* sp. 1(11.46), *Voacanga foetida* (15.46) and *Zanthoxylum ovalifolium* (12.91).

Plot 2 formed the ***Dipterocarpus retusus-Calophyllum soulattri* subassociation,** or for short it was called ***Dipterocarpus-Calophyllum* sub-association**, characterized by 15 species in Group 3, whose occurrences were restricted to this community. Two of the species were prevalent (IV >10), including *Dipterocarpus retusus* (IV = 77.4). They constituted the character species of the *Dipterocarpus-Caloppyllum* subassociation. Other component species were listed in Group 1, Group 5 and Group 6, among which were prevalent species, including *Calophyllum soulattri* (24.20), *Dipterocarpus retusus* (77.40), *Garcinia celebica* (12.78), *Mangifera timorensis* (12.13), *Syzygium polyanthum* (14.36) and *Syzygium racemosum* (11.46).

Plot 3 made up the ***Garcinia celebica-Syzygium sp.* 1 subassociation**, or for short it was named as ***Garcinia-Syzygium* subassociation.** It was characterized by 14 species listed in Group 4, whose occurrences were restricted to this community. Other species composing this association included species listed in Group 6 and Group 7, among which were prevalent species, including *Calophyllum soulattri* (11.74), *Cryptocarya ferrea* (19.41), *Dysoxylum alliaceum* (16.04), *Elaeocarpus floribundus* (15.02), *Garcinia celebica* (34.86), *Mallotus philippensis* (16.66), *Prunus arborea* (10.85), *Syzygium polyanthum* (16.54), *Syzygium racemosum* (13.71), and *Syzygium* sp. 1 (37.06).

It can be noted in Table 1 that *Mallotus philippensis* and *Cryptocarya ferrea* had relatively high IVs in the three plots. High IVs in *Syzygium* sp. 1 and *Micromelum minutum* were shared by Plot 1 and Plot 3. Similarly Plot 2 and Plot 3 jointly shared relative high values of *Calophyllum soulattri, Garcinia celebica* and *Syzygium polyanthum.* The remaining species with high IVs were the character species of subassociations as

Table 2. Species grouping and distribution in Plot 1, Plot 2 & Plot 3 in a lower montane forest of Mt. Batulanteh. BA = Basal area (m^2); D - Absolute Density (trees/ha), F = Absolute Frequency (%); IV (Importance Value)

No.	Species	PLOT 1				PLOT 2				PLOT 3			
		BA	D	F	IV	BA	D	F	IV	BA	D	F	IV
	Group 1												
1	*Acronychia trifoliolata* Zoll & Moritz	1.73	106	67	19.06	0.16	11	11	2.42	0.88	22	17	6.32
2	*Calophyllum soulattri* Burm. f.	0.11	17	17	3.24	1.83	150	83	24.20	2.05	33	28	11.74
3	*Cryptocarya ferrea* Blume	2.37	156	72	24.71	0.03	17	11	2.61	2.12	72	61	19.41
4	*Drypetes longifolia* (Blume) Pax & K. Hoffm.	0.03	6	6	1.06	0.16	17	11	2.83	0.40	39	39	9.21
5	*Garcinia balica* Miq.	0.01	6	6	1.02	0.06	6	6	1.18	0.33	17	17	4.37
6	*Garcinia celebica* L.	0.52	78	33	9.63	1.23	72	44	12.78	4.52	161	72	34.86
7	*Palaquium obtusifolium* Burk.	0.18	6	6	1.48	0.08	11	11	2.29	0.22	22	22	5.23
8	*Premna nauseosa* Blanco	0.86	39	33	8.59	0.02	6	6	1.12	0.49	44	22	7.89
9	*Syzygium polyanthum* (Wight) Walp.	0.56	11	17	3.47	1.61	67	56	14.36	3.41	39	33	16.54
10	*Syzygium racemosum* (Blume) D.C.	2.51	61	39	15.11	1.92	6	33	11.46	2.35	39	33	13.71
11	*Syzygium* sp. 1	1.01	67	39	11.46	1.61	145	67	21.41	3.67	189	89	37.06
12	*Voacanga foetida* (Blume) Rolfe	0.85	106	56	15,64	0.13	11	11	2.36	0.24	17	17	4.13
	Group 2												
1	*Aglaia domestica* (Correa) Pelleger	0.02	6	6	1.04								
2	*Aglaia lawii*(Wight.) C. J. Saldanha	0.05	22	17	3.47								
3	*Aglaia silvestris* (M. Roem.) Merr.	0.03	6	6	1.06								
4	*Alstonia scholaris* (L.) R. Br.	0.59	6	6	2.58								
5	*Champereia manillana* (Blume) Merr.	0.03	6	6	1.07								
6	*Cinnamomum burmanni* (Nees & T. Nees) Blume	3.96	196	56	23.81								
7	*Dysoxylum arborescens* (Blume) Miq.	0.03	6	6	1.06								
8	*Dysoxylum caulostachyum* Miq.	0.47	61	44	10.27								
9	*Elaeocarpus ganitrus* Roxb. ex G. Don	3.55	33	28	14.83								
10	*Grewia eriocarpa* Juss.	3.79	56	50	19.41								
11	*Hymenodictyon orixense* (Roxb.) Mabb.	0.26	6	6	1.69								
12	*Kleinhovia hospita* L.	0.05	6	6	1.11								
13	*Litsea diversifolia* Blume	0.11	17	17	3.26								
14	*Macaranga tanarius* (L.) Mull. Arg.	0.11	6	6	1.01								
15	*Micromelum minutum* Wight & Arn.	1.11	244	72	27.24								
16	*Homalanthus populneus* (Geiseler) Pax	0.16	6	6	1.42								
17	*Phyllanthus emblica* L.	0.87	6	6	3.31								
18	*Rapanea avenis* (Blume) Mez	0.66	6	6	2.75								
19	*Schoutenia ovata* Korth.	0.61	6	6	2.61								
20	*Sterculia foetida* L.	0.04	6	6	1.09								
21	*Syzygium acuminatissimum* (Blume) D.C.	0.18	6	6	1.36								
22	*Syzygium laxiflorum* (Blume) D.C.	0.01	6	6	1.02								
23	*Tetrameles nudiflora* R. Br.	2.26	6	6	7.05								
24	*Zanthoxylum ovalifolium* Tutcher	0.31	89	56	12.91								
	Group 3												
1	*Actinodaphne diversifolia* Merr.					0.01	6	6	1.09				
2	*Alseodaphne cuneata* (Blume) Boerl.					0.03	11	11	2.19				
3	*Chionanthus ramiflorus* Roxb.					0.31	22	17	4.16				
4	*Dacrycarpus imbricatus* (Blume) de Laub.					0.04	6	6	1.15				
5	*Dipterocarpus retusus* (Blume)					26.50	272	89	77.40				

Table 2. Species grouping and distribution in Plot 1, Plot 2 & Plot 3 in a lower montane forest of Mt. Batulanteh. BA = Basal area (m^2); D - Absolute Density (trees/ha), F = Absolute Frequency (%); IV (Importance Value) (Continued)

No.	Species	PLOT 1				PLOT 2				PLOT 3			
		BA	D	F	IV	BA	D	F	IV	BA	D	F	IV
6	*Ficus benjamina* L.					4.38	11	11	9.88				
7	*Ficus fistulosa* Reinw. ex Blume					0.04	6	6	1.15				
8	*Gomphandra javanica* (Blume) Valeton					0.57	11	11	3.14				
9	*Urophyllum streptopodium Wall.*					0.02	6	6	1.11				
10	*Mallotus dispar* (Blume) Mull. Arg.					0.01	6	6	1.09				
11	*Mangifera timorensis* Blume					5.42	17	11	12.13				
12	*Meliosma pinnata* (Roxb.) Maxim.					0.01	6	6	1.09				
13	*Orophea enneandra* Blume					0.12	6	6	1.10				
14	*Palaquium obovatum* (Griff.) Engl.					0.01	6	6	1.09				
15	*Saurauia nudiflora* D.C.					0.16	39	28	6.46				
	Group 4												
1	*Bridelia insulana* Hance									0.51	6	6	2.50
2	*Chisocheton* cf. *sandoricocarpus* Koord. & Valeton									0.03	11	11	2.42
3	*Dacryodes rostrata* (Blume) H. J. Lam									0.08	11	11	2.53
4	*Dehaasia incrassata* (Jack.) Kosterm.									1.18	28	22	8.28
5	*Diospyros cauliflora* Blume									0.03	6	6	1.24
6	*Dysoxylum alliaceum* (Blume) Blume									0.82	89	50	16.04
7	*Elaeocarpus ganitrus* Roxb. ex G. Don									0.78	11	11	4.40
8	*Elattostachys verrucosa* (Blume) Radlk.									0.13	11	11	2.66
9	*Ficus pubinervis* Blume									1.06	6	6	3.99
10	*Ficus variegata* Blume									0.14	6	6	1.53
11	*Maranthes corymbosa* Blume									0.72	6	6	3.09
12	*Phoebe opaca* Blume									0.12	11	11	2.64
13	*Pittosporum moluccanum* Miq.									0.06	6	6	1.32
14	*Pygeum parviflorum* Craib									0.01	6	6	1.20
	Group 5												
1	*Bischofia javanica* Blume	0.32	6	6	1.83	0.02	6	6	1.10				
2	*Erythrina subumbrans* (Hassk.) Merr.	0.12	11	6	1.73	2.30	11	11	6.20				
3	*Pterospermum javanicum* Jungh.	0.37	11	11	2.96	0.90	17	11	4.14				
	Group 6												
1	*Ardisia lanceolata* Roxb.					0.47	56	50	10.88	0.03	11	6	1.73
2	*Croton cascarilloides* Raeusch.					0.47	50	33	8.50	0.11	17	17	3.79
3	*Erythrina lithosperma* Miq.					1.16	78	44	13.06	0.76	11	11	4.35
4	*Myristica fatua* Houtt.					0.24	28	22	5.11	0.12	17	17	3.79
5	*Petunga microcarpa* (Blume) D.C.					0.18	50	39	8.62	0.22	11	11	2.92
6	*Syzygium manii* (King) N. P. Balakr.					0.30	67	44	10.73	0.17	6	6	1.207
7	*Syzygium* sp. 1					1.61	145	67	21.41	3.67	189	89	37.06
	Group 7												
1	*Aglaia odoratissima* Blume	0.11	11	11	2.25					0.48	28	22	6.40
2	*Elaeocarpus floribundus* Blume	0.13	11	6	1.70					3.72	28	22	15.02
3	*Elaeocarpus ganitrus* Roxb. ex G. Don	3.55	33	28	14.83					0.78	11	11	4.40
4	*Mallotus philippensis* (Lam.) Mull. Arg.	6.07	72	44	26.02					2.84	50	39	16.66
5	*Neonauclea parviflora* (Koord. & Valeton) Ridsdale	0.05	6	6	1.12					0.27	17	17	4.20
6	*Prunus arborea* (Blume) Kalkman	0.20	6	6	1.53					1.78	39	22	10.85

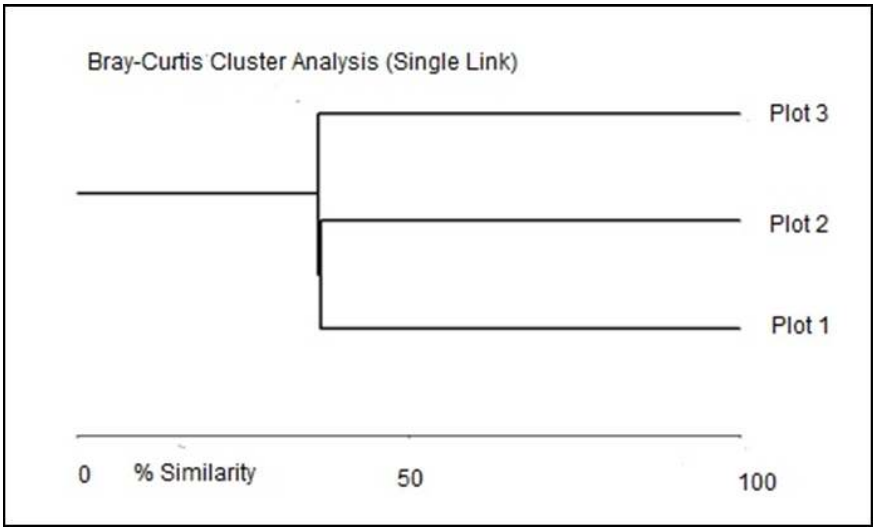

Fig. 2. Dendrogram of similarity based on species composition of the plots in a lower montane forest at Mt. Batulanteh, Sumbawa.

indicated also in the description above.

If on the average, a species had one or fewer stems per hectare, it can be considered as a rare species (Hubbell & Foster, 1986) on the local scale and is not in any way is accepted on the global scale as defined by IUCN criteria of rareness. Applying this concept the following can be considered rare at least locally in the Mt. Batulanteh area (Table 1):

Plot 1 (24 species):

Aglaia domestica, Aglaia sylvestris, Alstonia scholaris, Bischofia javanica, Champereia manillana, Dysoxylum arborescens, Drypetes longifolia, Elaeocarpus floribundus, Erythrina subumbrans, Garcinia balica, Hymenodictyon orixense, Kleinhovia hospita, Macaranga tanarius, Neonauclea parviflora, Homalanthus populneus, Palaquium obtusifolium, Prunus arborea, Rapanea avenis, Schoutenia ovata, Sterculia foetida, Syzygium acuminatissimum and *Syzygium laxiflorum*

Plot 2 (11 species) :

Actinodaphne diversifolia, Bischofia javanica, Dacrycarpus imbricatus, Ficus fistulosa, Garcinia balica, Geniostema acuminata, Mallotus dispar, Meliosma pinnata, Orophea eneandra, Palaquium obovatum and *Premna nauseosa*

Plot 3 (9 species):

Bridelia insulana, Diospyros cauliflora, Ficus pubinervis, Ficus variegata, Maranthes corymbosa, Pittosporum moluccanum, Pygeum parviflorum and *Syzygium manii*

They are very vulnerable to disappearance even as a result of slight disturbances. Their poor regeneration as shown in Table 4 may amplify this unfavorable situation.

Structure

Size and density as well as horizontal and vertical distribution of trees define forest structure (Kershaw, 1964; Mueller-Dombois & Ellenberg, 1974). The structure of forests in the study sites is depicted by graphs (Fig. 3 & 4) and simulated profile diagrams (Fig. 5). Diameter classes show that 87.4% of trees in Plot 1, 86.9% in Plot 2 and 77.4 % in Plot 3 were dominated by small individuals with diameters of 5 – 29.9 cm and only few trees had diameters > 30 cm (Fig. 3). Trees with large diameters of 60 – 70 cm occurred in Plot1 (*Grewia eriocarpa*) and Plot 3 (*Syzygium polyanthum, S. racemosum* and *Elaeocarpus floribundus*). In Plot 2, *Dipterocarpus retusus* could reach the diameter of about 97.3 cm.

Vertical distribution of trees according to their crown heights in the three plots is presented in Fig. 4 and Fig. 5. The simulated forest profile diagrams (Fig. 5) show that the forests in three sites had four strata: Stratum A (>25 m), stratum B (15 – 25 m), stratum C (5 – 15 m) and stratum D (<5 m). The highest number of individuals was recorded in the Stratum C, except in Plot 3. The number of individuals decreased drastically as the crown height increased. Only in Plot 2 trees with height of up to 40 m was recorded and represented by *Dipterocarpus retusus*.

St. (Sratum) A with height > 25 m represented the layer of emergent trees. In Plot 1 it was represented by only two trees of *Cinnamomum burmanii* and *Grewia eriocarpa,* with height of 26 m and 30 m, respectively. In Plot 2 it comprised several species, including *Dipterocarpus retusus, Erythrina lithosperma, Erythrina subumbrans, Ficus benjamina, Mangifera timorensis, Pterospermum javanicum, Syzygium polyanthum* and *Syzygium* sp. 2. It was dominated in number and height by *Diterocarpus retusus,* which amounted to 20 trees and could reach the height of 40

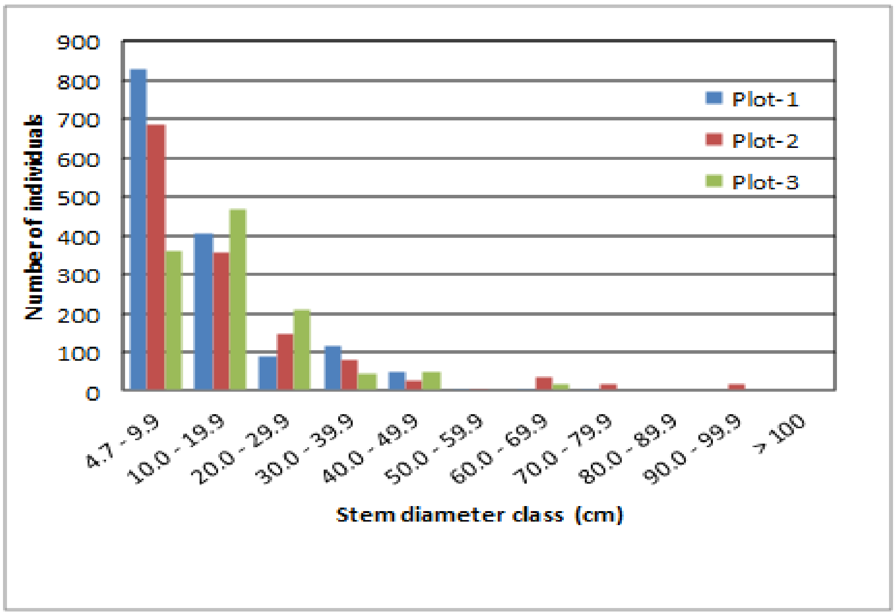

Fig. 3. Diameter class distribution of trees in Plot 1, Plot 2 and Plot 3 in the lower montane forest at Mt. Batulanteh, Sumbawa. The largest diameter recorded in the plots was represented mainly by *Dipterocarpus retusus.*

m. Another species, but only one tree, that could reach 40 m high was *Mangifera timorensis.* In Plot 3 the emergent trees belonged to *Acronychia trifoliolata, Cryptocarya ferrea, Elaeocarpus floribundus, Elaeocarpus ganitrus, Ficus pubinervis, Garcinia celebica, Maranthes corymbosa, Prunus arborea, Syzygium racemosum* and *Syzygium* sp. 2. The two tallest tree were *Elaeocarpus floribundus* (37 m) and *Maranthes corymbosa* (30 m).

It can be noted in Table 2 that Plot 1, which was a secondary forest, had more species (12) having number of trees > 10 compared to Plot 2 (8 species) and Plot 3 (5 species). *Micromelum minutum* had the highest number which was 44 or about 16.2 % of the total in the plot and *Cryptocarya ferrea* the second highest which was 28 or 10.3 % and jointly was 732 or 26.6 % of the total. It is interesting that *Dipterocarpus retusus* had 49 trees in Plot 2 and constituted 20 % of the total number of trees with the total basal area (BA) of 4.77 m^2 or 20.2 % of the total. Both number of trees and basal area contributed a great deal to the high importance value (IV = 77.4).

The figures of BA point to the fact that there were only a few species with high values, including *Mallotus philippensis* (the highest, 1.09 m^2) *Cinnamomum burmanni* (0.91 m^2), *Grewia eriocarpa* (0.68 m^2) and *Elaeocarpus ganitrus* (0.64 m^2). The BA values were comparable to the number of trees and the importance values, they all showed that there were about 10 species, although not identical, had high values. As indicated above, in Plot 2, which was disturbed 49 taking primary forest, *Dipterocarpus retusus* dominated the plot. Both number of trees and basal area contributed a great deal to the high importance value (IV = 77.4). The other two species with high BA were *Mangifera timorensis* (0.98 m^2) and *Ficus benjamina* (0.78 m^2). The rest of species were of smaller BA values, implying also of smaller stem diameters (Fig. 3). High BA values in Plot 3 were observed in *Garcinia celebica* (0.81 m^2), *Elaeocarpus floribundus* (0.67m^2), *Syzygium* sp.1 (0.66 m^2) *and Syzygium polyanthum* (0.61 m^2). Just like in Plot 1 and Plot 2 the BA values in the remaining species were small comparable to their diameters.

Regeneration

Regeneration in tropical forests is a complex process depending on so many factors including the incidental occurrences of natural gap formation (Richards, 1996; Whitmore, 1984). Complete profile of size class distribution from seedlings to the largest diameter trees could be an indicative of regeneration.

Size-class distributions, however, depend on growth and mortality (Jones, 1950 in Richards, 1986) and may be related to site conditions as well as to the incidence of natural or artificial disturbances in the past (Richards, 1996).

Group 1.1, Group 2.1 and Group 3.1 consisted of species that were repesented in almost all diameter classes up to 100 cm. They represented species approaching or already a mature state in the forest. Most notably among them was *Dipterocarpus retusus* in Plot 2 (Group 2.1) which reached the diameter of 97 cm and filled almost all diameter classes below it down to the lowest diameter with high number of individuals. The species has been regenerating well. Other species

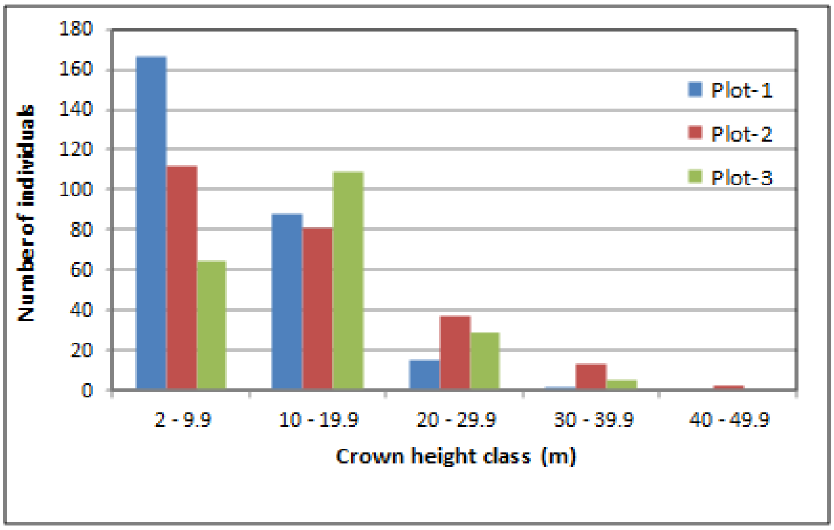

Fig. 4. Vertical distribution of crown heights in Plot1, Plot 2 and Plot 3. in the lower montane forest at Mt. Batulanteh, Sumbawa. Note that only in Plot 2 the crown height of up to 50 m was encountered and represented by few species, including *Dipterocarpus retusus.*

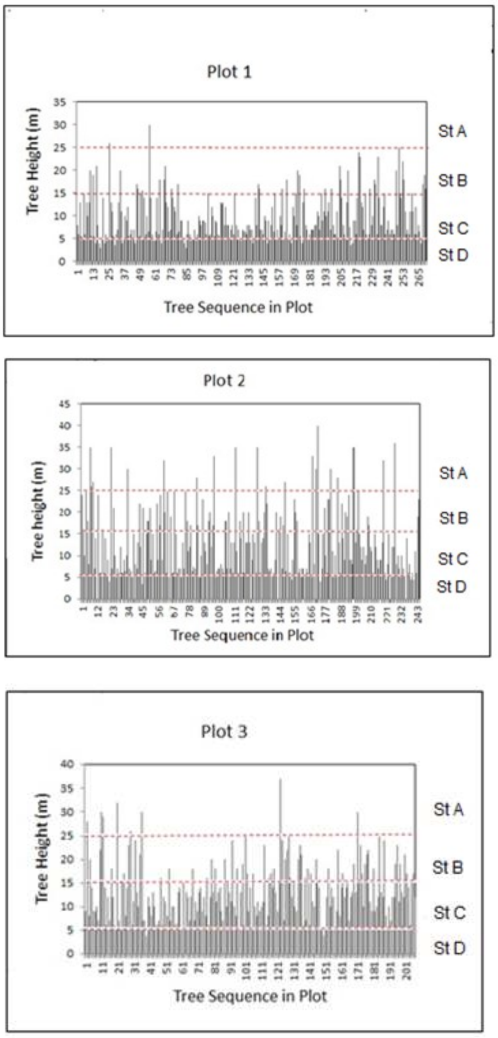

Fig. 5. Simulated profile diagrams of forests on Plot 1, Plot 2 and Plot 3, showing height stratification St 1 (> 25 m), St 2 (15-25 m), St 3 (5-15 m) and St 4 (< 5 m) in the lower montane forest at Mt. Batulanteh, Sumbawa.

in this Group 2.1 that were regenerating well were *Drypetes longifolia* and *Syzygium polyanthum.* In Plot 1 and Plot 3 the species of this group (Group 1.1 and Group 3.1) could reach the maximum diameter of less than 80 cm and the number of trees in each diameter class was low, except in the lowest diameter class (5-10 cm) including in the Group 1.3, Group 1.4 and Group 3.3 and Group 3.4 the number of trees were relatively high. Overall the forests in the three plots were re-generating. Other species whose distribution were scattered in the high diameter classes and absent in the 5 –10 cm diameter may eventually disappear from the forest. They included *Alstonia scholaris*, *Bischofia javanica, Elaeocarpus floribundus, Hymenodictyon orixence, Homalanthus populneus, Palaquium obtusifolium, Phylanthus emblica, Prunus arborea, Rapanea avenis, Schoutenia ovata* and *Tetrameles nudiflora* from Plot 1; *Erythrina subumbrans, Ficus benjamina, Ficus fistulosa, Garcinia balica, Gomphandra javanica* and *Pterospermum javanicum* from Plot 2; and *Bridelia insulana, Dehaasia incrassata, Elattostachys verrucosa, Erythrina lithosperma, Ficus pubinervis, Ficus variegata, Maranthes corymbosa, Neonauclea parviflora, Pittosporum moluccanum* and *Syzygium* sp. and from Plot 3.

To complement established species in Group 1.1, Group 2.1 and Group 3.1, species that will thrive and build as well as constitute the main components of the forests in the future were those listed in Group 1.2, Group 1.3, Group 2.2, Group 2.3, Group 3.2 and Group 3.3. The leading species were those with high density, including *Acronychia trifoliolata, Cryptocarya ferrea, Cinnamomum burmanni, Micromelum minutum, Garcinia celebica, Voacanga foetida* in Plot 1; *Ardisia lanceolata, Calophyllum soulattri, Garcinia celebica, Petunga microcarpa, Syzygium manii* and *Syzygium* sp. 1 in Plot 2; and *Dysoxylum alliaceum, Drypetes longifolia, Garcinia celebica* and *Syzygium* sp. 1 in Plot 3. Species that were present only in sapling stage (diameter of 5–10 cm) will follow.

DISCUSSION

The forest on the slope of Mt. Batulanteh, as sampled by the three plots in the present study could be identified as the evergreen montane forest within the regime of the seasonal forest area as indicated by the Schmidt & Ferguson (1951) rainfall type C and the climate diagram (Fig. 1) of the nearest rainfall station at Batu Dulang (1,162 m alt). June to September is the dry season where the mean monthly rainfall < 100 mm with the lowest at 49 mm in August. It is comparable to the *Pithecellobium-Oletum* as-sociation within the evergreen moist lower mon-tane forest region of Meijer Drees (1951) in East-ern Sumbawa.

The result of the study regarding the species composition did not in any way present the representative account of he lower montane forest in Mt. Batulanteh, but it gave a more objective description of the forest complementing and confirming the qualitative accounts made by Kostermans & Kartawinata (1961), Kostermans (1963) and Wiriadinata *et al.* (2013). It also made possible to compare species richness of lower montane forest at Mt. Batulanteh quantitatively with others conducted elsewhere as presented in Fig. 6. Species richness of less than 100 in a hectare could be considered a norm in the montane forest and a sample area of one hectare, based on single plot or multiple plots, was approaching a minium area, as shown also in species-area cuves by Kartawinata (2005). Fig. 6 shows the comparison of the number of tree species in the present plots with those in the wet lower montane forests at Mt. Halimun and Mt. Gede-Pangrango in West Java and lowland forests in Kalimantan and Sumatra (Sheil *et al*., 2010; Simbolon & Mirmanto, 1997). Kostermans (1963) and Kostermans & Kartawinata (1961) gave accounts of vegetation around Mt. Batulanteh, based on their qualitative observations during the 1961 botanical exploration. They reported that, the dry deciduos forest at the 800-1,500 m asl was always assumed to be present in the past, with *Protium javanicum, Schoutenia obovata* and *Schleichera trijuga* as prevalent tree species. By 1961 it was completely destroyed by shifting cultivation. In the disturbed deciduous forest below 1.000 m asl, the common species belong to genera *Schoutenia, Garuga, Grewia, Capparis, Doryxlon, Sumbaviopsis, Erioglossum, Drypetes, Dillenia, Phyllanthus, Lagerstroemia, Clerodendron* and *Alstonia.* It was further indicated that other natural dry vegetation existed by that time was very poor secondary forests dominated by *Lantana camara* with scattered *Alstonia scholaris, A. splendens* and *Tamarindus indicus* as the tree species that remained. In the montane zone it was noted that *Dipterocarpus retusus* was unique and dominant within a small restricted area with *Serianthes minahassae* as an emergent tree. Outside the restricted community of *D. retusus*, an endemic *Heritiera gigantea* dominated the forest. The dry evergreen motane forest, characterized by *Heritiera gigantea* and *Abarema harmsii*, was observed between the dry decidous forests below 1,000 m asl and humid evergreen forest above 1,200 m asl. The true montane forest occurred at 1,000-1,500 m asl, where the common trees were the species of Meliaceae of genera of *Dysoxylum, Chisocheton, Amoora* and *Aglaia.* In the lower section other common trees included *Cinnamomum burmanni, Pterospermum diversifolium, Heritiera gigantea,*

Table 3. Regeneration expressed in terms of density (trees/ha) of species along to diameter class distribution in Plot 1, Plot 2 and Plot 3 in a lower montane forest at Batulanteh, Sumbawa.

		DIAMETER CLASS (CM)									
PLOT	SPECIES	5-10	10-20	20-30	30-40	40-50	50-60	60-70	70-80	80-90	90-100
Plot 1	Group 1.1.										
	Syzygium sp. 1	39	17	11					6		
	Grewia eriocarpa Juss.	17	22		6	6		11			
	Group 1.2.										
	Cinnamomum burmanii (Nees & T. Nees) Blume	30	48	12	18	6					
	Mallotus philippensis (Lam.) Mull. Arg.	6	6	6	28	17					
	Syzygium racemosum (Blume) D.C.	22	6	11	6	6					
	Cryptocarya ferrea Blume	90	28	6	6						
	Acronychia trifoliolata Zoll. & Moritz	50	50	6	6						
	Group 1.3.										
	Micromelum minutum Wight & Arn.	213	34								
	Garcinia celebica L.	62	28								
	Voacanga foetida (Blume) Rolfe	50	56								
	Dysoxylum caulostachyum Miq.	39	22								
	Aglaia odoratissima Blume	6	6								
	Erythrina subumbrans (Hassk.) Merr.	6	6								
	Premna nauseosa Blanco	6	28								
	Group 1.4.										
	Zanthoxylum ovalifolium Tucher	90									
	Aglaia lawii (Wight.) C. J. Saldanha	22									
	Other species	72									
	Other scattered species: 18										
Plot 2	Group 2.1.										
	Dipterocarpus retusus Blume	50	67	45	50	22	6	28			6
	Drypetes longifolia (Blume) Pax & K. Hoffm	50	22	6	6						
	Syzygium polyanthum (Wight) Walp.	39	28	17	6						
	Syzygium racemosum (Blume) D.C.	22	6	22		6					
	Group 2.2.										
	Syzygium sp. *1*	106	34	13							
	Calophyllum soulattri Burm. f.	73	62	17							
	Garcinia celebica L.	70	62	11							
	Croton cascarilloides Raeusch.	40	6	6							
	Chionanthus ramiflorus Roxb.	11	11	6							
	Group 2.3.										
	Syzygium manii (King) N. P. Balakr.	56	11								
	Petunga microcarpa (Blume) D.C.	45	6								
	Ardisia lanceolata Roxb.	39	22								
	Myristica fatua Houtt.	11	17								
	Acronychia trifoliolata Zoll. & Moritz	6	6								
	Group 2.4										
	Saurauia nudiflora D.C.	39									
	Cryptocarya ferrea Blume	17									
	Other species (6 trees/ha)	77									
	Other scattered species: 18										
Plot 3	Group 3.1.										
	Syzygium polyanthum (Wight) Walp.	11	11	6		6		6			
	Syzygium racemosum (Blume) D.C.	6	22	6				6			
	Calophyllum soulattri Burm. f	6	6	6	17						
	Elaeocarpus floribundus Blume	6	6			11		6			
	Prunus arborea (Blume) Kalkman	6	17	11		6					
	Group 3.2										
	Garcinia celebica L.	34	73	67							
	Cryptocarya ferrea Blume	17	28	28							
	Aglaia odoratissima Blume	11	11	6							
	Garcinia balica Miq.	6	6	6							
	Syzygium sp. *1*	62	101	28							

Table 4. Regeneration expressed in terms of density (trees/ha) of species along to diameter class distribution in Plot 1, Plot 2 and Plot 3 in a lower montane forest at Batulanteh, Sumbawa. (continued)

PLOT	SPECIES	DIAMETER CLASS (CM) 5-10	10-20	20-30	30-40	40-50	50-60	60-70	70-80	80-90	90-100
	Group 3.3										
	Voacanga foetida (Blume) Rolfe	6	11								
	Dysoxylum alliaceum (Blume) Blume	50	39								
	Drypetes longifolia (Blume) Pax & K.Hoffm	22	17								
	Croton cascarilloides Raeusch.	11	6								
	Palaquium obtusifolium Burk.	11	17								
	Premna nauseosa Blanco	17	28								
	Myristica fatua Houtt.	11	6								
	Group 3.4.										
	Acronychia trifoliolata Zoll & Moritz	17									
	Chisocheton cf. Sandoricocarpus Koord. & Valeton	11									
	Other species (6 trees/ha)	58									
	Other scattered species : 11										

Lansium kostermansii, Fagara ovalifolia and *Calophyllum soulattri*. Other vegetation types noted included the dwarf elfin forest of the summit.

It should be noted that the most unique nature of the montane forest at Mt. Batulanteh was that the species of Fagaceae which characterized montane forests in Malesia (Soepadmo, 1972; Steenis *et al.,* 1972; Whitmore, 1984) was absent here as also reported by earlier study (Kostermans, 1963). Our finding on *Dipterocarpus retusus* confirmed observations by Kostermans (1963) who reported that *Dipterocarpus retusus* with height of up to 40 m was strongly dominant in a forest covering a very limited area of about three km^2. It was reported that *Serianthes minahasae* was the emergent tree, which was not recorded in the present study. The absence of the species could have been due to disturbance through illegal poaching and extraction. Many species were reported to be unique, including *Abarema harmsii, Abarema sumbawaensis, Acer laurinum, Albisia chinensis, Duabanga moluccana, Heritiera gigantean, Michelia montana, Pterospermum diversifolium*, *Talauma sumbawaensis,* and *Septogarcinia sumbawaensis* were not recorded in the present study area. It was due to the fact that our samples were not large enough as to be able to record more species. Wiriadinata *et al*. (2013) misidentified *Dipterocarpus* in the Batu Dulang area on the slope of Mt. Batulanteh as *Dipterocarpus hasseltii,* but Ashton (1984) stressed that *D. hasseltii* occurred only as far as Bali.

In Mt. Batulanteh area there were many species of Myrtaceae that have not been identified to species level, including *Syzygium* spp. which were distributed widely. There were many *Syzygium* specimens collected from Batulanteh, including *Syzygium* sp. 1 collected by Kostermans in 1961 and Indir Alam in 1928, stored in the Herbarium Bogoriense and to date they remain unidentified, which could represent undescribed species. This is true for other families including Leguminosae, Lauraceae, Euphorbiaceae, Annonaceae, *etc*., as indicated also by Kostermans (1963) and Wiriadinata *et al.* (2013). Further collecting efforts are necessary and chances to discover new species were great.

It was also reported that *Altingia excelsa*, *Blumeodendron elateriospermum*, *Ardisia zollingeri* and *Castanopsis acuminatissima* were the dominant species in the forest of the Halimun -Salak National Park (Mansur *et al*., 2011).

Regeneration in tropical forests is a complex process depending on many factors including the incidental occurrences of natural gaps (Richards, 1996; Whitmore, 1984). Complete profile of size class distribution from seedlings to the largest diameter trees could be an indicative of regeneration. Several species that were present in almost all diameter classes represented species approaching or already a mature state in the forest. They included *Dipterocarpus retusus, Drypetes longifolia* and *Syzygium polyanthum* which filled almost all diameter classes below 100 cm down to the lowest diameters with high number of individuals. They have been regenerating well. Overall the forests in the three plots were regenerating. It should be noted in Table 4 that, complementing established species in Group 1.1, Group 2.1 and Group 3.1, species that will thrive, build and constitute the main components of the forests in the future are those listed in Group 1.2, Group 1.3, Group 2.2, Group 2.3 Group 3.2 and Group 3.3.

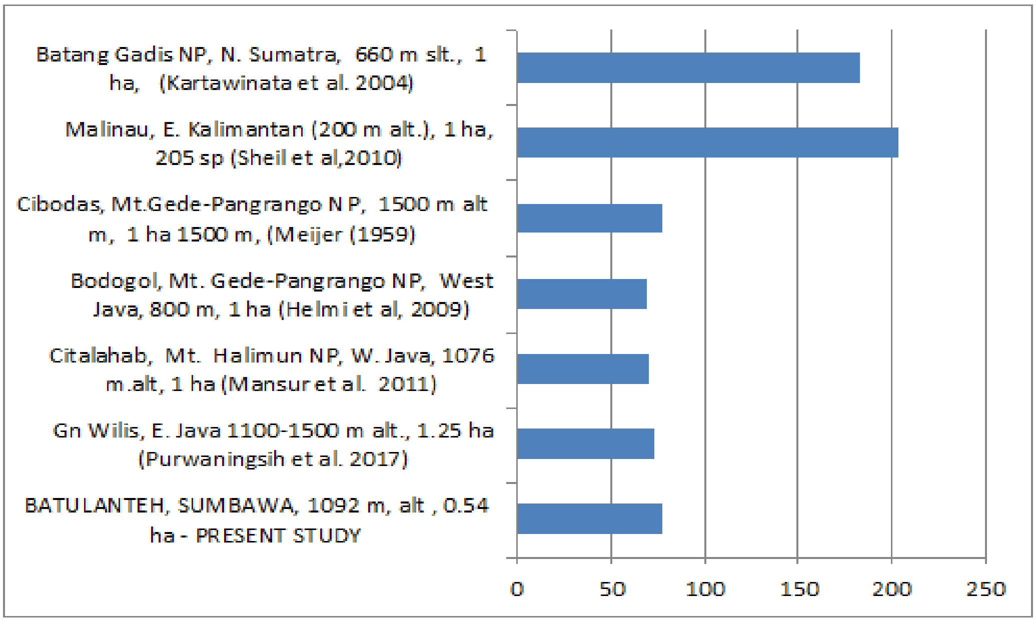

Fig. 6. Number of tree species in the present study site compared to those in montane forests in West Java and low-land forests in Kalimantan and Sumatra.

Forests in the Mt. Batulanteh area have been greatly disturbed by various human activities, often leading to degraded forests and lands. They are now regenerating and succession is slowly taking place heading to the forest similar to the original ones, including forests dominated by *Dipterocarpus retusus*. In view of the fact that succession is very slow and extremely inportant multi-function of the forest, such degraded forests and lands need to be restored to similar condition of original forest. The slow natural succession could be accelerated and assisted by applying ecological restoration method through planting primary forest species, rare species, endemic species, multipurpose species and species with high conservation values. It should be complemented with preventive actions to combat fire and tree poaching. For such purpose we could use important species in the Mt. Batulanteh forest including the unique *Dipterocarpus retusus* and species that are disappearing. Thus in this regard we are applying restoration and conservation at the same time. The ecological restoration would help to augment species diversity and improve forest hydrology. It would also support multiplying and expanding total forest area to satisfy the requirements of the Forestry Law (*UU no. 41 Tahun 1999 tentang Kehutanan Pasal 18 Ayat 2*) and Spatial Arrangement Law (*UU 26/2007 tentang Tata Ruang*) to preserve 30% of the total land area of a region as forests in order to maintain various ecosystem functions (Purwaningsih *et al.,* 2017).

CONCLUSION

The result of this study provides a description of the forest locally, although does not constitute a representative of the montane forests at Mt. Batulanteh. They are developing and regenerating disturbed forests with heterogeneity of species composition representing primary and secondary forest species. The species richness was, however, smaller than those in several lowland forests elsewhere. The biomass and the carbon stock were higher than those in Mt. Halimun. Floristically, the forest has been designated association with two subassociations. The subassociations have been predicted to change very slowly as there generation was also slow. Therefore, the successions leading to terminal communities similar to the original would be a very slow process. Species that will survive and maintain themselves in the forest in the future are currently represented in almost all diameter classes, although with low density.

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