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Morphological variation of *Hoya multiflora* Blume at different habitat type of Bodogol Research Station of Gunung Gede Pangrango National Park, Indonesia

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ABSTRACT

Rahayu S, Jusuf M, Suharsono, Kusmana C, Abdulhadi R. (2010) Morphological variation of Hoya multiflora *Blume at different habitat type of Bodogol Research Station of Gunung Gede Pangrango Natonal Park, Indonesia. Biodiversitas 11: 187-193. Hoya multiflora* Blume (*Asclepiadaceae*) is an Asiatic tropical epiphytic shrub which has been utilized as ornamental plant and reported to possess medicinal properties. The aim of this study was to evaluate the morphological variation of *Hoya multiflora* populations at the different habitat types of Bodogol Research Station of Gunung Gede Pangrango National Park in Indonesia. We collected 48 samples from three sub populations with six different habitat types. Morphological variation was found in stem, leave, and inflorescence. According to the discriminant and cluster analysis, the 48 samples were separated into three groups at 12% dissimilarity. The groups were determined by canopy cover degree.

Key words: morphological diversity, *Hoya multiflora*, Gunung Gede Pangrango National Park.

INTRODUCTION

Hoya multiflora Blume (*Asclepiadaceae*) is widely distributed throughout India to New Guinea (Hooker 1885; Schlechter 1914; Thaitong 1994), at the elevation of 200-1200 m above sea level (Backer and van der Brink Jr. 1965; Rintz 1980). This species is characterized by its short (non vein) stem, leathery (non succulent) oblong leaves and the flowers have white coronas and yellow/white reflexed corollas (Wanntorp et al. 2006). There can be up to 40 of this rocket like flowers in an umbel and they produce lots of nectar, and produces white latex from all of its part.

Hoya multiflora is one of the economically important ornamental plants in the world. In addition, this species has been classified as medicinal plant (Zachos 1998) and its medicinal properties have been used traditionally to treat arthritis-rheumatism (Burkill 2002), and stomach/intestinal ailments (Ambasta 1986) as well. Though the active compound of this plant has not been identified yet, presumably it contains Indomethacin-like compound. It is a common non-steroidal anti-inflammatory drug (NSAID), which has been used for more than 30 years to treat symptomatic pain of arthritis-rheumatism. Recently, this compound has been tested for a new drug as anti HIV (Bourinbaiar and Lee-Huang 1994), and it seems to be specific since no toxicity has been observed at the IC_{50} dose.

Despite their high economic importance, little is known about their morphological diversity. The variations of morphological characters provide a range of selection for horticultural purposes, and can also describe the genetic diversity among the populations. Morphological characters are expression of the genetic diversity as interact with their environment. Specific adaptation information will be beneficial for agronomic and horticultural plants which had been and continue to be developed by extensive testing (Vogel et al. 2005). There are some variations on *H. multiflora* characters according to the geographical range (Goyder 2008). Thus, it is imperative to study the morphological diversity of *H. multiflora,* especially those which are presence at Gunung Gede Pangrango National Park, Bogor, Indonesia. The *H. multiflora* populations in this area grow on various habitats and host plants.

The objective of this study is to evaluate the morphological diversity at different habitat types at Bodogol Research Station, Gunung Gede Pangrango National Park, Indonesia.

MATERIALS AND METHODS

Study site

There were three subpopulations (Figure 1, red circle) of *H. multiflora* at Bodogol Research Station, Gunung Gede Pangrango National Park, West Java, Indonesia used as sample sources. The six different habitat types were identified at the study area. The habitat type was differentiated by its dominant tree, sapling species and canopy cover. The subpopulation-1 has two types of habitat and therefore divided into two sites; the subpopulation-2 has three types of habitat and divided into three sites, and subpopulation-3 only has one habitat type (Figure 1, blue circle). The habitat types of the sampling sites were listed in Table 1.

Plant material

Four eight plant samples were collected from the six different habitat sites at Bodogol Research Station as listed in Table 1. The samples were collected as cuttings for living collection and housed in a shade house at Bogor Agricultural University (IPB), Darmaga, Bogor.

Morphological observation

A descriptor list was needed to make a simple observation. The development of the descriptor was based on the observation of both quantitative and qualitative characters of the vegetative and generative structures. The description of characters terminology are following the "Plant Form" of (Bell and Bryan 2008) and "Botanical Latin" of Stearn (2004). All measurement was in metric and color observation was taken with the Royal Horticulture Society (RHS) color chart (2007).

Data analysis

Data analysis consisted of discriminant and cluster analysis by using SPSS software (Kirkpatrick and Feeney 2005).

RESULT AND DISCUSSION

Morphological variations

A descriptor list has been developed as a result of the preliminary observation as listed in Table 2. Twenty four characters displayed morphological variation among *Hoya multiflora* populations at Bodogol. Plant growth habit ranged from upright (Figure 2A) and prostrate types (Figure 2B). Node length was ranged from the very short (0.9 cm) to the very long (12.2 cm). These two characters were correlated with the plant performance. The upright plant with short node will give the best performance as pot plant. Leaf blade shape was varied between obovate and oblong, and the intensity of green color varied from 146 A (yellowish green) to 147 A (green) of RHS color chart standard.

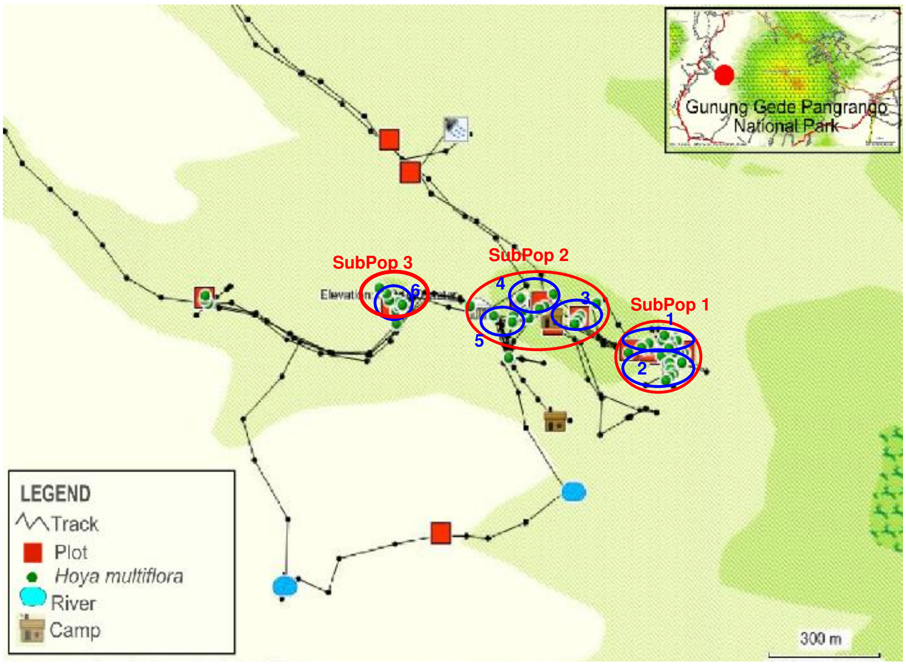

Figure 1. The *Hoya multiflora* population at Bodogol Research Station, Gunung Gede Pangrango National Park as sample source

Table 1. The habitat types of *Hoya multiflora* populations at Bodogol Research Station, Gunung Gede Pangrango National Park

Sub population	Site	Habitat type	Canopy cover	Sample number
1	1	*Maesopsis eminii-Cyathea contaminans* forest	60.23%	1,2,3,4,5,6,7,8,9
1	2	Primary mixed forest	61.53%	10,11,12,13,14,15,16, 17,18,19
2	3	*Maesopsis eminii-Calliandra calothyrsus* Forest	75.34%	20,21,22,23,24,25
2	4	*Schima wallichii* forest	64.15%	26,27,28,29,30,31,32,33,34
2	5	Ridge open-building mixed	54.62%	35,36,37,38,39,40,41
3	6	*Altingia excelsa* Forest	80.23%	42,43,44,45,46,47,48

Table 2. Characters of descriptor list for *Hoya multiflora* used in this study

Characters	Type of characters	Qualitative character states 0	1
1 Plant: habit	qualitative	upward	horizontal
2 Stem: anthocyanin coloration	qualitative	absent	present
3 Node: length	quantitative		
4 Petiole: length	quantitative		
5 Petiole: anthocyanin coloration	qualitative	absent	present
6 Leaves: shape	qualitative	obovate	oblong
7 Leaves: ratio width/length	quantitative		
8 Leaves: intensity of green color of upper part	qualitative	light *	dark *
9 Inflorescence: number of umbel / branch	qualitative	one	more than one
10 Inflorescence: number flower / umbel	quantitative		
11 Peduncle: length	quantitative		
12 Peduncle: anthocyanin coloration	qualitative	absent	present
13 Pedicel: length at the full opened flower	quantitative		
14 Pedicel: color at the first open flower	qualitative	yellow green *	green*
15 Pedicel: anthocyanin coloration	qualitative	absent	present
16 Calyx: anthocyanin coloration at the first open flower	qualitative	absent	present
17 Corolla: anthocyanin coloration at the 1st bud	qualitative	absent	present
18 Corolla: number of color	qualitative	one (flush)	two (+white)
19 Corolla: color of lamina tip	qualitative	yellow *	orange*
20 Corolla: length of corolla lobe	quantitative		
21 Corolla: intensity of reflection	qualitative	weak	medium
22 Corolla: curvature of corolla lobe	qualitative	weak	medium
23 Corona: type	qualitative	unopened	opened
24 Corona: length of corona lobe	quantitative		

Note: * Taken with the Royal Horticulture Society (RHS) Color Chart

There were variations on corolla coloration, both on bud and opened flower stage. Variation between absence and presence on the flower bud anthocyanin coloration was found among the population as presented in Figure 2C and Figure 2D. There were two types of flower coloration among the populations. The pale color (Figure 2E) stated as having two corolla colors and full color (Fig.2F) stated as having one corolla color. Variation was also found at the pedicel length and corolla reflexion (Figure 2G). Pedicel length was varied from 3 cm to 6 cm. Corona type was varied as closed type (Figure 2H) and open type (Figure 2I).

Variation among the observed morphological characters was performed as expression of the genetic variation among populations in interaction with their environment as adaptation process. Genetic change is what occurs in a population when natural selection acts on the genetic variability of the population. By this means, the population adapts genetically to its circumstances (Orr 2005). Populations differ in their phenotypic plasticity, which is the ability of an organism with a given genotype to change its phenotype in response to changes in its habitat, or to its move to a different habitat (Price et al. 2003; Prince 2006). Phenotypic plasticity may occur and first appear at the vegetative characters such as leaf morphology. The morphological variation in leaf shape of *Ranunculus repens* was concordance by physiological variation in their adaptation to survive at amphibious habitat (Lynn and Waldren 2001, 2002, 2003).

Similarity

According to the discriminant analysis, there were five functions which discriminated the samples (Table 3 and Table 4). The first function with the largest variability explained 45.5% of the among site variation based largely on six characters namely pedicel anthocyanin, peduncle length, intensity of green color of leaves, corolla color, leaf blade shape and flower number per umbel. The second function explained 23% of the variation with two main characters namely calyx anthocyanin and pedicel color. The third function explained 14% variation related to six characters i.e. corolla reflextion, corolla number of color, petiole length, corona type, corolla curvature and stem anthocyanin. The first to third functions has cumulatively explained 82.4% of the variation. The fourth function related to four characters i.e. petiole anthocyanin, corolla length, leaves ratio and number of umbel. Then the fifth function related to corolla bud anthocyanin, plant habit, corona length, peduncle anthocyanin, node length and pedicel length.

Table 3. Functions at Group Centroids.

	Function 1	2	3	4	5
Eigenvalue	45.5	23.0	14.0	9.5	8.0
Cumulative%	45.5	68.5	82.4	92.0	100.0
Site 1	-1.075	0.470	0.911	-1.193	-0.469
Site 2	-0.699	0.395	-1.735	-0.136	-0.154
Site 3	1.576	-2.815	0.005	0.007	-0.561
Site 4	-0.194	-0.366	0.262	-0.059	1.444
Site 5	-2.040	0.174	0.675	1.451	-0.402
Site 6	3.319	1.540	0.290	0.347	-0.152

Note: Unstandardized canonical discriminant functions evaluated at group means.

The distribution of samples on a canonical plane was presented in Figure 3. It was spanned by the first and second canonical axis which in total covered 68.5% of the variation (eigenvalues). Along the first (horizontal) axis, with eigenvalue equal 45.5%, the samples were separated mostly according to the six characters (pedicel anthocyanin, peduncle length, intensity of leaves green color, corolla color, and leaf shape and flower number per umbel).

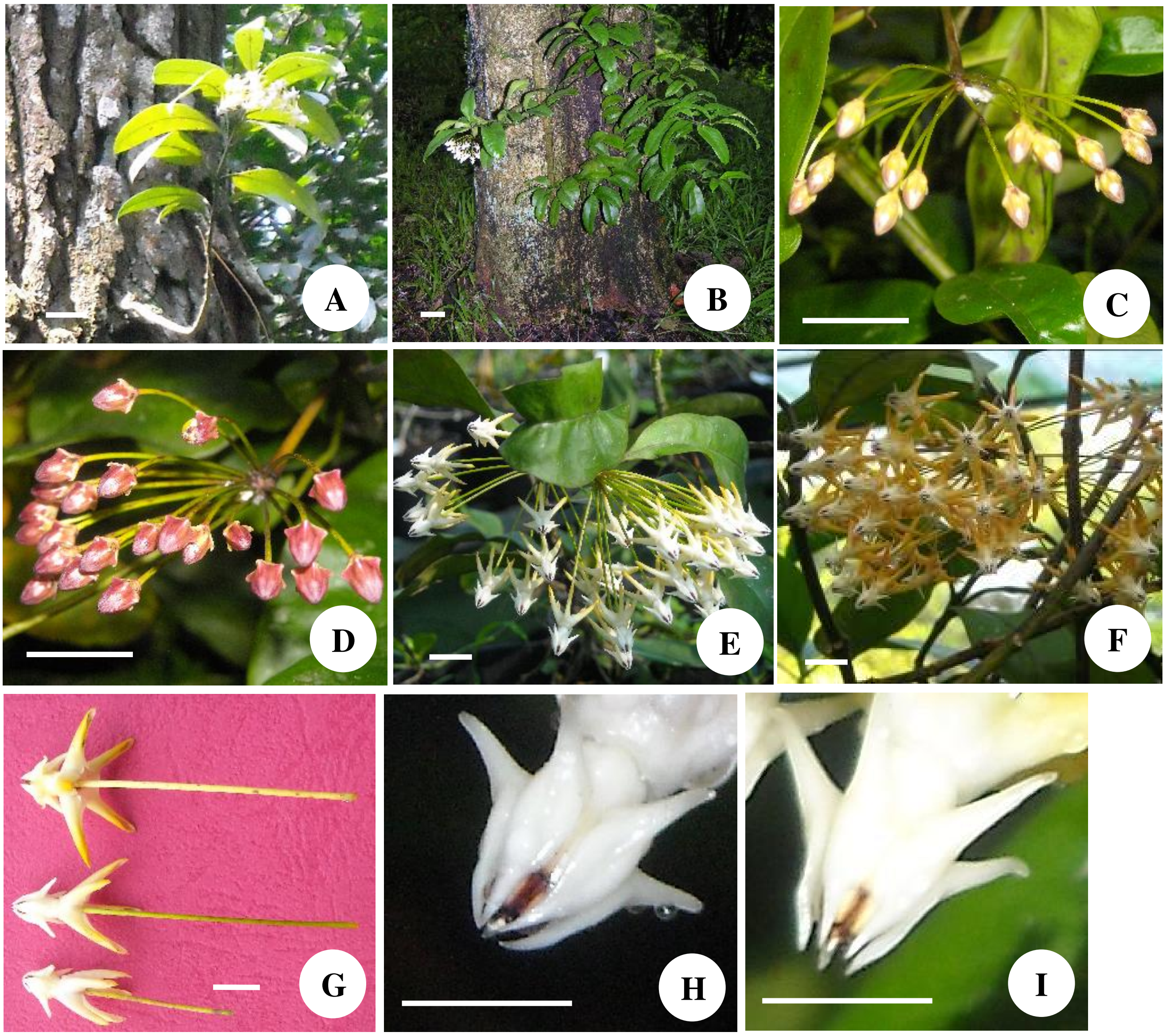

Figure 2. Diversity in inflorescence of *Hoya multiflora*: a. upright plant b. horizontal plant habit c. absent/very weak in anthocyanin coloration in flower bud d. strong anthocynin in flower bud, e. pale corolla color, f. strong corolla color, g. variation in pedicel length and corolla reflexion. h. closed corona type, i. opened corona type. (Scale: a-b = 5 cm; c-i = 1 cm)

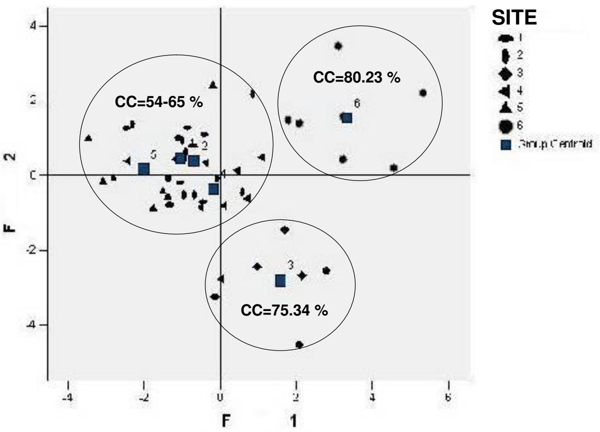

Figure 3. Distribution of samples on canonical plane

The right direction was occupied by site 3 and site 6, which have pedicel anthocyanin coloration, long peduncle, deepest color on leaves and flower, oblong leaves and numerous flowers. The left direction was placed by sites 5, 1 and 2 which possess the opposite characteristic with the sites 3 and 6 i.e. lack of pedicel anthocyanin coloration, short peduncle, lighter color on leaves and flower, ovate leaves and fewer flowers. Sites 3 and 6 were in habitats with dense canopy and site 5 had the most open canopy (Table 1). The canopy density may influence the intensity of green color in leaves. In the condition of dense canopy, the sunlight is weak, which in turn is able to trigger chlorophyll production to catch the more sunlight. Shade plants contain more chlorophyll b or have smaller chlorophyll a:b ratios. At given nitrogen availability chlorophyll a: b ratios increase with increasing irradiance (Kitajima and Hogan 2003). It is very often observed in the

Table 4. Standardized Canonical Discriminant Function Coefficients and Correlation between Observed Characters and Canonical Variables of *Hoya multiflora*

Observed characters	1		2		1`1 3		4		5	
	Canonical discriminant function coefficients	Corre-lation	Canonical discriminant function coefficients	Corre-lation	Canonical discriminant function coefficients	Corre-lation	Canonical discriminant function coefficients	Corre-lation	Canonical discriminant function coefficients	Corre-lation
Pedicel anthocyanin	0.980	0.331(*)	0.590	-0.170	-0.718	-0.307	0.168	-0.023	-0.134	-0.045
Peduncle length	10.673	0.250(*)	10.019	-0.067	0.175	-0.063	0.093	0.132	-0.386	-0.244
Leaves green color	0.054	0.150(*)	0.217	0.128	-0.156	0.043	-0.090	0.039	0.304	-0.142
Corolla color	0.560	-0.136(*)	-0.319	0.063	0.111	0.106	0.169	0.075	0.751	0.082
Leaves shape	-0.173	0.097(*)	10.510	0.040	0.249	0.074	0.013	0.053	-0.296	-0.068
Flower number	10.104	-0.053(*)	0.164	0.002	0.560	0.029	-0.397	0.039	0.014	0.012
Calyx anthocyanin	0.718	-0.262	10.037	0.299(*)	-0.180	0.105	0.712	0.230	0.431	0.020
Pedicel color	0.480	0.089	-0.562	-0.222(*)	-0.170	-0.172	0.110	0.050	0.813	-0.002
Corolla reflextion	0.294	-0.035	10.031	0.039	-0.365	-0.282(*)	-0.255	-0.032	0.547	-0.043
Corolla number of color	0.296	0.104	0.558	-0.058	0.967	0.275(*)	0.221	-0.170	0.430	0.121
Petiole length	-0.621	0.048	10.222	0.063	-0.821	-0.247(*)	-0.051	0.083	0.068	0.071
Corona type	-0.284	-0.027	0.870	0.181	0.141	-0.223(*)	0.624	0.154	-0.685	-0.076
Corolla curvature	-0.927	0.032	-0.307	-0.172	0.058	-0.203(*)	0.139	-0.022	-0.133	-0.146
Stem anthocyanin	-0.112	-0.046	-0.949	-0.045	-0.877	-0.154(*)	0.239	-0.049	-0.057	-0.087
Petiole anthocyanin	-0.088	-0.236	0.041	-0.054	0.084	0.111	0.635	0.466(*)	-0.051	0.101
Corolla length	0.802	0.117	-0.664	-0.060	-0.174	-0.119	0.422	0.210(*)	0.251	0.056
Leaves ratio	-0.630	0.078	-0.709	-0.148	0.521	0.015	0.630	0.172(*)	0.071	-0.081
Umbel number	-0.127	0.008	-0.191	0.027	-0.385	-0.135	0.437	0.144(*)	-0.012	0.104
Corolla bud anthocyanin	-0.605	-0.169	0.217	0.069	0.375	0.131	-0.373	-0.057	-0.698	-0.429(*)
Plant habit	0.603	0.151	-0.124	-0.048	0.015	0.130	0.484	0.282	-0.071	-0.334(*)
Corona length	0.226	-0.053	-0.518	0.059	-0.009	0.008	-0.435	-0.131	0.896	0.251(*)
Peduncle antho	-0.357	0.042	-0.340	-0.030	0.532	-0.038	-0.370	-0.006	-0.047	-0.193(*)
Node length	0.505	0.103	-0.997	0.042	0.650	-0.151	-0.229	0.085	0.620	0.179(*)
Pedicel length	-0.508	-0.121	-0.301	-0.034	-0.568	-0.095	-0.279	-0.102	-0.437	-0.171(*)

Note: * indicate the largest correlation among the five canonical functions for each character

tropics, that individual plants of a given species growing in deep shade inside a forest and exposed to full sun-light in an open habitat respectively, form morphologically very different phenotypes, which are also strongly distinguished by pigmentation especially as a response to photosynthetic apparatus (Lüttge 2008).

The plants living in a shade and humid area have been predicted to have more nutrients to be absorbs so will affect on the growth (peduncle length, leaves size and number of flower). This condition is identical with the experiment result of Issarakraisila and Settapakdee (2008) on the seedling of *Garcinia mangostana* as a shade tolerant plant. An increase of light intensity increased the thickness of lamina resulting in an increase of palisade and spongy tissues and the stomata frequency also increased. Both chlorophyll a and b declined gradually as the light intensity increased and the average ratio was 0.808. The growth of seedlings described as leaf size, leaf number per plant, total leaf area, height, fresh weight and dry weight were dramatically reduced when exposed to 100% light intensity condition. Maximum growth was found when exposed to 40% light intensity condition. Clones of population native to shade and to exposed environments show differences in the photosynthetic response to light intensity during growth (Björkman and Holmgren 2006).

So far, the samples were grouped based on their morphological similarities. As shown in Figure 3, there were three clusters of 48 samples from the six sites. The first cluster was consist of all samples from site 6 at the above right of the plane, the second was consist of samples of site 3 at the below of the plane, and the third was consist of samples from sites 5, 2, 1 and 4 at the above left of the plane. This result was identical to the result of a cluster analysis by using mean coordinates on the five canonical axis (Table 3). A dendogram displayed on Figure 4 showed the separation of six sites into three groups at 12% dissimilarity level. The first group was site 6, the second was site 3 and the third was consisting of sites 5, 2, 4 and 1. Sites 5, 2, 4, and 1 possess dissimilarity at below 5%.

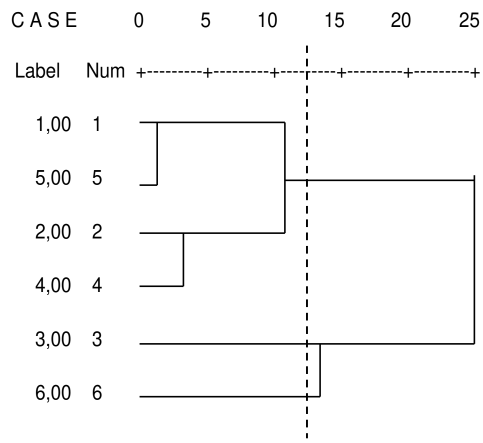

Figure 4. Dendogram of 6 groups of *Hoya multiflora* population, generated from canonical coordinate of means.

The similarity between six sites was performed by morphological characters, which were discriminated by its different habitat. According to the analysis the sites 5, 2, 4, and 1 were similar at 95%, while sites 6 and 3 were separated at 12% dissimilarity level. Their similarity degree was match with the canopy cover (Table 1). Sites 6 and 3 occupied dense canopy cover (80.23% and 75.34%), while the other sites at medium canopy cover (from 54-64%). These six sites were different in dominant tree species, however the four sites (5, 2, 1, and 4) have relatively similar habitat, particularly on the degree of canopy cover (from 54.62% to 64.51%). It was means that morphological variations among the samples were influenced by the environment, especially the degree of canopy cover. Light intensity is the most factors related to the canopy cover. According to Lüttge (2008), light is one of the environmental important factors in the tropical forest that become a stress factor which support such phenotypic variability in relation to plasticity. Phenotypes are the receivers and modulators of environmental input and producers of output performance at the community level.

Plants may be genetically determined for growth at low or high light intensity. However, there are also ontogenetic and developmental modifications, where light exerts a signalling function rather than being only the energy source of photosynthesis, and plants may acclimate or adapt ecophysiologically to low and high irradiance, respectively (Lüttge 2008). The potential for light acclimation is species specific and may involve major structural and functional changes in the photosynthetic apparatus (Bailey et al. 2001). In sun plants increased chlorophyll a/b ratios and a comparatively small size of chlorophyll a and b binding antennae contribute to protection from too high irradiance (Krause et al. 2001). Plants permanently exposed to full sunlight have effective protective mechanisms (Krause et al. 2006). The understorey shrub *C. glabellus* shows the distinct differences between sun and shade plants. Shade plants have lower leaf conductance to water vapor, gH2O, than sun plants which leads to lower gas exchange and growth (Bonal et al. 2000; Sack et al. 2005).

Phenotypic plasticity must be considered in relation to co-occurrence of different genotypes within a population which are each adapted to a slightly different environment. Genetic variation is reflected in phenotypic plasticity (Booy et al. 2000). Plasticity itself can be considered as a trait, which is subject to selection (West-Eberhard 1989). However, plasticity per se is not adaptive. Adaptive plasticity in plants is commonly interpreted for fitness estimates like size and fecundity. The specialization hypothesis, however, predicts that plasticity in such characters is not a product of selection but, rather, a product of specialized (i.e. ecotypic) adaptation to particular environmental condition (Lortie and Aarssen 1996). This much depends on the physiological costs of plasticity (van Kleunen and Fischer 2005). In any case, phenotypic plasticity offers material for selection, since selection is acting on the phenotypes. Thus, the promotion of phenotypic plasticity by variable and medium stress may be one of the reasons for the extraordinarily high biodiversity of tropical forests (Lüttge 2008).

CONCLUSION

Variation on morphological characters was found in *Hoya multiflora* populations at Bodogol Research Station of Gunung Gede Pangrango National Park, Indonesia. The variation was found in stem, leaves, and inflorescence of the samples among six different habitat types. According to the discriminant and cluster analysis, the six sites were separated into three groups at 15% dissimilarity. The similarity of habitat was performed by its canopy cover degree rather than dominant tree species. The first group had the highest canopy cover (80.23%) having dominant characters i.e. pedicel anthocyanin coloration, long peduncle, deepest color on leaves and flower, oblong leaves and numerous flowers. The second group with the canopy cover of 75.34% was characterized by intermediate morphological characters, and the third group, which included four sites (sites 5, 2, 1 and 4) with low canopy cover (54.62% to 64.15%) had intermediate and lowest morphological characters.

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