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

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Running title: Population structure of *Hoya* spp. in BNCEC, GGPNP, Indonesia

ABSTRACT

Hoya is a species of flowering plants. In 2011, eight *Hoya* species were recorded at the Bodogol Nature-Conservation Education Center (BNCEC), Bogor, Indonesia. The purpose of this study is to analyze the population structure and distribution pattern of *Hoya* species at BNCEC. Data of *Hoya* were taken from July to August 2016. A purposive sampling method was used with a plot of 400m^2. The results show that the population structures of each species were different. The population structure of *H. mutiflora* was in the shape of an inverted population pyramid. It was because there were more adult individuals than those of seedling and young ones. The population structures of *H. campanulata* and *H. imperialis* were of the same type as a natural population pyramid. These pyramids show a population balance between seedling, young, and adult individuals. The population structure of *H. lacunosa* was in the shape of an hour glass, in which the sum of the seedling and adult individuals is larger than the young. There were no clear population structures of *H. hasseltii* and *H. vitellinoides*, as no adult individuals were discovered for these two species. The distribution pattern of *Hoya* populations in BNCEC was 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 plants. The indigenous people used *Hoya* as an ingredient in traditional medicine (Zachos 1998). *Hoya multiflora* Blume, one of *Hoya* species, has been researched to contain a medicinal compound that can be used in traditional medicine (Rahayu 2011a). The drug compound in *Hoya* can treat some diseases, such as 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* can also be used as a bio-insecticide that can control the growth of pre-adult *Aedes aegypti* and *Culex quinquefacsiatus* (Cahyadi 2005; Kusumawati 2005; Mukharam 2005; Rustandi 2005). *Hoya* is also known as an 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 of America as one of the exotic ornamental plants (Hodgkiss 2007).

Hoya is one of the epiphytes that live 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 forest land for community cultivation and farming. The second threat comes from the increasing use and popularity of *Hoya* in the trade market. Therefore, conservation 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 population in their habitat, the population structure of that species, its distribution, and current data on the forest serving as the habitat (Risna *et al*. 2010). Until now, the population data of *Hoya* species are very limited. Some previous studies focused more on the study of species diversity and its supporting factors. Based on Molloy and Davis' assessment criteria that were adopted and modified by Risna *et al*. (2010), population amount 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). Some distribution areas of *Hoya* in Indonesia are Sumatra, Bukit Batikap-Borneo, Mount Salak and Gunung Gede Pangrango (Rahayu 2012). Based on the research of Rahayu (2012) in Gunung Gede Pangrango National Park (GGPNP), 8 species of *Hoya* are found at the Bodogol Nature-Conservation Education Center (BNCEC). However, there is no population data for each of the species. Therefore, the records of the population amount of every *Hoya* species in BNCEC are required. Population data collection within a community is 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). Moreover, this can then be used as original data to base decisions on official conservation matters.

The purpose of research was to analyze the population structure and distribution pattern of each *Hoya* species at the BNCEC, and to visualize it on a distribution map of Gunung Gede Pangrango National Park (GGPNP). Population data of *Hoya* species are expected to be used as the baseline data for the conservation of *Hoya* species.

MATERIALS AND METHODS

Location and Time

The research was conducted in 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 (Figure 1). The data were collected from July to August 2016.

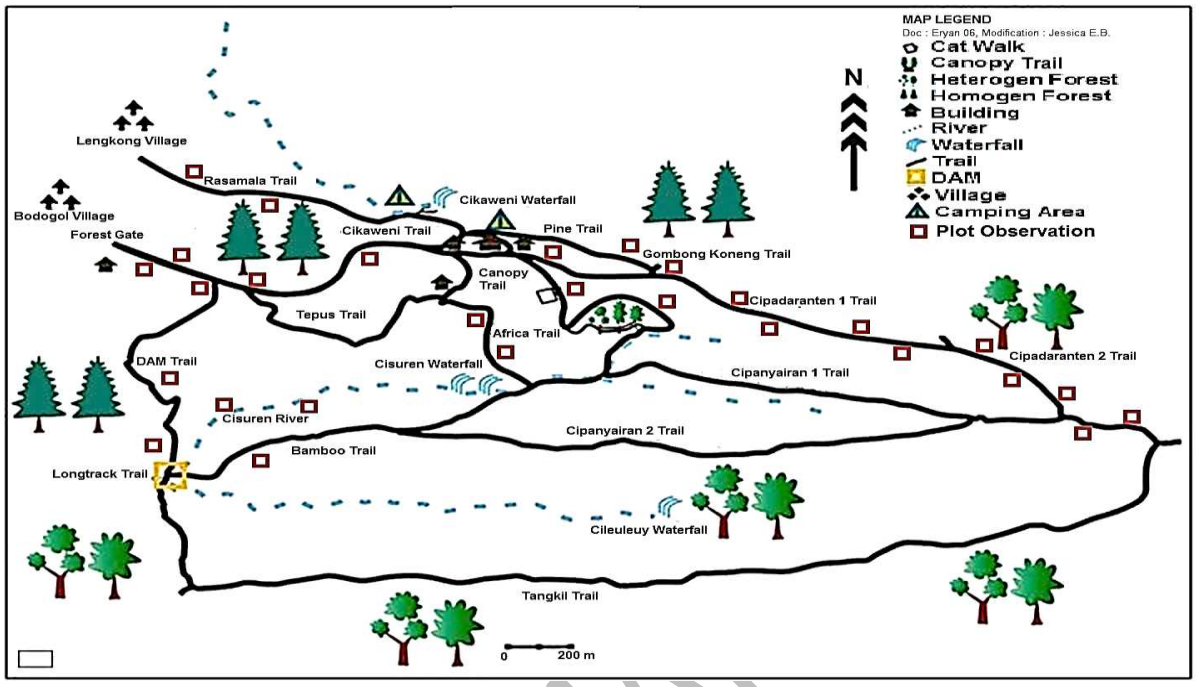

Figure 1 Sampling location at Bogor Nature-Conservation Education Center, Indonesia (Scale 100 m – modified from http://4.bp.blogspot.com/_o74cdp5DoeQ/SU8ZCh-EGAI/AAAAAAAAACw/UbANHVxkzpo/s1600-h/peta+ppkab.jpg)

Research Implementation

Research steps are:

1. Exploration

Individual *Hoya* species was searched using the exploration method (Rugayah *et al*. 2004). This exploration step was done to observe *Hoya*'s presence in 11 study sites at the BNCEC.

2. Plot observation

Populations of a *Hoya* species at the BNCEC was observed using purposive sampling (Hariyanto *et al.* 2008). A minimum of two plots of 20m x 20m each was established on each of the eleven study sites. The total number of plots was 28. The individual numbers of *Hoya* species were recorded and documented. The data of *Hoya* were recorded by calculated the individual with counted method from the main root until the end of the main stem. If that individual of *Hoya* had branched, we could count the longest stem. The information recorded included the host plant species, and dates. This information was written on a ribbon name-tag and placed on the host trees.

3. Identification of *Hoyas* species

The identification processes was conducted in two steps, *i.e*. field identification and identification based on herbarium specimen. Species identification was performed by using the

following literature by Rahayu's determination key of *Hoya* plants at the BNCEC, GGPNP (Rahayu 2012). The identification was 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 *Hoya* species were collected as a herbarium specimen and compared with the specimens at herbarium sites.

4. Classification by ages

The growth phase of *Hoya* was divided into three groups *i.e.* seedling, young, and adult (modified from Rahayu (2011b)), with reference to the characteristics of each *Hoya multiflora* category (Table 1). Morphological distinguishing characters of each age category were modified for each individual *Hoya* species.

Table 1 Identifying mark of each individual age 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

Data Analyses

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

The Morisita index of dispersion (Morisita 1959) is as follows:

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

where:

Id = Morisita index of dispersion

n = number of observations

x = number of individual plants

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

$$Mu = \frac{\chi^2_{0,975} - n + \sum x_i}{(\sum x_i) - 1} \quad \textit{for uniform pattern,}$$

$$Mc = \frac{\chi^2_{0,025} - n + \sum x_i}{(\sum x_i) - 1} \quad \textit{for clumped pattern,}$$

where:

Mu = Morisita's Index of dispersion for a uniform pattern

Mc = Morisita's Index of dispersion for a clumped pattern

$\chi^2_{0,975}$ = Chi-square at db (n-1), 97.5%

$\chi^2_{0,025}$ = Chi-square at db (n-1), 2.5%

$\sum x_i$ = 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 the BNCEC

Plant inventory showed that there are six *Hoya* species discovered, they are *Hoya multiflora*, *Hoya campanulata*, *Hoya lacunosa*, *Hoya imperialis*, *Hoya hasseltii*, and *Hoya vitellinoides* wirhin in 11 study sites (Table 2). This result was different from the previous study that found eight *Hoya* species at the BNCEC (Rahayu 2012). In this study, *Hoya coriaceae* and *Hoya latifolia* species could not be in the sampling plot at the BNCEC. It was hypothesized at the lack of these two species at the BNCEC caused by the activities of the people around the National Park. Based on the monthly data report of Gunung Gede Pangrango National Park (GGPNP) between 2003 and 2005, showed deforestation illegal activity of people around BNCEC. People took some species plant at forest, *i.e.* wood carpentry, firewood, rattan wood, bamboo, ferns, and ornamental plant (Sudomo & Siarudin 2008). According to Alikodra (2012), the disappearance of a species and ecosystem in nature is caused by human behavior and decisions, so that they are responsible for the destruction of the natural habitats. Based on observation, local people had an easy access to enter the BNCEC site (Sudomo & Siarudin 2008). Moreover, there was a minimal monitoring by park officials. The GGPNP official website stated that any activity related to the National Park requires permission and was supervised by the National Park officials (Taman Nasional Gunung Gede Pangrango 2007).

Table 2 *Hoya* species in BNCEC, at GGPNP, 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-identification as *H. hasseltii*)
6	*Hoya vitellinoides*	Present	Present
7	*Hoya coriacea*	Present	Absent
8	*Hoya latifolia*	Present	Absent

Age Classes

Observations showed that there were differences in the morphological characteristics of the age classes in 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 in the GGPNP.

Table 3 Morphological character of the age class based on the number of leaves, nodes, the presence of fruit and flowers of each *Hoya* species

Hoya species	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. campaulata	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	-	-	-

Table 3 explains the differences of morphological character in age-class of the six *Hoya* species at the BNCEC. According to Rahayu (2010), *Hoya* has two types of rods, which are determinate and indeterminate ones. Table 3 showed that six *Hoya* species at the BNCEC divided into 3 types, *i.e.* seedling, young and adult. Indeterminate plants were characterized by the growth of the leaf nodes at the top end of the stem, even while the plants have begun to bloom (Adisarwanto 2005). Thus, the node became one of the observable morphological characteristics of the *Hoya* species. The lowest and the highest node number of the seedling class were *H. multiflora* species which had 4 nodes and 8 nodes was found in *H. hasseltii* species. Meanwhile, the lowest and the highest node number of the young class were *H. vitellinoides* species which had 4 nodes and 9 nodes was found in *H. hasseltii* species. According to Rahayu (2010), based on *Hoya*'s life phase, the number of nodes and the length of stems in each class of seedling and young which generally has germination period of 1-2 days, and the first 10 leaves appear within 4-6 months after germination.

The shortest stem length of the seedling class was *H. multiflora* species, which was in the range of 1-12 cm. The longest stem length of the young class was found in *H. campanulata*, which was 1-100 cm. The shortest and longest stem length of the young class was found in *H. multiflora* (13-48 cm), *H. campanulata* and *H. vitellinoides* respectively. *Hoya multiflora* and *H. vitellinoides* had thick, round, and woody rod stems, while *H. campanulata*, *H. lacunosa*, and *H. haseltii* had long, bald, and thin stems. The shortest stem length of adult plant was *H. multiflora* species, which was more than ≥49 cm. The longest adult stem length was of *H. campanulata* species, which was ≥4 m.

The differences in the morphological characters of the adult class were 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. *H. multiflora* is the species with the highest number of flowers and fruits, followed by *H. lacunosa*, and *H. campanulata*. The adult individuals of *H. imperialis* were found to have flower buds.

The adult class of *H. multiflora* species was characterized by the appearance of branches coming out of the main root. These results are consistent with Rahayu's (2010) research which states that adult *Hoya* individuals aged 1.5-2 years old will grow root branches. The flowering period of *Hoya* plants almost occurs throughout the year, which begins after the plant is 1.5-2 years old. The flowers it developed from buds to blooms in over a month, and the blooms finished after 4 days to 2 weeks, it depended on the species. *H. multiflora, H. campanulata,* and *H. lacunosa* were found to bear fruit in August. This was not similar with the previous study. According to Rahayu (2010), period of bear fruits of *Hoya* occurred from October to December.

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

No.	*Hoya* Species	Seedling	Young	Adult	Number
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

The result of the age categorization based on the morphological characteristics for the six *Hoya* species at the BNCEC was presented in Table 4. The species with the most seedling individuals was *H. campanulata* with 77 individuals, whereas *H. vitellinoides* did not have any seedling individual. The species with the largest number of young individuals was *H. campanulata* with 55 individuals, whereas *H. imperialis* and *H. hasseltii* respectively have 3 individuals. The

247 species with the highest number of adult individuals was *H. multiflora*, with the number of 136
248 individuals. *H. hasseltii* and *H. vitellinoides* have no adult individual. The species with the highest
249 number of individuals found at the BNCEC was *H. multiflora* with 224 individuals, whereas the
250 ones with the lowest are *H. hasseltii*, and *H. vitellinoides* with 5 individuals.
251
252 **Population Pyramids**
253 Not all of *Hoya* species were found to have individuals in each age class of heir population
254 (Figure 2). According to Michael (1995), the pyramid shape of *H. multiflora* was an inverse
255 triangle, in which there were more adult individuals than the seedling or young individuals (Fig.
256 2A). The most individual of *H. multiflora* at the BNCEC is blooming and or have been in the
257 flowering stage. This blooming and flowering condition should increase the *H. multiflora*
258 population, yet it has not. It was found that there were 22 individuals in the same sampling using
259 the same canopy. In contrast, 50 individuals were found in the previous research of Rahayu's
260 (2010). There were only found 15 individuals at Cimongkleng track. It was less than previous
261 research that had found 62 individuals (Rahayu 2010). Michael (1995) stated that the high number
262 of adult individuals caused decreasing the number of populations of that species. It was possible
263 that the decrease of *H. multiflora* individuals caused by reduction in the number of large trees as
264 hosts in some areas at the BNCEC. This reduction might be caused by collapsing trees or
265 intentional tree cutting by visitors' security. It might be some trees had a larger diameter and need
266 to be cut down.
267 Based on the shape described by Michael (1995), the pyramid shape of *H. campanulata* and
268 *H. imperialis* belongs as a perfect triangle or a growing population triangle (Fig. 2B and 2C). The
269 perfect triangular shape is marked by a high number of seedling and young individuals in the
270 population. This condition shows the potential for life and growth in both species. Michael (1995)
271 and Irwan (2003) state that when there are more young individuals than adults in a population, the
272 population will grow and increase rapidly. Wirakusumah (2003) stated that indications of growth,
273 development, survival, and regeneration in nature are the characteristics of young individual
274 species. This implies that the population of *H. campanulata* and *H. imperialis* could well develop
275 and be maintained in nature.
276 Based on Figured 2D showed that the pyramid type of *H. lacunosa* has an hourglass shape.
277

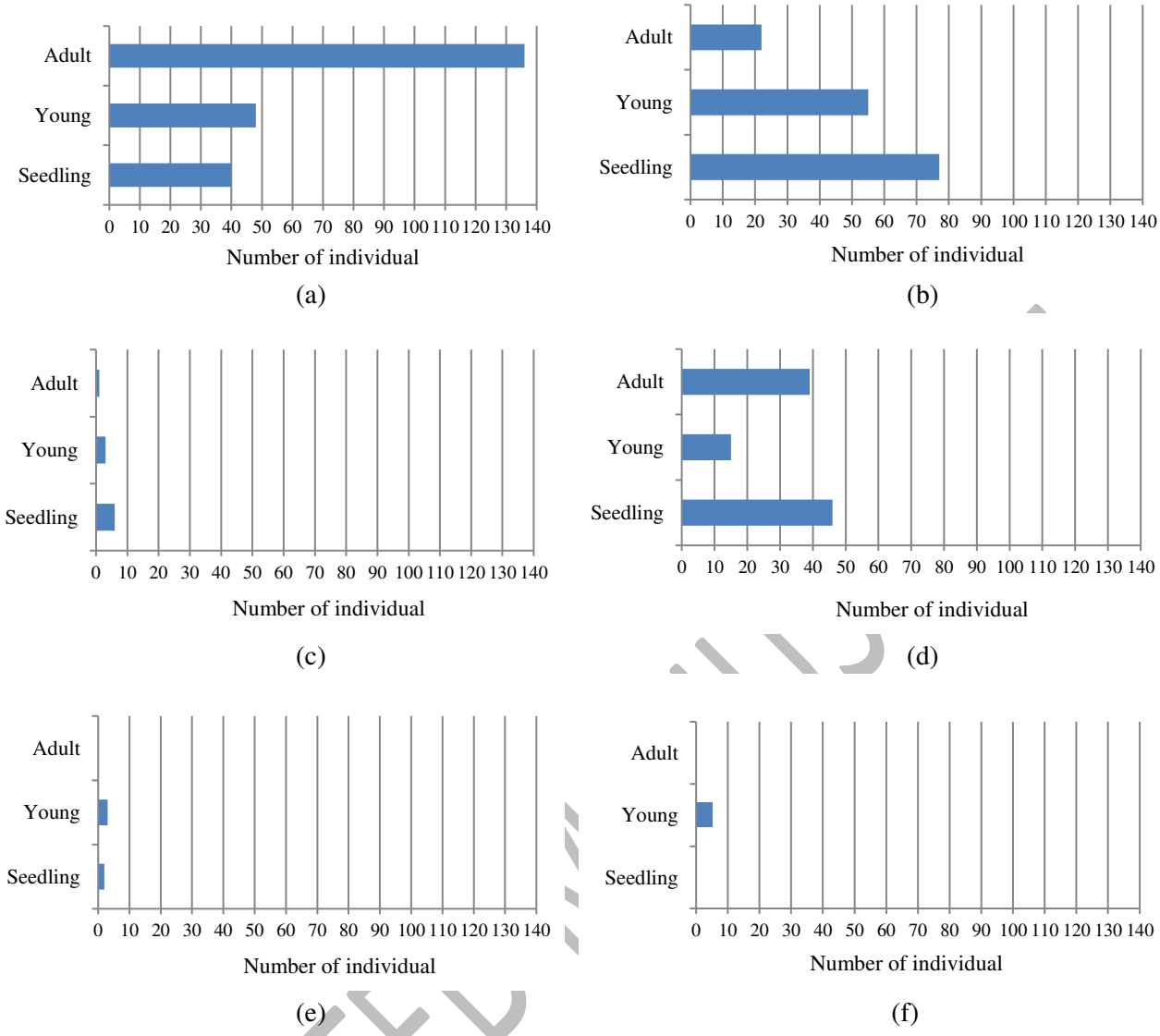

Figure 2 Population pyramids of age classes in six *Hoya* species at BNCEC: a. *H. multiflora*; b. *H. campanulata*; c. *H. imperialis*; d. *H. lacunosa*; e. *H. hasseltii*; f. *H. vitellinoides*.

The hourglass shape showed the high number of seedling and adult individuals but had the lowest number in the young class. The higher number of seedling individuals indicates that this species has many individuals that would survive and grow. In contrast, the large number of adults indicated the number of productive individuals. This would be problematic if seedling individuals would not survive. If this happened, the number of *H. lacunosa* at the BNCEC will decrease. Wirakusumah (2003) stated that the population will thrive if the seedling and young individuals survive.

Figured 2E and 2F showed that *H. hasseltii* and *H. vitellinoides* species did not have complete age categories. The population structure of these two *Hoya* species could not be visualized as an age pyramid, which created unpredictable continuation of the population of both species. Based on the data, *H. hasseltii* only has 3 seedlings and 2 young individuals. According to Michael (1995), a population with a sufficient number of seedling and young individuals, could sustain the

population. Sugito (2012) explained that habitats that support the development of young individuals will make the individual survive until regenerate. Based on the result, *H. hasseltii* was found at slopes area at Long track and semi open area and this result was the same result to Rahayu's research (2012). According to Boughey (1973), the stability of plant population size, could be seen from the constant circumstances of the environment. Based on that, populations of this species could survive if they get proper support from their environment.

At the BNCEC, *H. vitellinoides* was only found on one tree in the Canopy Trail. Five *H. vitellinoides* individuals were found and classified as young individuals. It mean that first, *H. vitellinoides* is the result of seed dispersal from the adult individuals growing in the vicinity. Second, there was a problem in the population despite the area being an ideal habitat for the species. *H. vitellinoides* was found at a humid and shaded area. This result was the same result to Rahayu's research (2012). A few number of *H. vitellinoides* in the population of BNCEC, is probably caused by individuals which are not yet adult, so new individual has not been produced. Therefore, this condition has not been able to increase the population amount of *H. vitellinoides* at the BNCEC.

Distribution of *Hoya*

The distribution patterns calculated using the Morisita's index (1959) indicated that all six *Hoya* species at the BNCEC were clumped (Table 5). This result was similar with the previous study that indicated the same clumped distribution type (Rahayu 2010). This distribution patterns correlated to the type seeds of *Hoya*. *Hoya* seeds were light and parachute-shaped. Therefore, the seeds would easily be flown by the wind or carried by insects to a new location, and perched on the moist surface of tree trunks, so that they grew on the spot. Lamb and Rodda (2016) stated that *Hoya* seeds could disperse to two locations: the forest floor and the moist tree trunks. Rahayu (2010) shows that 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). The clustering patterns of each *Hoya* species are defined when individuals are discovered on different host trees but still within close proximity to one another. This condition was found in almost all plots sampled.

Table 5 Distribution pattern of *Hoya* in 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. haseltii	28	5.0485	1	clumped

H. vitellinoides	28	5.0485	1	clumped
Amount	9.705	1.04250	0.661	clumped

330

331 The population condition of each *Hoya* species is shown by the population distribution map
332 at the BNCEC (Figure 3). *Hoya* species which were found in study sites at the BNCEC spread in
333 diverse habitat conditions. Wirakusumah (2003) stated that habitat conditions, adaptation patterns,
334 and competition in getting the nutrients required by individuals influence the sustainability of
335 individual plants.

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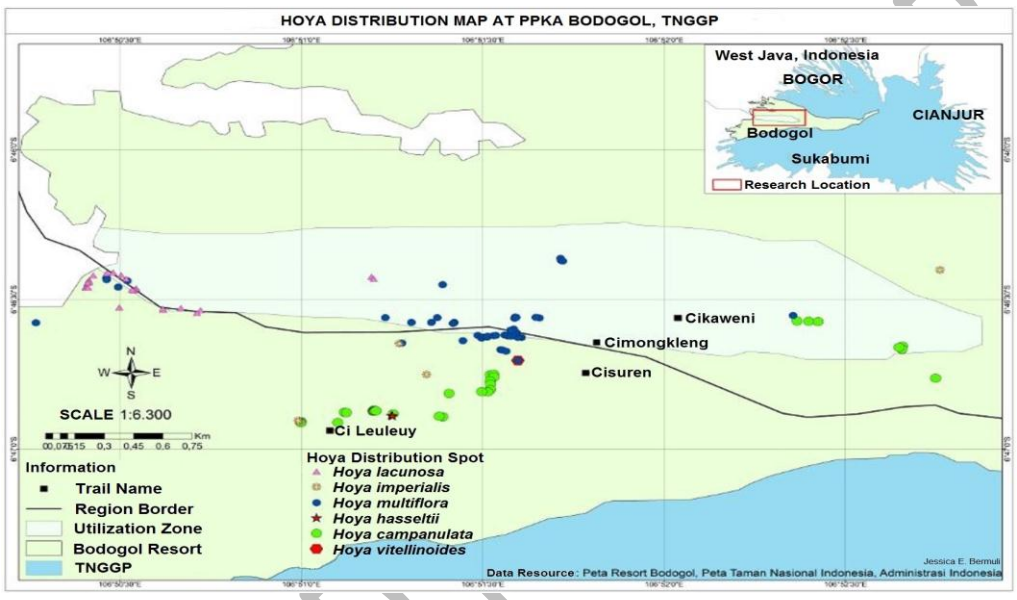

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338 Figure 3 Distribution map of six *Hoya* species at BNCEC

339

340 *Hoya* species were found in the 11 study sites at the BNCEC, GGPNP (Figure 4).
341 Cipadaranten 2 (CPd2) and Long Track (LT) were the areas with the highest number of *Hoya*
342 species (*i.e.* 3 species each). *H. campanulata* was the most-frequently found species in both study
343 sites. Three of the six species of *Hoya, H. multiflora*, *H. campanulata*, and *H. lacunosa* were the
344 species with the largest population found in these 11 study sites. *H. multiflora* was distributed in
345 seven study sites in BNCEC with most individuals found in Cipadaranten 1. *H. campanulata* was
346 distributed in three study sites, of which Long Track became the most common place where *H.*
347 *campanulata* was found. *H. lacunosa* was also distributed in three study sites. Damar site was the
348 site with the highest number of individuals for *H. lacunosa*. *H. imperialis* was found in three study
349 sites, with Long Track and Africa sites being the most common places for *H. imperialis*. *H.*
350 *hasseltii* was found only in Long Track. Lastly, *H. vittelinoides* was found only in one tree in
351 Canopy Trail site.

352 Based on the number of individuals at the BNCEC, Long Track and Cipadaranten 2 were the
353 areas with the greatest number of *Hoya* species (*i.e.* 3 species each) as well as the site with the most

number of species found (Figure 4). This might be related to the environmental conditions for growth. Generally, *Hoya* prefers moist habitats with higher temperatures, which has brought about by full sunlight exposure throughout the year. These settings condition *Hoya* to thrive (SBG 2013). Based on the 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 data between species were found at the BNCEC and the growth areas explained that *Hoya* thrives well in a habitat that gives them support.

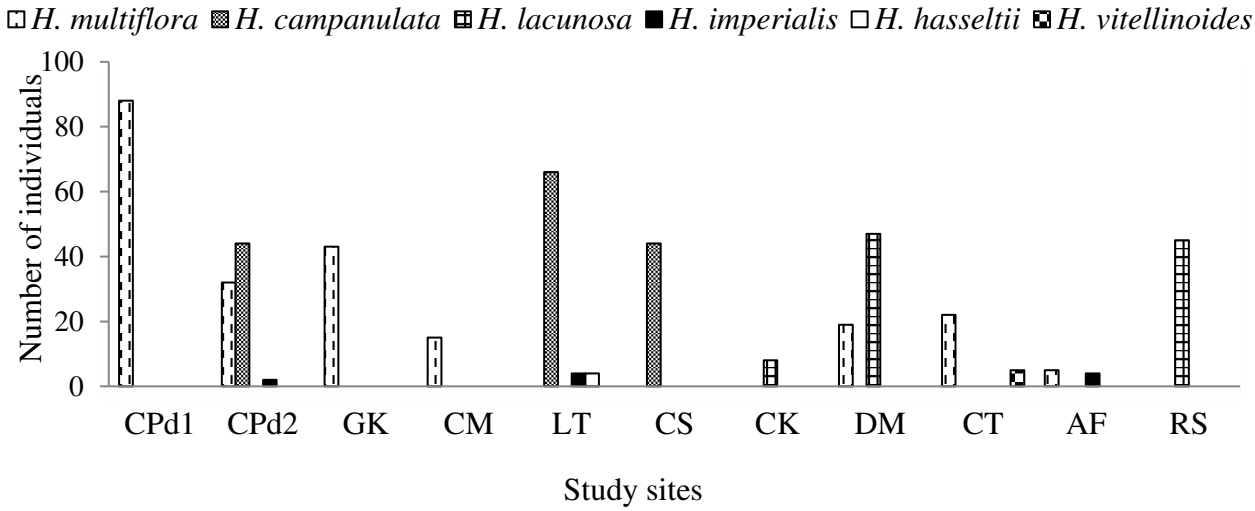

Figure 4 The number of *Hoya* species in 11 study sites at BNCEC. Study sites of exploration; CPd1= Cipadaranten 1; CPd2=Cipadaranten 2; GK=Gombong Koneng; CM=Cimongkleng; LT=Long Track; CS=Cisuren; CK=Cikaweni; DM=Damar; CT=Canopy Trail; AF=Africa; RS=Rasamala

H. multiflora was found between 728 m and maximum 876 m above sea level (asl). This was in similar with the previous study. Rahayu (2012) found *H. multiflora* that lived at an altitude between 700 m and 900 m asl (Rahayu 2012). In this research, *H. multiflora* species were found in 7 study sites, 5 of which are different from the result of Rahayu (2010). *H. campanulata* species lived between 669 m and 1007 m asl. *H. lacunosa* was found between 718 m and 784 m asl. *H. imperialis* was found between 660 m and 777 m asl. *H. hasseltii* and *H. vitellinoides* were found lived between 738 m and 742 m asl. Six of the *Hoya* species at the BNCEC were found below 1,000 m altitude. The low altitude region had high diversity of species. It might be due to the warm 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 can also be found

in open or semi open areas (Rahayu 2012). In short, *Hoya* species were mostly found in 3m altitude regions, residing on tree barks.

Conservation

Hoya is a plant species with many beneficial functions. The beauty and uniqueness of its flowers, medical roles (Rahayu 2011a), and utilization as a biological insecticide (Cahyadi 2005; Kusumawati 2005; Mukharam 2005; Rustandi 2005) make *Hoya* plants sought by the people. Conservatory actions are needed to prevent massive exploitation of the species. Based on the results, there is a decline in the number of individuals of *H. multiflora*. These imply the arising threats in the species natural habitat. Such threats may include a decrease in the number of host trees, or a consequence of disturbance by humans. Therefore, conservation efforts are needed to protect the existence of *Hoya* species. There are several conservation strategies or methods that can be implemented, *i.e. in situ* and *ex situ c*onservation. *In situ* and *ex situ* conservation strategies can be applied to *H. multiflora, H. campanulata, H. lacunosa* and *H. imperialis*. *Ex situ* conservation is suggested for *H. hasseltii* and *H. vitellinoides*, because of their small number of individuals and the lack of adult individuals. *Ex situ* conservation method can be done in several places, such as Bogor Botanical Gardens and Cibodas Botanical Garden. *Ex situ* conservation method in Botanical Gardens is in accordance with the previous study and offers two advantages as formulated by Rahayu (2011a). Firstly, the diversity of *Hoya* species can be maintained, and secondly, conservatory activities can be valuable resources for further research.

CONCLUSION

There are six *Hoya* species with different population structures, *i.e. H. multiflora, H. campanulata, H. lacunosa, H. imperialis, H. hasseltii,* and *H. vitellinoides*. The population structures from six species of Hoya were different. The population of *H. multiflora* is an inverted triangle, with fewer young plants than the adults. *H. multiflora* population is predicted to decrease. The population structures of *H. campanulata* and *H. imperialis* are in a perfect triangle shape, with more young individuals than adults. The populations of two *Hoya* species that have a good survival chance are expanding rapidly. The population structure of *H. lacunosa* is in the hourglass shape and is predicted to decrease. It has more seedling and adult plants than the young ones. Adult individuals of *H. hasseltii* did not exist, whereas *H. vitellinoides* was only found as young individuals. These two *Hoya* species do not show a clear shape of population structure, therefore its sustainability cannot be predicted. However, a larger number of young individuals will keep the population afloat.

All *Hoya* species found in the BNCEC, GGPNP, Indonesia, were dispersed with a clumped distribution pattern (Morisita's index = 0.66). This distribution pattern correlated with the *Hoya* seeds and the wind. *Hoya* seeds were light and parachute-shaped. This condition made the dispersion pattern of *Hoya* seeds was clumped.

SUGGESTIONS

With various threats to the existence of *Hoya,* both from the original habitats and from human disturbance, it is necessary to put conservation efforts for all types of *Hoya* at the BNCEC. *In situ* and *ex situ* conservation efforts are required for *H. multiflora, H. campanulata, H. lacunosa* and *H. imperialis*, while *ex situ* action is more fitting for *H. hasseltii,* and *H. vitellinoides*. *Ex situ* conservation can be carried out in botanical gardens. It targets the maintenance of the diversity of *Hoya* species contained at the BNCEC.

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