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# POPULATION STRUCTURE OF *Hoya* spp. (APOCYNACEAE: ASCLEPIADOIDEAE) AT BODOGOL NATURE-CONSERVATION EDUCATION CENTER, INDONESIA

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**ABSTRACT**

*Hoya* species are a type of epiphytic flowering plants that are known to have traditional medicinal values. Since 2011, eight *Hoya* species are recorded at the Bodogol Nature-Conservation Education Center (BNCEC), Bogor, Indonesia. For effective conservation measures, this study is aimed to analyze the population structure and distribution pattern of *Hoya* species at BNCEC. Data collection was done from July to August 2016 using a purposive sampling method in a 400m$^2$ plot. The results show that each species differed in their population structures. The *H. multiflora* population structure has the shape of an inverted pyramid, where there were more adult individuals than seedling and young ones, both *H. campanulata* and *H. imperialis* have the shape of a natural population pyramid, showing a population balance between seedling, young, and adult individuals. *H. lacunosa* has the shape of an hourglass, in which the number of seedlings and adult individuals is larger than the young. *H. hasseltii* and *H. vitellinoides* have no clear population structures as no adult individuals were discovered for these two species. The distribution pattern of *Hoya* populations at BNCEC is of the clumped type (Morisita's index = 0.661).

**Keywords**: *Hoya campanulata, Hoya hasseltii*, *Hoya vitellinoides,* Morisita's index, population pyramid

## INTRODUCTION

*Hoya* spp. (Apocynaceae: Asclepiadoideae) is a type of epiphytic flowering plants used by indigenous people as an ingredient in traditional medicine (Zachos 1998). A compound found in *Hoya multiflora* Blume was used for traditional medical practices (Rahayu 2011a). The medicinal substance was used to treat arthritis-rheumatic disease (Burkill 2002), abdominal pain or inflammation of the intestines (Ambasta & Wickens 1988), and asthma (Heyne 1979). In addition to being used in traditional medicine, *Hoya* was also used as a bio-insecticide that controlled the growth of pre-adult mosquitoes *Aedes aegypti* (vector of dengue virus) and *Culex quinquefacsiatus* (the house mosquitoes) (Cahyadi 2005; Kusumawati 2005; Mukharam 2005; Rustandi 2005). Moreover, *Hoya* is a known ornamental plant. All *Hoya* plants have unique, beautiful, and fragrant flowers (Lamb & Rodda 2016). Since 1970, the beauty of *Hoya* has been well-known throughout Europe and the United States as one of the exotic ornamental plants (Hodgkiss 2007).

*Hoya* is an epiphyte that lives on the trunks of host trees (Rahayu 2010). However, the existence of *Hoya* populations in their natural habitat is at risk. The first threat is due to the deforestation of large trees that serve as hosts for *Hoya.* Deforestation is the consequence of opening the forest land for community cultivation and farming. The second threat comes from the increasing use and popularity of *Hoya* in the trade market. Conservation, therefore, is a crucial action to save the population of *Hoya* plants. Conservation activities require sufficient information about the species, such as the amount of species

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population in their habitat, the population structure of that species, its distribution, and current data on the forest species serving as the habitat (Risna *et al.* 2010). Until now, the population data of *Hoya* species are very limited. Some studies focused more on the study of species diversity and its supporting factors. The assessment criteria of Molloy and Davis (1992) that were adopted and modified by Risna *et al.* (2010), the number of populations and the condition of the population type are required to determine the priority of the species for official conservation measures.

*Hoyas* grow and spread throughout several regions in the world. Based on Kleijn and van Don Kelaar (2001), Wanntrop *et al.* (2006), and Goyder (2008), *Hoya* is a native plant of Southeast Asia and its neighboring regions. Indonesia hosts about 50-60 species of *Hoya* (Rahayu 1999). These are distributed in Sumatra, Bukit Batikap-Borneo, Mount Salak, and Gunung Gede Pangrango (Rahayu 2012). In Gunung Gede Pangrango National Park (GGPNP), 8 species of *Hoya* are found at the Bodogol Nature-Conservation Education Center (BNCEC) (Rahayu 2012). However, there is no population data for each of the species. As such, information on the population of every *Hoya* species at BNCEC is required. Population studies within a community are needed to see the patterns of interaction, to record the population of the dominant species, and to predict the survival of each population within the community (Irwan 2003). Henceforth, these can be used as baseline data for decision making regarding the conservation of the Hoya species.

The purpose of this research was to analyze the population structure and distribution pattern of each *Hoya* species at the BNCEC and to visualize a distribution map of the Gunung Gede Pangrango National Park (GGPNP).

## MATERIALS AND METHODS

### Location and Time

The research was conducted at the 11 study sites within the Bodogol Nature Conservation Education Center (BNCEC) in Gunung Gede Pangrango National Park (GGPNP), covering Cipadaranten 1, Cipadaranten 2, Gombong Koneng, Cimongkleng, Long Track, Damar, Canopy Trail, Cisuren, Africa, Rasamala, and Cikaweni (Fig. 1). The data were collected from July to August 2016.

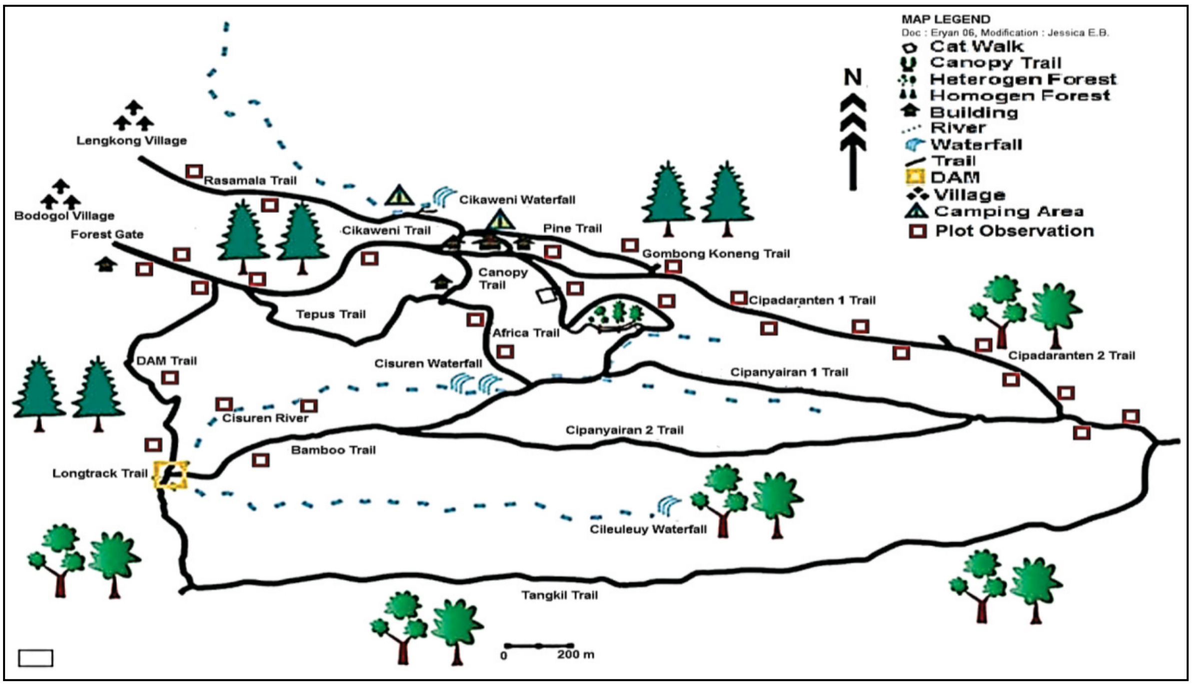



Figure 1 Sampling location at Bogor Nature-Conservation Education Center, Indonesia (Scale 100 m (Bermuli 2017))

## Research Implementation

*Exploration*

The individual *Hoya* species were observed and identified using the exploration method at the 11 study sites at the BNCEC (Rugayah *et al.* 2004).

*Plot Observation*

The populations of *Hoya* species at BNCEC were observed using purposive sampling (Hariyanto *et al.* 2008). A minimum of two 20m x 20m plots was established in each of the eleven study sites, totaling 28 observation plots. The individual numbers of *Hoya* species were recorded and documented by calculating the individuals using the counting method from the main root until the end of the main stem (bud). If that individual of *Hoya* had branched, the longest stem was also counted. The recorded information, including the host plant species and dates of exploration, was written on a ribbon name-tag and placed on the host trees.

*Identification of Hoya Species*

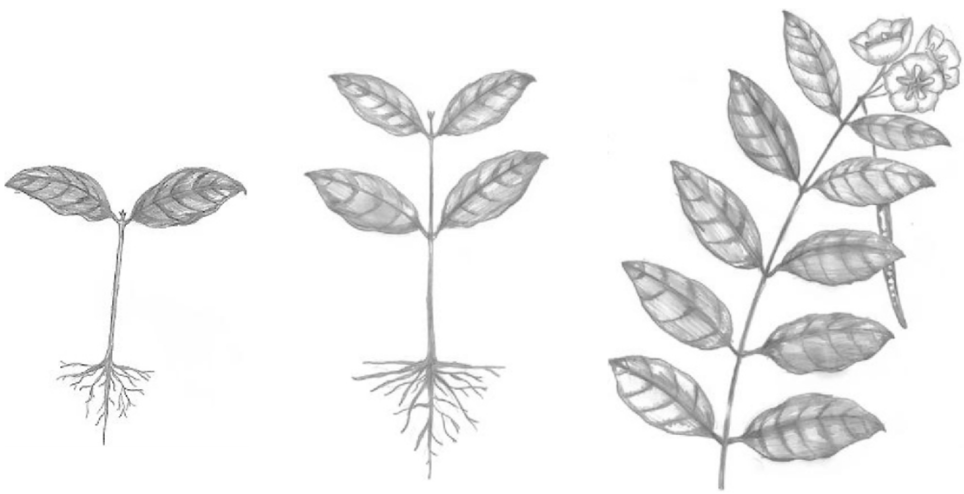
The species were identified in the field, and their identity was confirmed based on herbarium specimens. The species were identified using Rahayu's determination key of *Hoya* plants at the BNCEC, GGPNP (Rahayu 2012), followed by documentation of the physical condition of the *Hoya* species, whether it has white sap in a wound, opposite leaf pattern, palmate or reticulate (Hoffman *et al.* 2002), and fragrant flower (Lamb & Rodda 2016). All the identified *Hoya* species were collected as herbarium specimen and compared with the specimens at the herbarium sites in LIPI Cibinong.

*Classification by Ages*

The growth stages of *Hoya* were divided into three, *i.e.* seedling, young, and adult (modified from Rahayu (2011b)), regarding the characteristics of each *Hoya multiflora* category (Table 1) and visualized (Fig. 2). The morphological distinguishing characters of each age category were modified for each *Hoya* species.

Table 1 Identifying mark of the individual age classes of *Hoya* (Rahayu 2011b)

| No. | Age Classes | Characteristics |
|---|---|---|
| 1. | Seedling | Location of leaves on the stem: 1-1* |
| 2. | Young | Location of leaves on the stem: 2-2 and face to face** |
| 3. | Adult | There is a flower stalk that grows between two petioles*** |



(a) seedling (b) young (c) adult

Figure 2 Visualized characteristics of every age class in table 1: a. seedling; b. young; c. adult

**Data Analyses**

Analyses of the population structures based on age categories were carried out using the Microsoft Excel Program 2007. The results of the calculations were presented in age pyramids. The population distribution patterns were analyzed using Morisita's Index based on the results of data collection from vegetation analysis (Morisita 1959). The *Hoya*'s distribution map at the BNCEC was analyzed qualitatively.

Morisita's Index of dispersion (Morisita 1959) is as follows:

$$Id = n \frac{(\Sigma x^2 - \Sigma x)}{(\Sigma x)^2 - \Sigma x}$$

where:
*Id* = Morisita index of dispersion
n = number of observations
x = number of individual plants

The patterns of distribution were defined by Chi-square test as follows:

$$Mu = \frac{X^2_{0,975} - n + \Sigma x_i}{(\Sigma x_i) - 1} \text{ for uniform pattern,}$$

$$Mc = \frac{X^2_{0,025} - n + \Sigma x_i}{(\Sigma x_i) - 1} \text{ for clumped pattern,}$$

where:
Mu = Morisita's Index of dispersion for a uniform pattern
Mc = Morisita's Index of dispersion for a clumped pattern
$X^2_{0,975}$ = Chi-square at df (n-1), 97.5%
$X^2_{0,025}$ = Chi-square at df (n-1), 2.5%
$\Sigma x_i$ = Number of individual plants at sample unit –i
n = Number of sample units
Morisita's Index (IP) was measured by four formulas, as follows:

1. If Id ≥ Mc > 1.0 :

$$Ip = 0.5 + 0.5 \left(\frac{Id - Mc}{n - Mc}\right)$$

2. If Mc > Id ≥ 1.0 :

$$Ip = 0.5 \left(\frac{Id - 1}{Mc - 1}\right)$$

3. If 1.0 > Id > Mu :

$$Ip = -0.5 \left(\frac{Id - 1}{Mu - 1}\right)$$

4. If 1.0 > Mu > Id :

$$Ip = -0.5 + 0.5 \left(\frac{Id - Mu}{Mu}\right)$$

The patterns were defined by the *Ip* number as follows:
*Ip* = 0, random pattern
*Ip* < 0, uniform pattern and
*Ip* > 0, clumped pattern

## RESULTS AND DISCUSSION

### *Hoya* Species at BNCEC

Six *Hoya* species were identified within the 11 study sites at the BNCEC, namely *Hoya multiflora*, *H. campanulata*, *H. lacunosa*, *H. imperialis*, *H. hasseltii*, and *H. vitellinoides* (Table 2) while a previous study found eight *Hoya* species at the same study area (Rahayu 2012). In this study, *Hoya coriaceae* and *Hoya latifolia* were not in the sampling plots. Their absence at the BNCEC was probably due to the activities of the people around the National Park. The monthly report of Gunung Gede Pangrango National Park (GGPNP) between 2003 and 2005 recorded deforestation and illegal activities of the people surrounding BNCEC. People took some plant species from the forest for wood carpentry, firewood, rattan wood, bamboo, ferns, and as ornamental plants (Sudomo & Siarudin 2008). Accordingly, the disappearance of a species and natural ecosystem is influenced by human behavior and decisions, so that people are responsible for the destruction of the natural habitats (Alikodra 2012). The local people had easy access to enter the BNCEC site (Sudomo & Siarudin 2008). Moreover, there was minimal monitoring by park officials. The GGPNP official website stated that any activity related to the National Park requires permission, and this was supposedly supervised by the National Park officials (Taman Nasional Gunung Gede Pangrango 2015).

Table 2 *Hoya* species at BNCEC, Gunung Gede Pangrango National Park, Indonesia

| No. | Species of *Hoya* | Rahayu (2012) | Observation Result |
|---|---|---|---|
| 1 | *Hoya multiflora* | Present | Present |
| 2 | *Hoya campanulata* | Present | Present |
| 3 | *Hoya lacunosa* | Present | Present |
| 4 | *Hoya imperialis* | Present, (*new record*) | Present |
| 5 | *Hoya* cf. *micrantha* | Present | Present (re-identified as *H. hasseltii*) |
| 6 | *Hoya vitellinoides* | Present | Present |
| 7 | *Hoya coriacea* | Present | Absent |
| 8 | *Hoya latifolia* | Present | Absent |

Table 3 Morphological characteristics of the different age classes of *Hoya* species

| *Hoya* species | Age Class Distribution | | | | | | |
|---|---|---|---|---|---|---|---|
| | Seedling | | Young | | Adult | | |
| | Node (max) | Length of stem (cm) | Node | Length of stem (cm) | Length of stem (cm) | Node (min) | Flower &/ fruit |
| *H. multiflora* | 4 | 1-12 | ≥ 5 | 13-48 | ≥ 49 | 12 | Present |
| *H. campanulata* | 6 | 1-100 | ≥ 7 | 101-400 | ≥ 400 | 12 | Present |
| *H. lacunosa* | 7 | 1-60 | ≥ 8 | 61-100 | ≥ 101 | 12 | Present |
| *H. imperialis* | 5 | 1-80 | ≥ 6 | 81-230 | ≥ 231 | 12 | Present |
| *H. hasseltii* | 8 | 1-60 | ≥ 9 | 61-180 | - | - | - |
| *H. vitellinoides* | - | - | ≥ 4 | 101-400 | - | - | - |

## Age Classes

Differences in the morphological characteristics of the age classes were observed among the six *Hoya* species found at the BNCEC (Table 3). This age-class division was the result of a modification to Rahayu's (2011b) research in calculating the number of *H. multiflora* individuals at the GGPNP.

The individuals of the six *Hoya* species were classified as seedling, young, and adults based on morphological characteristics (Table 3). The *Hoya* species at the BNCEC has two types of rods, the determinate and the indeterminate ones (Rahayu 2010). Indeterminate plants were characterized by the growth of the leaf nodes at the top end of the stem, even while the plants have just begun to bloom (Adisarwanto 2005). Thus, the node became one of the observable morphological characteristics of the *Hoya* species. In the seedling age class, *H. multiflora* species had the lowest number of nodes (4 nodes) while *H. hasseltii* has the highest (8 nodes). In the young age class, *H. vitellinoides* has the lowest number of nodes (4 nodes) and *H. hasseltii* has the highest (9 nodes). In *Hoya*'s life phase, the number of nodes and the length of stems in the seedling and young classes generally has a germination period of 1-2 days, and the first 10 leaves appear within 4-6 months after germination (Rahayu 2010).

In the seedling class, *H. multiflora* species has the shortest stem length, which was in the range of 1-12 cm while *H. campanulata*, has the longest stem length (1-100 cm). In the young class, *H. multiflora* has the shortest stem (13-48 cm), while *H. campanulata* and *H. vitellinoides* respectively has the longest stems (101-104 cm). In the adult phase, *H. multiflora* has the shortest stem length, (≥ 49 cm) while *H. campanulata* has the longest stem length (≥ 400 cm).

The adult class differed in their morphological characters with the presence of flowers and/or fruits. Four of the six *Hoya* species at the BNCEC were found to have individuals in all age categories. The adult individuals of *H. multiflora, H. lacunosa*, and *H. campanulata* were already bearing flowers and fruits while those of *H. imperialis* were still producing flower buds.

The adult age class of *H. multiflora* were already producing branches coming out of the main root. These results confirmed Rahayu's (2010) findings that the 1.5-2 years old adult *Hoya* individuals were already growing root branches. The flowering of *Hoya* plants occurred almost throughout the year, starting after the plant is 1.5-2 years old. Its flowers developed from buds to blooms in over a month, and the blooms finished after 4 -14 days, depending on the species. *H. multiflora, H. campanulata,* and

Table 4 The number of individuals based on age class of *Hoya* species at BNCEC

| No. | *Hoya* Species | Age Class Distribution | | | Total Number |
|---|---|---|---|---|---|
| | | Seedling | Young | Adult | |
| 1 | *Hoya multiflora* | 40 | 48 | 136 | 224 |
| 2 | *Hoya campanulata* | 77 | 55 | 22 | 154 |
| 3 | *Hoya lacunosa* | 46 | 15 | 39 | 100 |
| 4 | *Hoya imperialis* | 6 | 3 | 1 | 10 |
| 5 | *Hoya hasseltii* | 2 | 3 | 0 | 5 |
| 6 | *Hoya vitellinoides* | 0 | 5 | 0 | 5 |
| | Total | | | | 498 |

*H. lacunosa* produced fruits in August, while Rahayu (2010) recorded the fruit-bearing period of *Hoya* from October to December.

The age class categorization was based on the morphological characteristics of the six *Hoya* species at the BNCEC (Table 1, Rahayu 2011b). *H. campanulata* has the most numbers of seedlings (77 individuals), whereas *H. vitellinoides* did not have any seedling. *H. campanulata* has the largest number of youngs (55 individuals), whereas both *H. imperialis* and *H. hasseltii* have the smallest (3 young individuals). *H. multiflora* has the highest number of adults (136 individuals) while both *H. hasseltii* and *H. vitellinoides* have no adult individual. The *H. multiflora* species has the highest total number of individuals found at the BNCEC (224 individuals), whereas both *H. hasseltii*, and *H. vitellinoides* have the lowest (5 individuals) (Table 3).

## Population Pyramids

Not all of the *Hoya* species had individuals in each age class of their population structure (Fig. 3). The pyramid shape of *H. multiflora* was an inverse triangle, in which there were more adults than seedlings or young individuals (Fig. 2A) (Michael 1995). Most individuals of *H. multiflora* at the BNCEC were blooming or in the flowering stage. This blooming and flowering condition should have increased the *H. multiflora* population, yet it did not. Previous research has shown that in the Canopy Trail track, 50 individuals were found (Rahayu 2010), and different from this study, which was as many as 22 individuals. The difference is also seen in the results obtained on the Cimongkleng track there are only 15 individuals. This was less than the results of previous research which found 62 additional individuals (Rahayu 2010). The high number of adult individuals resulted in a decreased number of populations of that species (Michael 1995) so that the population is categorized as an aging population (Boughey 1973). On the other hand, it was possible that the decrease of *H. multiflora* individuals was caused by the reduction in the number of large trees as hosts in some sites at the BNCEC. This reduction might be caused by collapsing trees or intentional tree cutting for visitors' safety. Some trees grew a larger diameter and needed to be cut down. This is in line with Alikodra (2012) that the loss or damage of a species and ecosystem in nature is caused by human behavior and human decisions which are the causes of much natural damage.

The pyramid shape of *H. campanulata* and *H. imperialis* was a perfect triangle or a growing population triangle (Fig. 3B and 3C) (Michael 1995) marked by the presence of a high number of seedlings and young individuals in the population. This condition showed the potential for life and growth in both species. The presence of more young individuals than adults in a population indicated that the population will grow and increase rapidly (Michael 1995; Irwan 2003). The indications of growth, development, survival, and regeneration in nature are the characteristics of young individual species (Wirakusumah 2003). This implied that the population of *H. campanulata* and *H. imperialis* could well develop and be sustainable. The pyramid type of *H. lacunosa* was that of an hourglass shape (Fig. 3D) characterized by the high number of seedlings and adult individuals but with the lowest number in the young class.

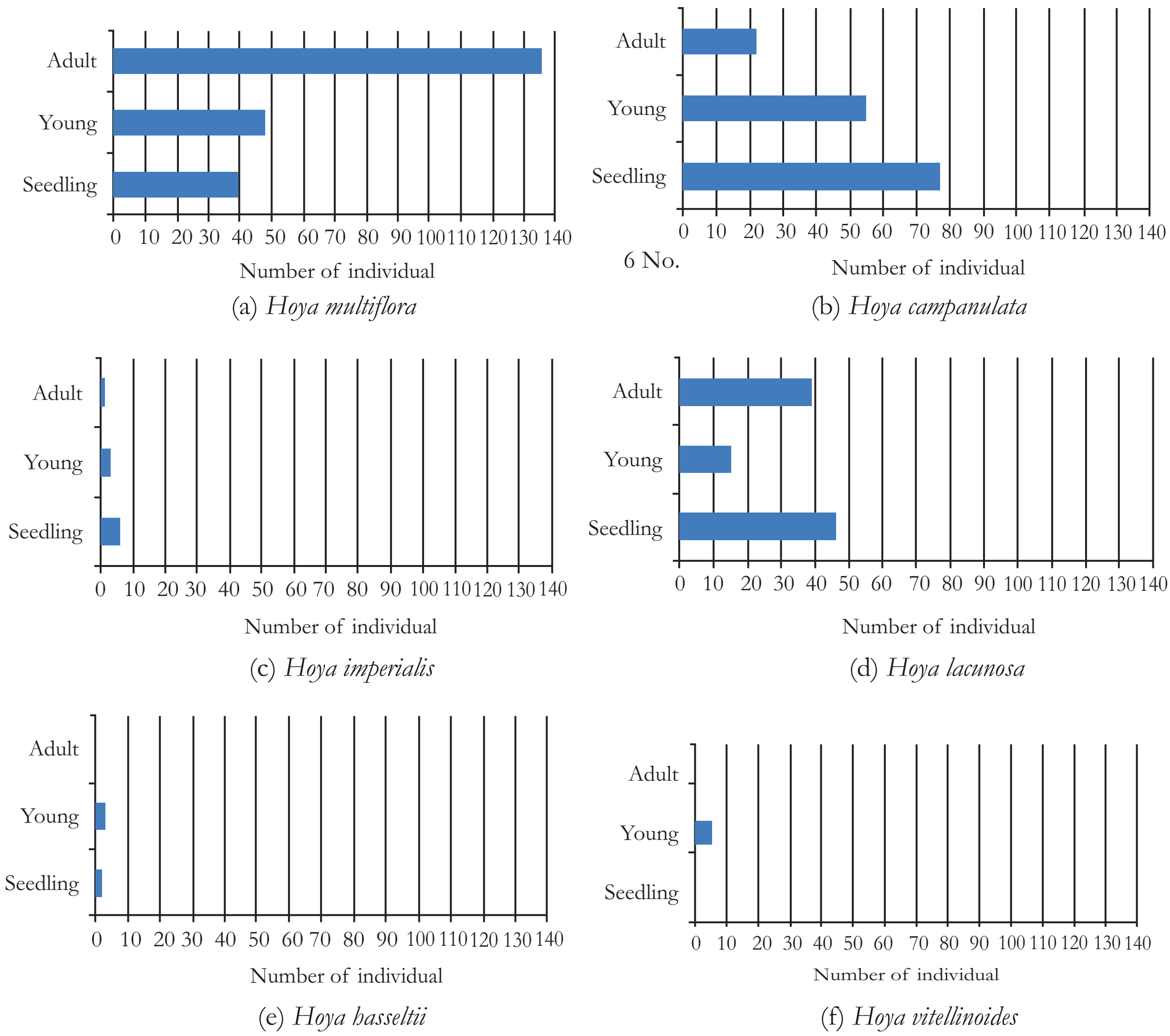



Figure 3 Population pyramids of age classes in six *Hoya* species at BNCEC: a. *H. multiflora*; b. *H. campanulata*; c. *H. imperialis*; d. *H. lacunosa*; e. *H. hasseltii*; f. *H. vitellinoides*

The higher number of seedling individuals indicates that this species has many potential individuals that would survive and grow. Whereas, a large number of adults indicated the number of productive individuals. However, a problem would arise if the seedling individuals will not survive. If this happened, the number of *H. lacunosa* at the BNCEC would decrease, yet the population will still thrive if the seedling and young individuals will survive (Wirakusumah 2003).

*H. hasseltii* and *H. vitellinoides* did not have complete individual representation at the different age categories (Fig. 3E, 3F). *H. hasseltii* had only 3 seedlings and 2 young individuals while *H. vitellinoides* had 5 youngs. The population structure of these two *Hoya* species could not be categorized as an age pyramid, resulting in an unpredictable population structure of both species. Only a population with sufficient number of seedlings and young individuals could sustain the population (Michael 1995). Furthermore, the habitats that support the development of young individuals will make the individual survive until it regenerates (Sugito 2012). In this study, *H. hasseltii* was found along slopes or elevated areas at the Long track and semi-open area, in similar areas as that of Rahayu (2012). The stability of plant population sizes could be influenced by the prevailing environmental circumstances (Boughey 1973). Hence, populations of this species could survive if they get proper support from their environment.

At the BNCEC, the five young individuals of *H. vitellinoides* were found only on one tree in the Canopy Trail. This might imply that the presence of *H. vitellinoides* was the result of seed dispersal from the adult individuals growing in the vicinity. Second, there might be a problem in the population dynamics despite that the area was an ideal habitat for the species considering that *H. vitellinoides* was found at a humid and shaded area. This result coincided with the study results of Rahayu (2012). The very few *H. vitellinoides* at BNCEC, probably represented those individuals who were not yet adult or at the reproduction stage, so, no new individual had been produced. Therefore, there was no increase in the population of *H. vitellinoides*.

## Distribution Pattern of *Hoya*

The distribution patterns computed using the Morisita's index (1959) indicated that all six *Hoya* species at the BNCEC were clumped (Table 5). The same clumped pattern was also observed in Rahayu (2010). This distribution pattern correlated with the seed type of *Hoya*. *Hoya* seeds are light and parachute-shaped. Thus, the seeds would easily fly with the wind or be carried by insects to a new location, and be perched on the moist surface of tree trunks, so that they grew on the spot. *Hoya* seeds could also disperse to two locations: the forest floor and the moist tree trunks (Lamb & Rodda 2016). The dispersion of seeds by wind can have two consequences: seeds flown away more than 10 km (*i.e.,* caused by high wind-speed), or not too far from the parental plant (*i.e.,* in low wind speed condition) (Rahayu 2010). The clustering patterns of each *Hoya* species were defined by those individuals discovered on different host trees but still within close proximity to one another, a condition that was typical in almost all of the sampled plots.

The *Hoya* species found in the study sites at BNCEC were spread in diverse habitat conditions (Fig. 4). Hence, habitat conditions, adaptation patterns, and competition in getting the nutrients required by individuals influence the sustainability of individual plants (Wirakusumah 2003).

Table 5 Distribution patterns of *Hoya* at the 11 study sites at BNCEC

| ***Hoya* species** | **Id** | **Mc** | **Ip** | **Pattern** |
|---|---|---|---|---|
| *H. multiflora* | 28 | 1.08947 | 1 | Clumped |
| *H. campanulata* | 28 | 1.14082 | 1 | Clumped |
| *H. lacunosa* | 28 | 1.25705 | 1 | Clumped |
| *H. imperialis* | 28 | 2.79933 | 1 | Clumped |
| *H. hasseltii* | 28 | 5.0485 | 1 | Clumped |
| *H. vitellinoides* | 28 | 5.0485 | 1 | Clumped |
| Amount | 9.705 | 1.04250 | 0.661 | Clumped |

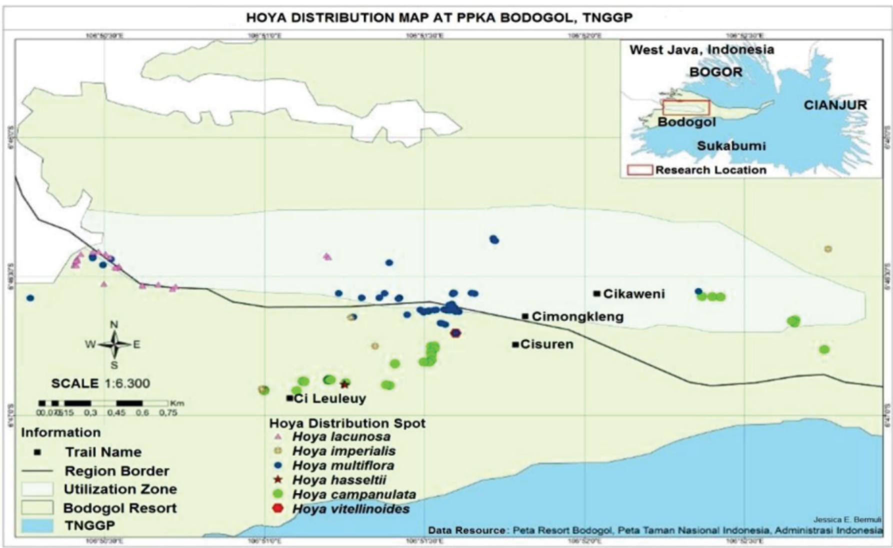



Figure 4 Distribution map of six *Hoya* species at BNCEC

## Population of *Hoya* Species

The highest number of *Hoya* species (i.e., 3 species each) was found in Cipadaranten 2 (CPD2) and Long Track (LT) (Fig. 5). *H. campanulata* was the most-frequently occurring species in both study sites. Three of the six species of *Hoya, H. multiflora*, *H. campanulata*, and *H. lacunosa* had the largest population size in the 11 study sites. *H. multiflora* was distributed in seven study sites at BNCEC with most individuals found in Cipadaranten 1. *H. campanulata* was distributed in three study sites, with most individuals found in the Long Track. *H. lacunosa* was also distributed in three study sites with Damar site having the highest number of individuals. *H. imperialis* was also found in three study sites, with Long Track and Africa sites having the most numbers of individuals. *H. hasseltii* was found only in Long Track while *H. vitellinoides* was found only in one tree in the Canopy Trail site.

Long Track and Ciparanten 2 were the areas with the greatest number of individuals of *Hoya* species as well as the sites with the most numbers of species found (i.e., 3 species each) (Fig. 5). This is probably related to the environmental conditions for growth. Generally, *Hoya* preferred moist habitats with higher temperatures, which was brought about by full sunlight exposure throughout the year. These conditions favored the survival of *Hoya* (SBG 2013). Based on this exploration, Long Track site had an average temperature of 26.8°C; average air humidity of 72.15%; average soil moisture of 64.2%; and an average light intensity of 1182.7 lux. Cipadaranten 2 site had an average temperature of 25.3°C; average air humidity of 81.8%; average soil moisture of 69%; and an average light intensity of 723.7 lux. The species data found at BNCEC and the conditions of the growth areas confirmed that *Hoya* could thrive well in an environment that provides them the mechanical and environmental support that they enjoy in their natural habitat.

## Habitat of *Hoya* Species

*H. multiflora* was found at 728 m - 876 m above sea level (asl). In a similar study (Rahayu 2012), *H. multiflora* thrived at an altitude between 700 m and 900 m asl. In this research, *H. multiflora* species were found in 7 study sites, 5 of which are different from that of Rahayu (2010). *H. campanulata* species survived at 669m - 1007m asl, *H. lacunosa* at 718 m - 784 m asl, *H. imperialis* was at 660 m - 777 m asl, while both *H. hasseltii* and *H. vitellinoides* were found at 738 m - 742 m asl. Six of the *Hoya* species at the BNCEC were found below 1,000m altitude. This low altitude region had high species diversity, which might be due to the warmer temperatures (Rintz 1978). *Hoya* thrives well in a habitat that is rich in water, such as riversides, coastal areas, swamps, and also lake areas (Rahayu 1999). Some of *Hoya* species are also be found in open or semi-open areas (Rahayu 2012). Hence, *Hoya* species were mostly found clinging on tree barks at 3 m altitude regions.

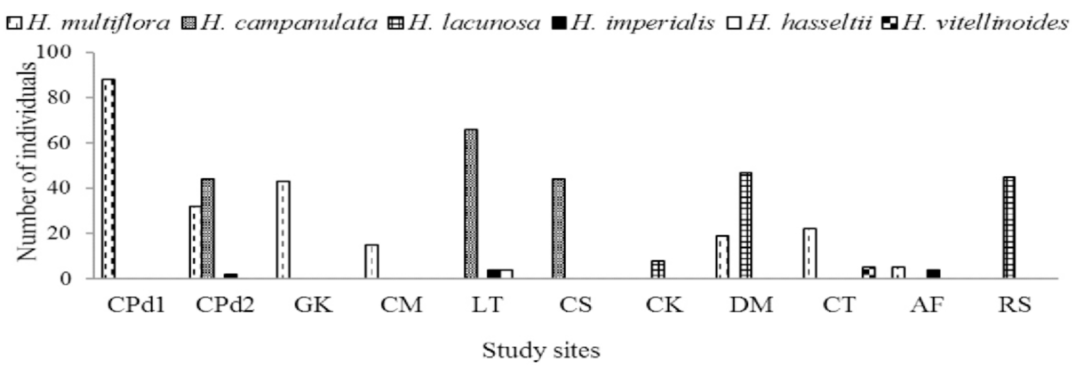



Figure 5 The number of *Hoya* species in 11 study sites at BNCEC
Notes: CPd1 = Cipadaranten 1; CPd2 = Cipadaranten 2; GK = Gombong Koneng; CM = Cimongkleng; LT = Long Track; CS = Cisuren; CK = Cikaweni; DM = Damar; CT = Canopy Trail; AF = Africa; RS = Rasamala.

**Conservation of *Hoya* Species**

*Hoya* is a plant with many beneficial roles. The beauty and uniqueness of its flowers, its medicinal values (Rahayu 2011a), and its utilization as a biological insecticide (Cahyadi 2005; Kusumawati 2005; Mukharam 2005; Rustandi 2005) has made the *Hoya* plants very important to the local people. Hence, conservation measures are needed to prevent the massive exploitation of the species. This study has shown a decline in the number of *H. multiflora individuals*. This implies some potential threats present in the species natural habitat, probably a decrease in the number of host trees, or a consequence of human disturbances. Thus, conservation efforts are necessary to protect the existence of the species. *In situ* and *ex situ* conservation strategies can be applied to *H. multiflora, H. campanulata, H. lacunosa,* and *H. imperialis* while *ex situ* conservation is suggested for *H. hasseltii* and *H. vitellinoides* because of the small number of their individuals and the lack of adult individuals. This conservation method can be done in several places, such as Bogor Botanical Gardens and Cibodas Botanical Garden. The *ex-situ* conservation method in Botanical Gardens can be in accordance with Rahayu's (2011a) thereby maintaining *Hoya* species diversity, and secondly, providing valuable information for further research on conservation measures for Hoya.

## CONCLUSION

The six *Hoya* species at the BNCEC had different population structures. The population structures of *H. multiflora* had the shape of an inverted triangle, with fewer young plants than the adults which implied a decreasing *H. multiflora* population. The population structures of *H. campanulata* and *H. imperialis* were that of a perfect triangle shape, with more young individuals than adults, implying that the populations of these two species had a good survival chance of expanding rapidly. The population structure of *H. lacunosa* was that of the hourglass shape and predicted to decrease. It had more seedling and adult plants than young ones. Adult individuals of *H. hasseltii* did not exist, whereas *H. vitellinoides* was only found as young individuals. These two *Hoya* species did not show a clear shape of population structures; therefore, its sustainability could not be predicted. However, a larger number of young individuals were expected to sustain the population.

All *Hoya* species found at the BNCEC, GGPNP, Indonesia, were dispersed in a clumped pattern (Morisita's index = 0.66). This distribution pattern coincided with the character of *Hoya* seeds that are light and parachute-shaped and the wind velocity. This condition contributed to the clumped dispersion pattern of *Hoya*.

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