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Establishing a long-term permanent plot in remnant forest of Cibodas Botanic Garden, West Java

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ABSTRACT

Mutaqien Z, Zuhri M (2011) Establishing a long-term permanent plot in remnant forest of Cibodas Botanic Garden, West Java. Biodiversitas 12: 218-224. Cibodas Botanic Garden (CBG) has unique characters; almost 10% of which is forested area adjacent to the natural forest of Mt. Gede Pangrango National Park. The area is a transition between natural forest and artificial habitat which mostly consists of exotic plant species. The permanent plot in CBG was established in 2007-2009. Two hundred and eighty four units of 10x10 square meters sub-plot were established in four locations, i.e. Wornojiwo, Kompos, Jalan Akar, and Lumut forest. Vegetation analyses were conducted for trees, saplings, shrubs, and herb species. The inventory found 137 species plants consisting of 74 tree species dominated by *Villebrunea rubescens* (Bl.) Bl. and *Ostodes paniculata* Bl., 30 shrub species dominated by *Strobilanthes hamiltoniana* (Steud.), 24 herb species dominated by *Cyrtandra picta* Bl., 6 fern species mainly consisted of *Diplazium pallidum* Moore, and 3 climber species dominated by *Calamus reinwardtii* Mart. In comparison with the natural forest of Mt. Gede Pangrango National Park, the CBG permanent plot showed a good representative of the vegetation of lower montane forest. A regular monitoring during the successive years is needed to maintain diversity, monitor forest dynamics and anticipate the spread of invasive plant from CBG.

Key words: Cibodas Botanic Garden, permanent plots, remnant forest.

INTRODUCTION

Cibodas Botanic Garden (CBG) was used as an experimental plot for the introduction of *Cinchona* to Indonesia. When it was stated as a biological station and forest reserve, the area was extended up to 1,200 ha covering from Cibodas to the summit of Mount Gede and Pangrango (Dakkus 1945; van Leeuwen 1945; Soerohaldoko et al. 2006). It was a well-known area for classical spot of botanical investigation. More than 8,000 studies were conducted in this area. Some of them were conducted by famous botanist such as; Reinwardt, Blume, Junghuhn, Treub, Zollinger, Teysmann, Koorders, Backer, Bakhuizen van den Brink Jr., von Faber, van Leeuwen and van Steenis (Meijer 1959; van Steenis 1972; Arrijani 2008).

CBG is managed by the Indonesian Institute of Sciences (LIPI) at present. It conserves about 6,764 individual plants from 1,270 species and 204 families. Ten percent of CBG is a forested area. It consists of fragmented forest and border forest adjacent to the natural forest of Mount Gede Pangrango National Park. The forested area is important to maintain genetic diversity which uncovered by the small number of plant collection of botanic garden (Hurka et al. 2004). Remnant forest of CBG also played important role as buffer zone between the garden and Mount Gede-Pangrango National Park to restrict the alien species plant possibly escape from CBG collection. Some researchers have been addressed non-native species colonization at the interface between protected areas and human-dominated systems (Pysek et al. 2003; Alston and Richardson 2006). The establishment of buffer zones around protected areas is often included on management strategy of plant invasions (Llewellyn et al. 2010).

The remnant forest of CBG has a potential to be developed as a field laboratory and environmental education. The composition and the dynamic of the forest are interesting to be studied. The 2.84 hectare plot was build in 2007 to 2009. It was set to monitor plant diversity and to collect long-term data on the growth, mortality, regeneration, and dynamics of forest. Ten years observation is needed to state it as a long term permanent plot (Bakker et al. 1996).

This paper aims to assess the eligibility of permanent plot in CBG which presented by the preliminary forest inventory data and it comparison with the natural forest vegetation. Hopefully our permanent plot will be a model for lower montane tropical forest vegetation dynamics.

MATERIALS AND METHODS

Cibodas Botanic Garden is located on the foothill of Mount Gede, Cipanas, Cianjur, West Java. CBG is situated at lower montane zone (1,300-1,425 m asl.). The annual rainfall is 2,950 mm/year, average temperature is 20^{o}C and relative humidity is 80%. Permanent plots were established on four of remnant forests sites inside CBG, i.e. Wornojiwo (PW), Kompos (PK), Jalan Akar (PJA), and Lumut Forest (PL). Wornojiwo and Kompos are fragmented forests

inside the CBG and two others are forest border of Mount Gede Pangrango National Park (Figure 1).

The plots are divided into 10x10 m^2 sub-plots. Total area and number of sub-plots on each site are presented on Table 1. Sub-plot numbers on each site were limited by large area and topographical aspect.

A rapid vegetation assessment was conducted in April-June 2010. Vegetation data was collected using purposive random sampling. Stands were classified into trees, saplings, shrubs, and herbs. Each tree were identified, marked, tagged, and measured (diameter at breast height (dbh), height, and canopy size). Saplings, shrubs, and herbs were identified and their abundance were measured.

Table 1. Total area and number of sub-plots

Site	Area (ha)	Number of sub-plots
Wornojiwo Forest (PW)	3.934	180
Kompos Forest (PK)	2.555	60
Jalan Akar Forest (PJA)	1.086	32
Lumut Forest (PL)	0.855	12
Total	8.43	284

The result of plot inventory data was compared to two plots (1 ha in each) of natural forest vegetation. One plot was located at the edge of the Mount Gede-Pangrango National Park (200 m from the garden) and another one was located at the interior of the national park forest (1 km from the garden). Parameter such as species richness, Shannon-Wienner diversity index (Odum 1971), species evenness (Heip 1974) and similarity index (Krebs 1999) was used to compare it.

RESULTS AND DISCUSSION

Vegetation of CBG's remnant forest

There are 137 plant species at the remnant forest, which consists of 74 tree species, 30 shrub species, 23 herb species, 6 fern species, and 4 climber species (Table 2). Only 36 tree species reach more than 10 cm in diameter, while 61 species were found as sapling (dbh<10 cm). Tree density was reached 306 tree/ha and tree biomass was achieved 699.24 ton/ha.

Table 2. Total species in the life form classes of CBG's remnant forest

Life form	Number of species
Tree	74
Shrub	30
Herb	23
Fern	6
Climber	4
Total	137

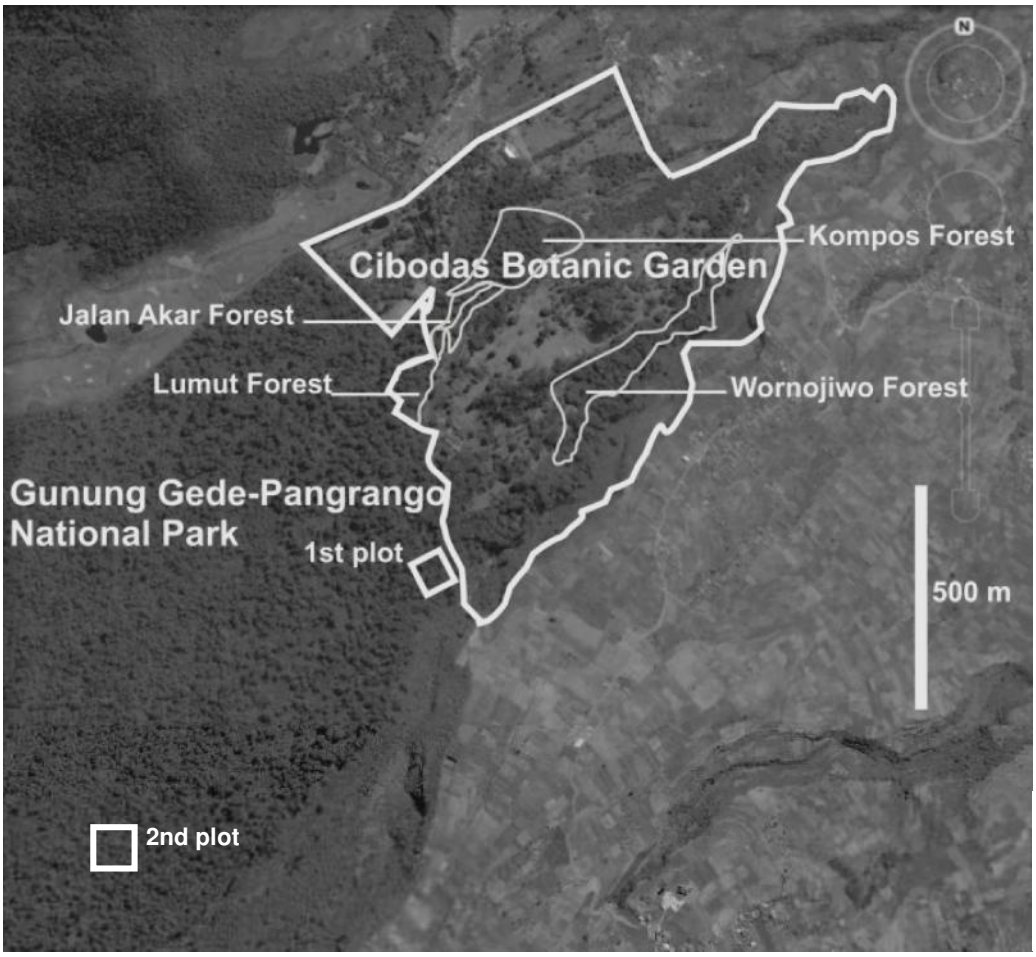

Figure 1. Location of permanent plot on Cibodas Botanical Garden

Table 3. Class diameter of trees of CBG's remnant forest

Tree species	Class diameter								Tree number
	10-20 cm	21-30 cm	31-40 cm	41-50 cm	51-60 cm	61-70 cm	71-80 cm	> 80 cm	
Villebrunea rubescens (Bl.) Bl.	33	3	1	1					38
Ostodes paniculata Bl.	7	11	3	3					24
Macropanax dispermum (Bl.) Kuntze	8	5	5						18
Castanopsis argentea (Bl.) A. DC.	1	1			1	2	1	7	13
Ficus ribes Reinw. Ex Bl.	8	1							9
Saurauia pendula Bl.	2	2							4
Decaspermum sp.	4								4
Cestrum aurantiacum Lindl.	3	1							4
Ficus fistulosa Reinw. Ex Bl.	2							1	3
Elaeocarpus oxypirens Koord. & Val.	2			1					3
Dysoxylum nutans Miq	1	1					1		3
Castanopsis javanica (Bl.) A.DC								3	3
Altingia excelsa Noronha				2				1	3
Saurauia reinwardtiana Bl.	1		1						2
Lithocarpus indutus (Bl.) Rehder						2			2
Ficus variegata Bl.		2							2
Ficus heterophylla Blanco	2								2
Viburnum sambucinum Reinw. ex Bl.	1								1
Turpinia sphaerocarpa Hassk.	1								1
Trema orientalis Bl.				1					1
Toona sureni Merr.		1							1
Schima wallichii Choisy						1			1
Saurauia cauliflora DC.		1							1
Rauvolfia javanica Koord. & Val.				1					1
Prunus arborea (Bl.) Kalkman	1								1
Persea rimosa Zoll. Ex Meissner								1	1
Neonauclea obtusa Bl.					1				1
Lithocarpus pallidus (Bl.) Rehder					1				1
Helicia serrata Bl.	1								1
Fagraea sp.	1								1
Ficus lepicarpa Bl.	1								1
Eurya sp.	1								1
Elaeocarpus sphaericus Schum.			1						1
Elaeocarpus angustifolius Bl.		1							1
Bridelia sp.					1				1
Acer laurinum Hassk.								1	1
	81	30	11	8	5	5	2	14	156

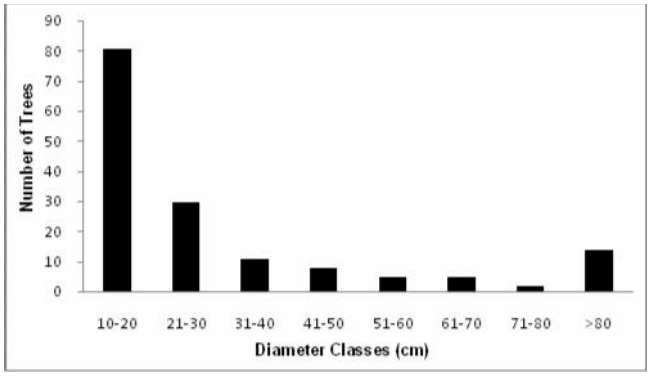

Figure 2. Distribution of tree class diameter of CBG's remnant forest

Villebrunea rubescens and *Ostodes paniculata* are the two most common trees, but they never reach more than 50 cm in diameter (Table 3). As the small diameter trees, their high abundance is related to colonization and turnover rate in the disturbed forest (Whitmore 1975). Furthermore, hurricane occurring in 1976 (Yamada 2010. *pers. comm.* 17 July) and 1984 in Cibodas (Whitten and Whitten 1996) might change the dynamics and increase the abundance of typical species of secondary forest (*V. rubescens*) and the pioneer species (i.e. *O. paniculata*). Disturbance in secondary forest would be advantageous for short-lived, light demanding, and fast growing species as well as for most pioneer species at gap sites in mature forests (Brokaw 1985). These growth traits affect largely the stand structure (Yoneda 2006).

Castanopsis argentea (chestnut) is presents almost in all class diameter and relatively easy to be found. This plant is relatively big and has heavy fruit which makes it poorly adapted for long-distance dispersal. It is typical of laurophyl forest dominated by evergreen Fagaceae. Heriyanto et al. (2007) stated that the highest distribution of *C. argentea* is around 1,400 m asl.

Altingia excelsa is one of the emergent trees in the lower montane forest. The biggest *A. excelsa* founded in this study reaching 170 cm diameter and laid in *C. argentea* canopy. *A. excelsa* is major trees species in the altitude 1,500-1,800 m asl and give the highest contribution to its community (Seifriz 1923; Arrijani 2008). Therefore, Seifriz (1923) was divided the vegetation of Mount Gede into 5 zone, one of which was rasamala (*A. excelsa*) sub-zone.

Distribution of tree diameter is a tool to describe the forest regeneration through age structure of tree. In our study, the distribution of tree in the CBG's remnant forest based on class diameter follows J-inverse curve (Figure 2). This shape showed the common patterns of tropical forest dynamics (Ogawa et al. 1965), similar to Meijer plot on lower mountain forest of Mount Gede (Meijer 1959), natural forest of Mount Papandayan (Setiawan and Sulistyawati 2008), lowland forest of Batang Gadis National Park (Kartawinata et al. 2004), lowland forest in Northern Siberut (Hadi et al. 2009) and lowland forest in Batanta Island, Raja Ampat (Mirmanto 2009).

Strobilanthes hamiltoniana (Steud)*, Dichroa febrifuga* Lour.*, Polyalthia subcordata* (Bl.) Bl.*,* and *Dendrocnide stimulans* (L.f.) Chew are the most common species in shrub layer (Table 4). In the herb layer, *Cyrtandra picta* Bl.*, Calathea lietzei* E. Morren*, Elatostema nigrescens* Miq*,* and *E. cuneatum* Wight are abundant. *Diplazium pallidum* (Bl.) T. Moore and *Calamus reinwardtii* Mart. are also abundant at the fern and climber life form, respectively.

Table 4. Species of shrub, herb, fern, and climber, as well as saplings of CBG's remnant forest

Shrub
Allophylus cobbe (L.) Raeusch
Ardisia crenata Sims
A. villosa Roxb.
A. fuliginosa Bl.
Ardisia sp.
Bocconia frutescens L.
Breynia microphylla (Kuzweil ex Teijsm. & Binn.) Müll. Arg.
Bridelia multiflora Zipp. ex Scheff.
Clerodendrum eriosiphon Schau
Coffea sp.
Dichroa febrifuga Lour.
Ficus ampelas K.D. Koenig ex Roxb.
F. cuspidata Reinw. ex Bl.
Dendrocnide stimulans (L. f.) Chew
Lasianthus laevigatus Bl.
L. stercorarius Bl.
L. rigidus Miq.
Lasianthus sp.
Magnolia candollei Link
Maoutia diversifolia Bl.
Maoutia sp.
Mycetia cauliflora Reinw
Pavetta montana Reinw. ex Bl.
Polyalthia subcordata (Bl.) Bl.
Psychotria angulata Korth
Saprosma dichotomum (Korth.) Boerl.
Solanum ferox L.
S. verbascifolium L.
Strobilanthes hamiltoniana (Steud.)*
Strobilanthes sp.

Herb
Achyranthes bidentata Bl.
Alpinia sp.
Amomum coccineum (Bl.) K. Schum.
Boehmeria rugosissima Miq.
Calathea lietzei E. Morren
Commelina sp.
Curculigo capitulata (Lour.) Kuntze
Curculigo recurvata W.T. Aiton
Elatostema cuneatum Wight
E. nigrescens Miq.
Cyclosorus sp.
Cyrtandra picta Bl.*
Forrestia mollisima (Bl.) Koord.
Impatiens chonoceras Hassk.
I. platypetala Hassk.
Musa acuminata Colla
Nervilia punctata Makino
Pilea angulata (Bl.) Bl.
P. melastomoides (Poir.) Wedd.
Schismatoglottis acuminatissima Schott
Zingiber inflexum Bl.
Z. odoriferum Bl.

Fern
Cyathea contaminans (Wall. ex Hook.) Copel.
Diplazium bantamense Bl.
D. javanicum Makino
*D. pallidum** (Bl.) T.Moore
D. repandum Bl.
Nephrolepis biserrata (Sw.) Schott

Climber
Calamus reinwardtii Mart. *
Plectocomia elongata Mart. ex Bl.
Tetrastigma papillosum Planch.
Smilax zeylanica L.

Sapling
Acer laurinum Hassk.
Alangium rotundifolium (Hassk.) Bloemb.
Alangium sp.
Antidesma tetrandrum Bl.
Bonnetia sp.
Casearia coriacea Vent.
Castanopsis argentea (Bl.) A. DC.
C. javanica (Bl.) A.DC
C. tungurrut (Bl.) A.DC
Cestrum aurantiacum Lindl.**
Cryptocarya ferrea Bl.
Decaspermum sp.
Dysoxylum excelsum Bl.
D. nutans Miq
Elaeocarpus obtusus Bl.
E. oxypyren Koord. & Val.
E. pierrei Koord. & Val.
E. sphaericus Schum.
Euonymus javanicus Bl.
Ficus alba Reinw. Ex Bl.
F. fistulosa Reinw. Ex Bl.
F. ribes Reinw. Ex Bl.
Ficus sp.
Flacourtia rukam Zoll. & Moritzi
Glochidion cyrtostylum Miq.
Glochidion sp.
Helicia serrata Bl.
Lithocarpus indutus (Bl.) Rehder
L. pseudomoluccus (Bl.) Rehder
Litsea noronhae Bl.
Macropanax dispermum (Bl.) Kuntze
Mastixia trichotoma Bl.
Meliosma ferruginea Bl.
Michelia montana Bl.
Mischocarpus fuscescens Bl.
Neonauclea lanceolata (Bl.) Merr.
Ostodes paniculata Bl.
Persea rimosa Zoll. Ex Meissner
Phoebe grandis (Nees) Merr.
Platea latifolia Bl.
Polyalthia subcordata (Bl.) Bl.
Polyosma sp.
Pygeum sp.
Pyrenaria serrata Bl.
Rauvolfia javanica Koord. & Val.
Saurauia cauliflora DC.
S. pendula Bl.
S. reinwardtiana Reinw. Ex Bl.
Schima wallichii Choisy
Sloanea sigun (Bl.) K. Schum.
Symplocos cochinchinensis (Lour.) S. Moore
Symplocos sp.
Syzygium pycnanthum (Bl.) Merr. & L.M. Perry
S. racemosum (Bl.) DC.
Toona sureni Merr.
Trevesia sundaica Miq.
Turpinia montana (Bl.) Kurz
T. sphaerocarpa Hassk.
Viburnum lutescens Bl.
Villebrunea rubescens (Bl.) Bl.

Note: * dominant/abundant species; ** alien species

Forest stratification was described by tree height. Figure 3 shows five strata on Wornojiwo forest. The emergent species is *Castanopsis argentea*. Its stratification is correlated with stand basal area which is almost a half of percentage basal area occupied by Fagaceae (Table 5). This value, 32.67 m^2 ha^{-1}, was higher than the basal area occupied by Fagaceae in a tropical montane forest of Doi Inthanon National Park, Northern Thailand; 8.17 m^2 ha^{-1} (Noguchi 2007). The percentage of Facaeae in CBG remnant forest (49.95%) is much higher than in Padang at the elevation above 700 m; >10% (Nishimura et al. 2006; Fujii et al. 2006). The dominance of Fagaceae is resulting from its vigorous growth rate and low logging impact because of its low timber quality (Yoneda et al. 2006).

The complexity of Wornojiwo forest described by 5 strata of plant i.e. 0-10 m, 10-20 m, 20-30 m, 30-40 m and above 40 m. Richards (1952) consider the tropical rain forest to be the most complex and highly organized terrestrial community in the world, has five or six distinct strata. It is similar with the montane humid forests in Meghalaya, northeast India, which have five-layered distribution of plant species in the community (Jamir et al. 2006). In the second layer *Macropanax dispermum* relatively abundant in the maximum height achieves 40 m. It is similar to the vegetation layer of Mount Manglayang, West Java (Mutaqien et al. 2008).

The canopy with relatively continuous gap occurring in several places was important for regeneration. Forest regeneration showed a good result, indicated by almost all

tree species had the sapling stage. Our detailed survey found 61 sapling species as pointed out in Table 4. Sapling can be found easily especially in Jalan Akar and Lumut forest which adjacent to natural forest of Mount Gede Pangrango National Park as seed source.

Table 5. Basal area in tree family of CBG's remnant forest

Rank	Family	Basal area (m^2 ha^{-1})	% Basal area
1	Fagaceae	32.67	49.95
2	Euphorbiaceae	12.3	18.81
3	Urticaceae	10.25	15.69
4	Araliaceae	5.09	7.79
5	Hamamelidaceae	1.87	2.86
6	Moraceae	1.24	1.90
7	Meliaceae	0.34	0.52
8	Lauraceae	0.29	0.45
9	Aceraceae	0.28	0.44
10	Actinidiaceae	0.28	0.43

Is the CBG's permanent plot representing the natural vegetation?

Forest inventory on CBG permanent plot were compared to natural forest vegetation at the edge and the interior of Mount Gede Pangrango National Park to get evidence of its representation of lower montane vegetation (Table 6). Although the vegetation of both CBG's permanent plot and the natural forest vegetation plot on Mount Gede Pangrango National Park are located at the same vegetation zone i.e. lower montane zone (Whitmore 1984), the natural forest vegetation has lower number of species than CBG's permanent plot but have higher value of H' and species evenness. It may be caused by; (i) natural factor, such as in the tropical regions tree species richness (trees > 10 cm dbh in 1 ha plot), decreases with increasing altitude (summarized in Aiba et al. 2002), (ii) logging which occurs in national park, although it is a protective area but some people living around this area are collecting forest natural resource easily. As found for forest islands in Wisconsin, disturbance contributes significantly to variability in the number of species (Dunn and Loehle 1988); (iii) effect of the existence of CBG which conserves many non-native plant species which could escape into forest; and (iv) edge effect which may increase biodiversity in adjacent area (CBG permanent plot). Natural forest closer to CBG has the highest value of tree density and H', but the % basal area is lower than the farther of natural forest plot. This points out that the first plot of natural forest has younger succession stage than the second one.

Species composition of the CBG permanent plot represented the lower montane forest vegetation of Java. In Java, the lower montane are dominated in terms of abundance by the Oaks (*Lithocarpus* and *Quercus*), Chestnuts (*Castanopsis*), and numerous species of Laurels (Fagaceae and Lauraceae, respectively) but the Magnoliaceae, Hamamelidaceae and Podocarpaceae are also well represented (Sukardjo 1978; Mukhtar and Pratiwi 1991; van Steenis 1972). Only *Castanopsis javanica* present in the all plot (Table 7). *Cestrum aurantiacum* as invasive alien species is dominant spread in the CBG permanent plot only. Their canopy would inhibit native sapling growth (Galbraith-Keith and Handel 2008).

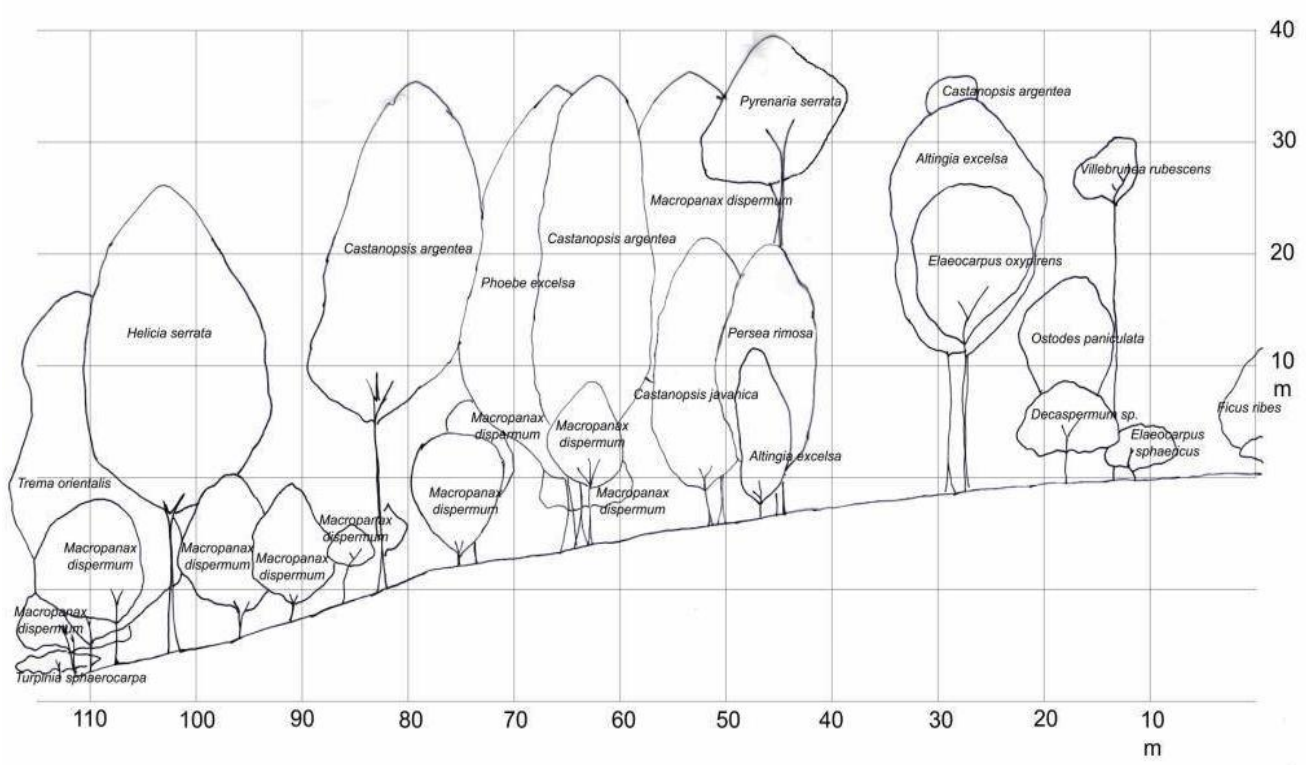

Figure 3. Profile diagram of Wornojiwo forest of CBG's remnant forest

Table 6. Comparison of tree stand of CBG permanent plot and plots in the natural forest vegetation of Mount Gede Pangrango National Park

	CBG permanent plot	First plot of natural forest	Second plot natural forest
Distance from CBG	Inside CBG	200 m (edge forest)	1 km (interior of the forest)
Altitude (m asl)	1,300-1,425	1,450-1,500	1,594-1,611
Number of tree species	74	63	51
Tree density (tree/ ha)	306	408	314
Basal area (%)	0.447	0.428	0.347
Shannon's Diversity Index (H')	2.84	3.29	3.20
Species Evenness	1.52	1.82	1.87

Table 7. Comparison the tree stand important value index (IVI) of the CBG permanent plot and natural forest vegetation in Mount Gede Pangrango National Park

CBG permanent plot		First plot of natural forest		Second plot of natural forest	
Species	**IVI**	**Species**	**IVI**	**Species**	**IVI**
Villebrunea rubescens	49.70	*Castanopsis tungurrut*	26.88	*Schima wallichii*	57.13
Ostodes paniculata	43.02	*Villebrunea rubescens*	18.94	*Turpinia sphaerocarpa*	32.55
Macropanax dispermum	29.90	*Sloanea sigun*	14.92	*Vernonia arborea*	12.48
Castanopsis argentea	37.31	*Altingia excelsa*	14.33	*Saurauia pendula*	11.09
Ficus ribes	16.21	*Ostodes paniculata*	14.09	*Macaranga rhizinoides*	9.72
*Cestrum aurantiacum***	7.40	*Castanopsis argentea*	13.29	*Manglietia glauca*	9.53
Decaspermum sp.	5.84	*Laportea stimulans*	11.06	*Persea rimosa*	9.28
Saurauia pendula	7.36	*Macropanax dispermum*	10.13	*Lithocarpus pseudomoluccus*	5.93
Altingia excelsa	9.39	*Castanopsis javanica*	9.60	*Saurauia blumiana*	5.72
Castanopsis javanica	9.33	*Turpinia sphaerocarpa*	9.11	*Castanopsis javanica*	5.35

Note: ** alien species

In general, plant composition of the remnant forest of CBG's plot is more similar to the first plot of natural forest rather than the second one. Table 8 shows that CBG permanent plot has 39% similarity to first plot of natural forest and only 31% similar to the second plot of natural forest. Both plots located in natural forest have the higher similarity, i.e. 52%. Jacob (1981) said that no two hectares have exactly the same species composition in the rain forest. It is indicated the remnant forest of CBG showed good representative of Mount Gede Pangrango forest vegetation. The representation will be best if the alien species (*C. aurantiacum*) removed from the permanent plot.

Table 8. Similarity index among the remnant forest of CBG's plot and the plots at natural forest of Mount Gede Pangrango National Park

	CBG permanent plot	First plot of natural forest	Second plot of natural forest
CBG's remnant forest plot	**1**	0.39	0.31
First plot of natural forest	0.39	**1**	0.52
Second plot of natural forest	0.31	0.52	**1**

Due to the small size and high degree of fragmentation, the CBG's remnant forest is susceptible to abiotic and biotic disturbance. Edge effects increased susceptibility to invasions by exotic plants and animals (Ross et al. 2002; Ecroyd and Brockerhoff 2005). In spite of climatic change, the presence of invasive species is one of the greatest threats to biodiversity (Primack and Miller-Rushing 2009). It refers to their adaptability to disturbance and to a broader range of biogeographic conditions and environmental controls (Burgiel and Muir 2010). The presence of invasive alien species i.e *Cestrum aurantiacum* and *Brugmansia candida* 100 m away from CBG proved the spread of invasive species from CBG was out of control. Monitoring in the successive years is needed to maintain diversity, monitor forest dynamics and also the spread of invasive plant from CBG.

CONCLUSION

There were 137 plants species consisting of 74 tree species, 30 shrub species, 24 herb species, 6 fern species, and 4 climber species present in CBG permanent plot. The dominance of fagaceous (*Castanopsis argentea*), *Villebrunea rubescens* and *Ostodes paniculata* indicated the remnant forest of CBG is secondary lower montane forest. In comparison with natural forest, the remnant forest

of CBG showed good representative of Mount Gede Pangrango forest vegetation. It is indicated by 39% of its species composition are similar with the edge forest and 31% are similar with the forest interior.

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