THE GROWTH DYNAMICS ON TREE SPECIES OF FAGACEAE FAMILY IN A TROPICAL MONTANE RAIN FOREST OF WEST JAVA, INDONESIA

Herwint Simbolon

Botany Division, Research Center for Biology-LIPI, Bogor

ABSTRACT

A one ha (100 x 100 m^2) permanent plot each was established at sub-mountain (1000 m altitude) and mountain forests (1800 m altitude) in Gunung Halimun National Park, West Java in 1996. Both plots were monitored periodically in order to understand the population dynamics of tree species, an important aspect on understanding forest ecology. Number of individuals and total basal areas of Fagaceae species represented about 10 and 20.5% of total species in sub-mountain and 38 and 56.1% of total species in mountain forest. The distribution pattern of tree height (H, in m) of the similar diameter (D in cm) was consistently lower in mountain forest than of sub-mountain forest. The highest mortality index in sub-mountain and mountain forests was occurred on *Lithocarpus* sp. (ruui) and *Castanopsis acuminatissima,* respectively. As a whole, in both study sites, number of mortal individuals of all Fagaceae species during 1996-200 was higher than of recruit individuals. The growth and population dynamics of the Fagaceae species in both sites within 1996-2000 study periods were also discussed.

Key **words:** Fagaceae species, distribution, height-diameter ratio, growth rate, altitudes, sub-mountain and mountain forest.

INTRODUCTION

The forests within Gunung Halimun National Park, West Java have been divided into three different altitudinal zones, those were colline zone at the altitude lower than 900 m, sub-mountain forest zone at 900 - 1,400 m, and mountain zone at 1,400 - 1,800 m (Simbolon and Mirmanto, 1997). In 1996, a 1-ha permanent plot was established at sub-mountain and mountain forests of Gunung Halimun National Park, West Java for sites of the forest dynamic study, an important aspect on understanding forest ecology (Suzuki *et ai,* 1997). In those plots, the number of species, tree density and total basal areas within each 1-ha permanent plot were 116 species, 983 individuals, 37.07 m^2/ha (in sub-mountain forest) and 44 species, 997 individuals, 42.94 m^2/ha (in mountain forest), respectively. Suzuki *et ai,* (1997) further reported that the dominant species in sub-mountain forest was *Altingia excelsa* (Hamamelidaceae) followed by *Schima wallichii* (Theaceae) and *Castanopsis tungurrut* (Fagaceae), and in mountain forest was *Quercus lineata* (Fagaceae), followed by *Schima wallichii* (Theaceae) and *Syzygium* sp. (Myrtaceae). For Fagaceae family itself, number of tree species, density and total basal areas within 1-ha the plot were 6 species, 92 individuals, 7.1 m^2/ha in sub-mountain forest and 6 species, 367 individuals, 24.0 m^2/ha in mountain forest.

In the present paper, data on Fagaceae species from 1996 to 2000 have been extracted from both of 1-ha permanent plots for further analysis. The patterns of local distribution and the allometric relationship between stem diameter and tree height of Fagaceae species grown in sub-mountain and mountain forests of GHNP are examined in greater detail. The paper also deals with the mortality, recruitment and growth of the tree species in both altitudinal zones.

METHODS

Study area

The study was conducted at sub-mountain forest at Cikaniki (6° 44' 57" S and 106° 32' 08" E) and mountain forest at Gunung Botol (6° 41' 24" S and 106° 28' 47" E) both areas are located within Gunung Halimun National Park, West Java. Topography of the areas mainly are hilly ranging from 900-1200 m altitude at Cikaniki and 1500 to 1800 m altitude at Gunung Botol areas (Suzuki *et al.,* 1977, Simbolon and Mirmanto, 1977). The geology of the area is mainly of quaternary volcanic formation. The soil in the study area belongs to latosol type that can be divided furthermore into brown latosol, red latosol, yellowish-red latosol and the associations among them (Djuansah, 1997).

The climate belongs to a type A (Schmidt Ferguson, 1951) with the annual rainfall is between 4000 - 6000 mm. The daily temperature varies between 18° and 26° C with relatively high humidity.

Suzuki *et al*, (1997) established a 1-ha permanent plot (100 m by 100 m) on sub-mountain forest (1000m altitude) at Cikaniki and on mountain forest at Gunung Botol (1800 m altitude) within Gunung Halimun National Park, West Java. The 1-ha plot was divided into 100 sub-plots of 10 x 10 m^2. All trees with stem girth at breast height *igbh)* or at 130 cm above the ground more than 15 cm were individually numbered with aluminum tag, mapped the position in the plot, identified to species, and measured *gbh*, and tree height. Based on these measurements, total basal areas, number of species, number of individuals and demography of each species in each sub-plot were determined. Initial census was completed in August 1996 and re-censuses again in 1997, 1998 and 2000, hence the length between the first and the last census was about 3.58 years.

Data on trees of Fagaceae were extracted from the collected data during 1996-2000 study periods and have been analyzed in order to understand its local pattern of distribution, mortality rate and growth rate.

The local distribution pattern of individual Fagaceae species within the plot at each category was examined by the Morisita's index of dispersion, /^(Morisita, 1959):

$$I_\delta = q\Sigma\{n_i(n_i\text{-}1)\}/\{N/(N\text{-}1)\}$$

where parameters *q*, *N* and n, are total number of quadrants, total number of individual trees and number of individuals at rth quadrat, respectively. When index is 1, individuals are randomly distributed, and aggregately distributed when the value is larger than 1.

Mortality rate *(m)* was examined by formula of Sheila *al.* (1995):

$$m = \{\backslash\text{-}\{\backslash\text{-}(N_o\text{-}N_l)INo\}^{(m)})$$

where: N_o and *Ni* are number of individuals at the beginning and end of the measurement interval time, *t* (year), respectively.

The growth rate of species was analyzed based on the diameter change in the periods of 1996-2000 for trees. Mean relative growth rate *(rGR)* was calculated based on the following equation:

$$rGR = (lnH_2\text{-}lnH,)l\{t_2\text{-}t,)$$

where: H_2 and *Hi* are height (m) or diameter at breast height (cm) of trees at time *ti* and t_2 (year), respectively.

RESULTS

Tree species of Fagaceae

Based on the latest data in 2000, number of individuals and total basal areas of Fagaceae species represented about 10 and 20.5% of total species in sub-mountain and 38 and 56.1% of total species in mountain forest. Among Fagaceae, the most dominant species was *Castanopsis tungurrut* in sub-mountain (or the third most dominant of all species) and *Quercus lineata* in mountain forests (also the first most dominant of all species, Table 1). *Quercus oidocarpa* was found in sub-mountain but not in mountain plot, contrarily *Lithocarpus elegans* was found in mountain but not in sub-mountain plots although both species were minor in both forest types.

Table 1. Number of individuals, basal area (relative to total of plot) and distribution indices of each species of Fagaceae within the plots of sub-mountain (SM) and mountain (M) forests.

Species	Individuals		BA (%)		Morishita Indices	
	SM	M	SM	M	SM	M
Total Fagaceae species	97	379	20.53	56.14	1.6538	1.188
1. *Castanopsis acuminatissima*	1	**119**	0.56	3.68	0	3.3329
2. Castanopsis javanica	23	30	4.26	3.05	3.162	2.759
3. *Castanopsis tungurrut* cf.	35	32	8.06	3.26	0.672	0.806
4. *Lithocarpus* sp. (ruui)	13	2	1.66	0.16	3.846	0
5. *Lithocarpus elegans* (susu)		6		0.41		6.667
6. *Quercus lineata*	16	**190**	5.94	44.97	1.667	1.064
1. Quercus oidocarpa	9		0.05		58.33	
All species	983	997	100.00	100.00		
BA of all species (m^2/ha)	37.1	42.94				

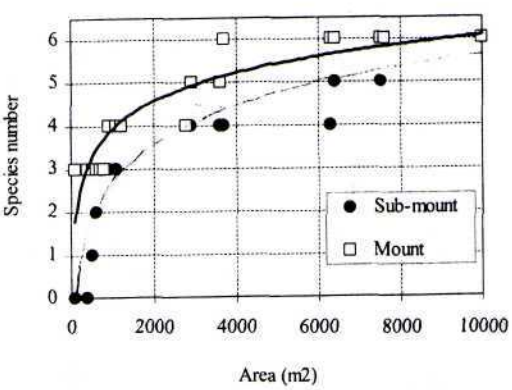

Fig 1. Species area relationship

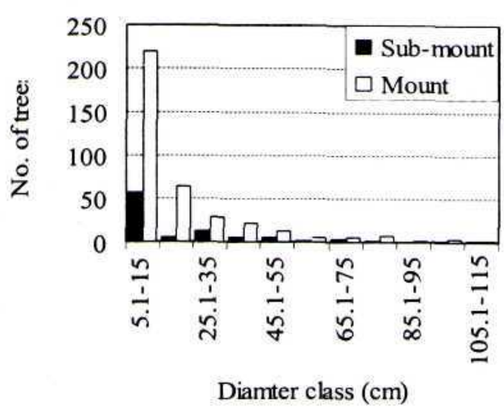

Fig 2. Diameter class distribution of Fagaceae

Total number tree species of Fagaceae in both forest types is similar but total number of tree species in sub-mountain forest (116 species) is bigger than in mountain forest (44 species). However, the increment rate of Fagaceae species in mountain forest is relatively higher than of in sub-mountain forests (Fig 1). The diameter class distribution of Fagaceae species in both forest types are presented in Fig 2.

Diameter-height relationship

The biggest tree in the sub-mountain study plot was *Castanopsis tungurrut* (112 cm in *D;* 53.9 m in *H)* and in the mountain plot was another Fagaceae species, *Quercus lineata* (111.7 cm in *D;* 33.6 m in *H).* Although the biggest tree in each sub-mountain and mountain forests was relatively similar in diameter and both were species of Fagaceae, the tree height was much different. The distribution pattern of tree height (H, in m) of the similar diameter (D in cm) was consistently lower in mountain forest than of sub-mountain forest as figured in Figs 3-4 and both curves were expressed in equations:

$H_{sub\text{-}mountain}$ = 10.982 In (D) - 11.872 r^2 = 0.8341

$H_{mountain}$ = 7.9566 In (D) - 7.1775 r^2 = 0.8904

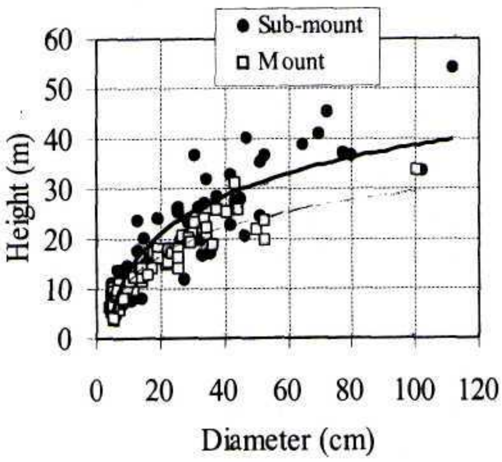

Fig 3. Diameter-height relationship

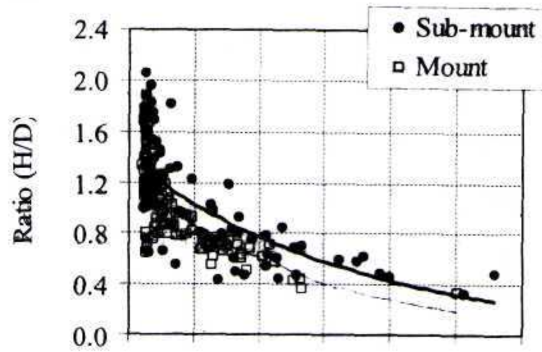

Fig 4. Diameter and ratio diameter-height relationship

Table 2. Average annual increment of diameter (dD/year) and relative growth rate (rGR) of Fagaceae species.

Species	Sub-mountain				Mountain			
	Mean dD/year	Sd	Mean rGR	Sd	Mean dD/year	Sd	Mean rGR	Sd
Castanopsis acuminatissima	0.138	0.103	0.009	0.013	0.171	0.196	0.017	0.020
Castanopsis javanica	0.403	0.493	0.020	0.024	0.343	0.513	0.019	0.019
Castanopsis tungurrut cf.	0.356	0.323	0.037	0.096	0.231	0.219	0.020	0.021
Lithocarpus sp. (ruui)	0.156	0.245	0.015	0.013	0.182	0.195	0.008	0.007
Lithocarpus elegans (susu)					0.418	0.488	0.029	0.040
Quercus lineata	0.315	0.266	0.015	0.012	0.230	0.248	0.010	0.009
Quercus oidocarpa	0.076	0.057	0.007	0.003				

Growth rate

The *rGR* of trunk diameter tended to decrease in a hyperbolic manner by increasing the tree diameter class. The relative growth rate of Fagaceae in sub-mountain forest was slightly higher than of in mountain forest (Figs 5-6). The range of annual increment of tree diameter in sub-mountain and mountain forests was varies, from 0.076 to 0.41 and 0.17 to 0.42 cm/year, respectively and its standard deviation were also relatively high and for some species even higher than their mean annual increment (Table 2). But there was a tendency that **the** average annual increment of middle size class trees (diameter of 40 to 60 cm) was higher than lower and higher size classes.

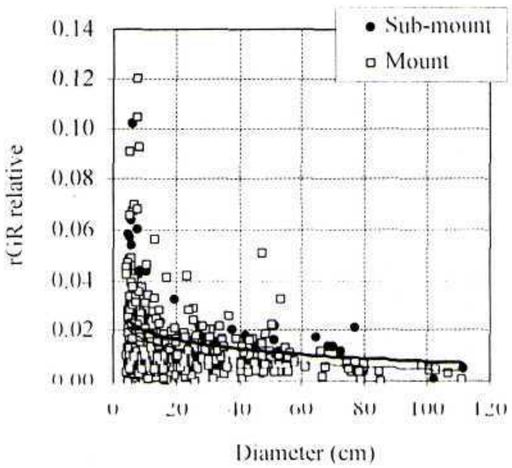

Fig 5. Diameter and relative growth rate relationship

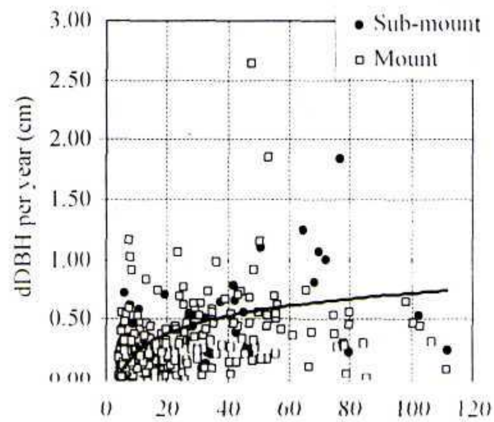

Fig 6. Diameter and annual diameter increment relationship

Table 3. Number of mortal (mort), recruit (rccr) and total individual trees (\) in each 1-ha plot at sub-mountain (SM) and mountain (M) forests from 1996 to 2000.

Species	Indices	Mountain				Sub-mountain				Indices	
Castanopsis acuminatissima	N	118	115	114	107	8	8	8	8	0.027	0
	Mort		4	1	8		0	0	0	0.0321	0
	Recr		1		1		0	0	0	-0.0047	0
Castanopsis javanica	N	30	30	29	27	21	21	20	20	0.029	0.0135
	Mort			1	2		0	2	0	0.029	0.0135
	Recr						0	1	0	0	-0.0131
Castanopsis tungurrut cf.	N	32	32	32	33	34	34	34	34	-0.0086	0
	Mort						1		1	0	0.0168
	Recr				1		1		1	-0.0086	-0.0168
Lithocarpus sp. (ruui)	N	2	2	2	2	13	14	13	13	0	0
	Mort							1		0	0.0221
	Recr						1			0	-0.0209
Lithocarpus elegans (susu)	N	6	6	6	6					0	
	Mort									0	
	Recr									0	
Quercus lineata	N	189	186	186	182	17	17	17	16	0.0105	0.0168
	mort		3	1	4				1	0.012	0.0168
	recr			1						-0.0015	0
Quercus oidocarpa	N					2	2	2	2		0
	mort										0
	recr										0
Fagaceae	N	377	371	369	357	95	96	94	93	0.0151	0.0059
	mort		7	3	14		1	3	2	0.0182	0.0181
	recr		1	1	2		2	1	1	-0.003	-0.0116

Mortality and recruitment

A few of 1996's individuals of Fagaceae in sub-mountain and mountain forests were mortal during the study periods; the percentages were 6.32 and 6.37% of initial number, respectively. However, the percentage of recruit individual in sub-mountain was higher than of in mountain forests, hence the mortality index of Fagaceae was little higher in mountain (0.0151) than in sub-mountain (0.0059). The highest mortality index was occurred on *Castanopsis javanica* and *C. acuminatissima* both were in mountain forest. As a whole, number of mortal individuals of all Fagaceae species during 1996-200 was higher than of recruit individuals, but some were inversely, while some other species have no mortal and recruit species (Table 3).

Although number of individuals in 2000 was lower than in 1996, total basal areas were higher (Table 4), indicates that mortal trees were mainly in lower diameter classes. BA increment in sub-mountain and mountain forests during the 3.58 years of study period was about 2.01 and 0.61% of initial BA, respectively.

DISCUSSION

Number of species in a 1-ha plot of sub-mountain (116 species) and mountain (44 species) forests was greatly different indicates that increasing the altitude from about 1000 m into 1800 m decreasing about 62% of tree species diversity. The number of tree species in sub-mountain was also greatly lower than of in a lowland forest in West Kalimantan with 329 tree species per ha (Simbolon *et al.*, 2000, Kohyama *et al.*, 2001) but about equal with peat swamp forest (70 species in Lahei to 141 species in Tanjung Puting) and heath forests (150 species in Lahei) in the lowland of Central Kalimantan (Suzuki *et al.*, 2000; Mirmanto *et al.*, 1998). The lower number of tree species in heath and peat swamp forests compare to other mixed forest in lowland areas has been explained due to extremely stress of environmental conditions, such as extremely low available nutrients, high acidity, un-aerobes condition etc. The increasing the altitudes was also increasing the stress of environmental conditions such as temperature, humidity, wind, availability of nutrients that might responsible for the limited number of adaptable species.

In contrast with number of all tree species, the number of Fagaceae species in sub-mountain was similar with them of in mountain forest, indicates that altitude changes within 1000 m to 1800 m may have no effect on the species diversity of Fagaceae. The absent of *Lithocarpus elegans* in sub-mountain and *Quercus oidocarpa* in mountain forest was mainly due the plot size sampling since both species were distributed near by but not inside the examined plots and both species were minor in sub- and mountain forest as indicated by number of individuals. However, among the Fagaceae species there were changes in the specific adaptability in relation to altitude as expressed in the changes of importance values. The most dominant Fagaceae species was changes from *C. tungurrut* at the sub-mountain forest and *Q. lineate* in mountain forest.

Table 4. Basal area (BA) increment (m^2/ha) during the study periods (1996-2000).

Species	Sub-mountain			mountain		
	BA'96	BA'OO	%	BA'96	BA'OO	%
Castanopsis acuminatissima	0.21	0.20	-2.00	1.58	1.64	3.63
Castanopsis javanica	1.58	1.75	9.63	1.78	1.81	1.33
Castanopsis tungurrut cf.	2.99	2.81	-6.52	1.25	1.35	7.40
Lithocarpus sp. (ruui)	0.62	0.67	7.60	0.07	0.07	6.57
Lithocarpus elegans (susu)				0.11	0.13	18.57
Quercus lineata	2.20	2.33	5.43	19.31	19.25	-0.34
Quercus oidocarpa	0.02	0.02	5.03			
Total Fagaceae	7.62	7.77	2.05	24.11	24.26	0.61

Great increment in the number of individuals of *C. acuminatissima* and *Q. lineate* in mountain compare to them of in sub-mountain forests may also indicate the habitat preference of both species. Other species without great change in the number of individuals explain that both altitudes were within the ranges of distribution of those species (Table 3). The Table also indicated that mortality index of individuals in mountain site was higher than in sub-mountain site.

Some Fagaceae species, mainly *Q. lineate* and *C. acuminatissima* were much more adaptable to higher altitudes were also indicated by great changes of Basal Areas (BA). Total BA of trees in mountain forest was greatly higher than of sub-mountain forests, and again the percentage BA of Fagaceae species in mountain forest was higher (56% of total) than of in sub-mountain forests (20% of total) (Table 1). Although there was a slight change on the importance values and BA between two forest types, no wonder both altitudes were still within the ranges of distribution of these Fagaceae species.

As have been commonly known, the trees with the same diameter of a species in higher altitude were consistently lower in tree height than in the lower altitudes. This phenomenon was also performed by Fagaceae species as showed in Figs 3 and 4. Although some species were much adaptable to the mountain forest habitat as indicated in the total BA and rGR, the mean tree height of the same diameter was consistently lower in mountain than of in mountain forest. Lower height of trees in the higher altitudes was commonly explained due to the wind speed and due to the stress of some other environmental conditions in the higher altitudes.

Suzuki *et al.* (1999) have reported that trees in sub-mountain need 200 years to grow from 5 cm to 100 cm DBH, while in mountain forest need 256 years. These findings are performed in Figs 5 & 6 where rGR of Fagaceae trees in sub-mountain forest were higher than of in mountain forest. However, when each species of Fagaceae was analysis in more detail it shows that mean rGR of *C. acuminatissima* in the mountain was slightly higher than of in sub-mountain; the mean rGR of *C. javanica* in sub- and mountain forests were nearly similar while mean rGR of other species in sub- was only slightly higher than of in mountain forests (Table 2). The results also imply that trunk diameter growth of Fagaceae species in sub- and mountain forests were relatively similar and both altitudes were within the ranges of distribution of those species.

The higher mortality index of individuals Fagaceae in mountain than in sub-mountain forest may much more related to the demography rather than to altitudinal habitat adaptation. As has been noted in the results of study, the percentage of mortal individuals in both altitudes within study periods were similar but the percentage of recruitment individuals in sub-mountain was higher than in mountain forests. As the results, the mortality index of the family in the sub-mountain forest was smaller. This also supported by the fact that the density of trees in both altitudes was equal while the total basal areas of mountain were higher than in sub-mountain forests. Therefore, the higher total basal area of the same density might slow down trunk diameter increment of tree in the area, as figured in number of recruitment trees from smaller diameter into larger diameter in the mountain forest.

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