High corolla color variation of *Hoya coronaria* Blume in Belitung Island: Potential use and conservation

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Abstract. Genus *Hoya* (Apocynaceae: Asclepiadadoideae) has become popular as an ornamental plant due to the beauty of its shiny, waxy, star-shaped corolla with various color. Normally, each species has specific corolla and corona color. However, some species have variations in corolla color, for example, *Hoya coronaria* Blume. Normally, *H. coronaria* has white with pinkish dotted corolla color, rarely with red corolla color. *H. coronaria* is distributed from South Thailand, Malay Peninsula, Java, Borneo, and Sumatra as well as in Belitung Island. We surveyed the population and corolla color of *H. coronaria* in Belitung Island in June 2019. The RHS color chart was used to determine the color. We found eight accessions with different corolla and corona color variation of *H. coronaria* in Belitung Island, ranging from white, cream, pink, peach, deep pink, yellow, red, and deep red. This variation was very high, and the population of *Hoya coronaria* was well developed in the heath forest habitat of Belitung Island. Further utilization was suggested as a domesticated ornamental plant with proper characterization to support further breeding program. *H. coronaria* was also a component of the heath forest habitat of Belitung Island, which is very fragile. Thus the ex-situ and in situ conservation were suggested for sustainability.

1. Introduction

*Hoya coronaria* Blume has been used as an ornamental plant with a relatively bigger size flower, star-shaped, and bright corolla color. This species is distributed in the South East Asian countries from Thailand [1], Malay Peninsula [2], Sumatra [3, 4], Java [5], Borneo [6], and the Philippines [7]. *Hoya coronaria* is also found in Belitung Island with an abundant population incorporated with the heath forest community and habitat [8]. The *Hoya coronaria* of Belitung Island, which typically grows in the heath forest, has narrower and thicker leaves compared with *Hoya coronaria* found from Sumatra main Island, Java, and Borneo [8]. It also has a variation on corolla color. As the poten for horticulture for the ornamental plant, the color variation on the flower is necessary. The more color variation will be more interesting for people and provide more choices in horticulture and ornamental plant. Flower color is one of the important targets to improve ornamental plant breeding [9]. Humans will search for new items and tend to collect as many as they can. Many human effort have been made to pursue high variation, especially in the ornamental plant, including high color variation. High color variation in an ornamental plant will give a sort of choice and sometimes perform an interesting spectral display. Normally, the high flower color variation occurs in horticultural crops, which is well domesticated and by the effort of human activities, such as from...
hybridization and selection [9]. We seldom find natural flower color variation of a species, but sometimes nature provides variation but not as many as resulted from the human activities. The high flower color variation from the natural population will be very interesting from the ecology, genetics, and utilization perspectives. Nature corolla color usually correlates to the pollinators [10].

Hoya coronaria Blume is usually reported having white corolla and corona color, some with pinkies dots, and some have red corolla color, but rarely. Recently, we have found more corolla color variation on the Hoya coronaria’s population in Belitung Island, especially growing in the heath forest community. An intensive survey then conducted in June 2019 to complete the records from the former survey done in 2016-2017 [8]. This survey will be used for further utilization and development of the Hoya coronaria as an ornamental crop commodity. Heath forest was nearly covered by Hoya coronaria in most sites visited. The habitat of Hoya coronaria in Belitung Island is the typical heath forest, namely the “Padang” community in Belitung words. Heath forest was nearly covered by Hoya coronaria in most sites visited [8]. The heath forest of Belitung Island is very fragile. It has very limited and poor soil with the dense layer of quartz sand [11, 12]. According to the IUCN [13], this kind of habitat is categorized as an endangered ecosystem. Utilization of ecosystem components in the future, such as Hoya coronaria from the Padang community habitat, should consider the ecosystem itself. The conservation perspective will be discussed in this paper.

This study aimed to inventory the variation of flowers color variation of Hoya coronaria in Belitung Island and to analyze how to use it wisely by considering the conservation aspect of the biodiversity and ecosystem. The advantage of this study was to promote the new finding on the natural discovery of natural high flower color variation on a species.

2. Materials and methods

The variation of the corolla color of Hoya coronaria in Belitung Island was observed by field survey on the living population of Hoya coronaria. The sampling method used was purposive sampling [14] by surveying the specific habitat of Hoya coronaria in Belitung Island, i.e., the heath forest or the “Padang” community around the island [8]. The location or site with the same habitat but without Hoya coronaria population was not mentioned in this study. A total of 16 locations was surveyed, as presented in Figure 1. The difference in corolla color was determined by observing every four months in every population from 2015 – 2019.

Figure 1. Study site (1) Tanjung Pandan, (2) Tanjung Binga, (3) Tanjung Kelayang, (4) Tanjung Tinggi, (5) Ru Island, (6) Membalong, (7) Bantan, (8,9) Selu Island, (10) Penyabong, (11) Manggar, (12) Kelapa Kampit, (13) Gantong, (14) Gunung Tajum, (15) Batu Mentas, (16) Dendang.
2.1. The Population survey
The population was determined by the location distance, which is predicted to be no pollen flow from one location to the other location. The pollination of Hoya depended on the presence of pollinator insect [15], so the population was based on the longest distance of pollinator insect coverage. The pollinator insect of Hoya is from Vespidae, which had distance coverage of about 2 km [16]. In some cases, there were subpopulations in the same location. The population number was measured by the number of individuals.

2.2. Morphological assessment with emphasis to flower color
The morphological variation of Hoya coronaria in Belitung Island was merely visible on the corolla color variation. To determine the difference of corolla color variation, we used a standardized color chart, i.e., the RHS color chart. RHS color chart was emitted by the Royal Horticulture Society based in London and has been used widely on the horticultural research and practices [17].

3. Results

3.1. The variation of corolla color
Hoya coronaria is the most abundant Hoya species in Belitung Island among the Genus Hoya found in Belitung. It was found both in the mixed forest and heath forest. Typically Hoya coronaria in Belitung Island has a narrower leaf blade compared with the same species from other locations, such as Sumatra, Java, and Borneo. However, the flower is still the same, except in the variation of corolla color, which has a higher variation in Belitung Island. Belitung Island has a high variation on corolla and corona color. It was almost found in heath forest habitat, especially in the lowland area close to the beach. The flower of Hoya coronaria at Belitung Island has a relatively big size, i.e., about 3 cm in diameter and has an interesting color. The variation of the corolla color of Hoya coronaria in Belitung Island is presented in Table 1 and Figure 2.

| Corolla color | Corona color | Number of Location | Number of Plant |
|---------------|--------------|--------------------|-----------------|
| White         | white        | 5 (j,l,f,d,c)      | j=4; l=7; f=8; d=3; c=6 |
| Cream         | cream        | 4(j,k,m,e)         | j=5; k=6; m=4; e=3 |
| Peach         | pink         | 5 (a,b,e,f,n)      | a=11; b=9; e=12; f=10; n=16 |
| Pink          | pink         | 15 (all)           | More than 100 |
| Deep Pink     | pink         | 4(e,d,h,j)         | e=4; d=5; h=3; j=2 |
| Red           | red          | 3(j,n,l)           | j=3; n=3; l=2 |
| Deep red      | red          | 2 (j,k)            | j=4; k=3 |
| Yellow        | yellow       | 2 (j,f)            | j=3; f=2 |

Note: Study site (a) Tanjung Pandan, (b) Tanjung Binga, (c) Tanjung Kelayang, (d) Tanjung Tinggi, (e) Ru Island, (f) Membalong, (g) Bantan, (h) Seliu Island, (i) Penyabong, (j) Manggar, (k) Kelapa Kampit, (l) Gantong, (m) Batu Mentas, (n) Dendang.

The color variation is variable, from no color (white) to deep red and yellow. The most found color is pink, found in all observed locations with the larger population number. As the plant is climbing, so we could not count all the different individuals among the population for the pink ones. The population of Hoya coronaria with pink color is very abundant in Ru Island, which is a small island with only one house (camp). The variation of corolla color was also found in Bangka [18].

The rarest corolla color found was the yellow-colored corolla. Up to now, there is no yellow corolla color found from other places except in Belitung and Bangka Island. The yellow color of Hoya coronaria was also found in Bangka Island [18-20], which is very close to Belitung Island. Another rare color is white. The color gradient scope is from pink, peach to red and deep red is in the same scheme, but the yellow color is different. The peach color may result from the blending color of pink
and yellow. However, this assumption needs to be checked by another research, especially in genetics, by allele investigation.

Figure 2. The variation of corolla and corona color of *Hoya coronaria* from Belitung Island. A. white, B. cream, C. white- pink, DEF. peach, GHI. Pink, J-K. red, L. yellow, M-N. yellow –red.
4. Discussion
The variation in Hoya population is necessary, as found in Hoya multiflora of West Java [21], but not as much as in high corolla color variation of *Hoya coronaria* in Belitung Island. This high corolla color variation may result from a high level of natural hybridization or natural mutation. The high population density and the presence of pollinator (insect) are the factors increasing natural hybridization probability. There are some observed insects, which visited *Hoya coronaria* flowers in the natural habitat. As they are still in the same genetic pool, hybridization may occur. It occurs to the red scheme flowered plant with the white plant. The white-flowered plant is common in the natural population of colored flower plants as a result of the lack of anthocyanin [22]. On the other hand, the plant with color flower has different alleles from the red one. If the red flower is hybridized with the white color, it may result in a blending color such as pink color. The intensity of each color can be caused by genetic factors or the environment, such as the degree of pH, and so on.

Another prediction is the natural mutation in the formation of the yellow-colored flower. The mutation could occur during the meiosis process, such as deletions, duplications, and other chromosome rearrangements [23]. The mutation changes the base sequence, which will change the gene formation and the amino acid and protein (enzyme) produced. The genetic variation expressed from the corolla color of *Hoya coronaria* in Belitung Island can be developed into natural/local varieties after intensive study. The varieties can be stated as a variety if the variety has consistent characters and needs to be observed completely and intensively.

4.1. Potential use
*Hoya coronaria* Blume has been used as an ornamental plant as well as the other Hoya species internationally [6]. It is widely used as we can check it from the internet. In a paradox, this species was still found in the wild of Belitung Island due to the lack of information regarding the uses of this species. The Belitung people do not utilize the *Hoya coronaria* plant as ornamental yet till now, and most of them still do not know about the species and the use of the species. No one cultivated the species or used this species as an ornamental plant. The people in Belitung even did not yet know about this species, especially some people working on the horticulture trade (very limited person). The use of this species in Belitung is only for traditional medicine, i.e., to cure skin disease (Pulau Nangka).

The use of *Hoya coronaria* and all Hoya species as an ornamental plant has still developed since the development of the internet and social media [6]. There are many special groups created, including Hoya group, so people become easier to introduce to Hoya [7]. The Hoya group enthusiastic has grown and increased by the time, even at the countries where are no Hoya resources. For example, there is Hoya group enthusiasm in European and American countries, especially in Sweden and Florida. As they have no Hoya resources, they need to import Hoya resources from the other country. It will be a good opportunity for the country, like Indonesia, to develop a systematic Hoya trade.

The diversity and high variation of *Hoya coronaria* corolla color will be a good attraction for Hoya lovers, as there are several color schemes from one species, and this will make a good display as an ornamental plant. Developing an interesting ornamental plant is the potent of *Hoya coronaria* from Belitung, which has high corolla color variation. This idea needs to be complemented by mastering the propagation and horticulture technique of this species. *Hoya coronaria* can be propagated by seed or stem cuttings. Some experiments have been done to propagate *Hoya coronaria* in Bangka Island. Putri et al. [20] and Yulianti et al. [24] used a variation of media to propagate *Hoya coronaria* in Bangka Island. Using different light intensity also affected the flowering initiation of *Hoya coronaria* [25].

Furthermore, the high corolla color variation of *Hoya coronaria* can be developed into permanent local variety after an intensive observation and investigation.

4.2. Conservation aspect
*Rri Hoya coronaria* in Belitung Island is adapted to the heath forest in the “Padang” vegetation community. The heath forest is categorized as an endangered ecosystem by the IUCN [13]. As an important component of the heath forest in Belitung Island for the Padang community, the utilization
of *Hoya coronaria* should be considered as an ecological balance. We still do not know the important role of *Hoya coronaria* for the Padang community. Still, at least some pollinator insects and ants were observed in association with *Hoya coronaria* populations of heath forest in Belitung Island. Another study mentioned that Hoya had evolved in association with ants [26-30] and needed the presence of pollinator insects [15]. Some studies reported the role of insects as a pollinator for the Hoya plant [31, 32].

The conservation paradigm should be implemented in the utilization of this genetic variation of *Hoya coronaria*. Utilization can be developed by implementing *in situ* and *ex situ* conservation. *In situ* conservation means conserving the natural habitat so the habitat will not change into other uses. *Ex situ* conservation means transferring the species into another location as a living collection, such as Botanical Gardens or specific places, such as Hoya collection gardens in a private area, hotel, resort, or other tourist destination places. *Ex situ* conservation in a botanical garden may have some advantages, in which it can conserve the natural habitat site. Besides, new crop plants can also be studied and developed via domestication [33]. There are many tourism destinations in Belitung Island, which can be incorporated into the formation of a specific Hoya garden collection.

Another and the first choice is the presence of Belitung Botanical Garden in Manggar [34]. It has a habitat and some white varieties of *Hoya coronaria*, such as red flowers, pink and peach flowers, as well as the yellow and white flowered *Hoya coronaria*. Another choice is the location pointed as a geopark site in Belitung Island [35]. A collection of *Hoya coronaria* with a color variety will be more interesting for that place.

5. Conclusion
The variation on the corolla color of *Hoya coronaria* in Belitung Island is high. There were eight different variations of corolla and corona color, i.e., white, cream, pink, deep pink, yellow, red, deep red, and peach. The most abundant corolla color is pink, and the rarest corolla color is yellow corolla with red corona color.

6. Recommendation
The utilization of high variation of *Hoya coronaria* corolla color in Belitung Island should be developed to increase sustainable development goals, i.e., no poverty as one of the new jobs to increase trade as ornamental plants. This utilization should consider and incorporate the conservation aspects, i.e., *in situ* conservation and *ex situ* conservation. *In situ* conservation can be developed and incorporated with the Belitung Geopark, while *ex situ* conservation can be incorporated with the formation of a new botanical garden in Belitung. Another way is still possible, i.e., thematic Hoya living collection at the private or company areas. Most of the important things are to master the biological aspect of *Hoya coronaria* as well as the propagation and plant care itself. Further investigation on the genetic variation by molecular marker as the background of the morphological variation of corolla color will be very important.

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7. References
[1] Thaitong O 1994 The Genus Hoya in Thailand *Proceedings of Botany 2000 ASIA International Seminar and Workshop* Melacca, Malaysia
[2] Rintz R E 1978 The peninsular Malaysian species of Hoya (Asclepiadaceae) *Malay Nat J.* 30(3/4): 467-522
[3] Rahayu S and Wanntorp L 2012 Notes on the species diversity of Hoya (Apocynaceae-Asclepiadoideae) of Sumatra *Asklepios*. 113: 17-25
[4] Rahayu S and Rodda M 2019 Hoya of Sumatra, an updated checklist, three new species, and a new subspecies *European J. Taxonomy*. 508: 1–23
[5] Backer C A and Bakhuizen van der Brink R C B Jr 1965 Flora of Java Vol II. P. (Noordhoff: Groningen) p 641
[6] Lamb A and Rodda M 2016 A Guide to Hoyas of Borneo (Sabah: Natural History Publications) p 204
[7] Aurigue F B 2013 A collection of Philippine hoyas and their culture (Los Baños: Laguna) p 114
[8] Rahayu S, Fahrurrazzi Y and Putra H F 2018 Hoya species of Belitung Island, Indonesia, utilization and conservation Biodiversitas. 19(2): 369-76
[9] Rosati C and Simoneau P 2006 Metabolic engineering of flower color in ornamental plants: a novel route to a more colorful world J. of Crop Improvement. 18(1): 301-24
[10] Dafni A, Tzhori H, Ben-Shlomo R, Vereecken N J and Ne’eman G 2020 Flower colour polymorphism, pollination modes, breeding system and gene flow in Anemone coronaria Plants. 397(9): 1-18
[11] Proctor J 1999 Heath forests and acid soils Bot J Scotland. 51: 1-14
[12] Oktavia D, Setiadi Y and Hilwan I 2015 The comparison of soil properties in heath forest and post-tin mined land basic for ecosystem restoration Procedia Environmental Sciences. 28: 124-31
[13] IUCN 2014 Guidelines for Using the IUCN Red List Categories and Criteria. Version 10.1. Prepared by the Standards and Petitions Subcommittee. [Online] accessed from http://www.iucnredlist.org/documents/RedListGuidelines.pdf
[14] Etikan I, Musa S A and Alkassim R S 2016 Comparison of convenience sampling and purposive sampling American J. of Theoretical and Appl. Statistics. 5(1): 1-4
[15] Rintz R E 1980 The biology and cultivation of Hoyas Asclepiadaceae. 19: 9-17
[16] Chasanah L R 2010 The diversity and frequency of visiting insect pollinators and their effectiveness in fruit formation of Hoya multiflora Blume (Asclepiadaceae) (in Indonesian) [Thesis] (Bogor: Bogor Agricultural University) p 48
[17] Griesbach R and Austin S 2005 Comparison of the Munsell and Royal Horticultural Society's color charts in describing flower color Taxon. 54(3): 771
[18] Deswanti P, Fahrurrozi Y and Rahayu S 2017 Morphological characterization of leaves and flowers of several varieties of Hoya coronaria (Apocynaceae:Asclepiadoideae) from Kerangas Forest area, Air Anyir Bangka (in Indonesian) Jurnal Ekotonika. 2(1): 1-9
[19] Anisa R, Fahrurrozi Y and Rahayu S 2017 Flowering process of several varieties of Hoya coronaria dari from Kerangas Forest area, Air Anyir, Bangka (in Indonesian) Jurnal Ekotonika. 2(1): 10-19
[20] Putri B F, Fahrurrozi Y and Rahayu S 2018 Effect of different types of growing media on Hoya coronaria yellow flower plant cuttings growth from Kerangas Forest area, Air Anyir, Bangka (in Indonesian) Jurnal Ekotonika. 3(1): 20-28
[21] Rahayu S, Juusuf M Suharsono Abdulhadi R and Kusmana C 2010 Morphological variation of Hoya multiflora Blume at different habitat type of Bodogol Research Station of Gunung Gede Pangrango National Park, Indonesia (in Indonesian) Biodiversitas. 11(4): 187-93
[22] Iwashina T 2015 Contribution to flower colors of flavonoids including anthocyanins : a review Nat. Product Com. 10(3): 529-544
[23] Cai X and Xu S S 2007 Meiosis-driven genome variation in plants Current genomics. 8(3): 151−61
[24] Yulianti I, Fahrurrozi F and Rahayu S 2018 Growth of varieties Hoya coronaria plant cuttings from Kerangas Forest area, Air Anyir, Bangka (in Indonesian) Jurnal Ekotonika. 3(1): 1-10
[25] Robika and Henri 2020 Growth of Hoya coronaria from Kerangas Forest on different light intensity (in Indonesian) Jurnal Al Kauyvah. 13(1): 105-15
[26] Rahayu S, Qoyim I and Astuti N B 2007 Interaction between Hoya diversifolia Blume (Asclepiadaceae) and ants (Formicidae) in Bogor Botanical Garden (in Indonesian) Bulatan Kebun Raya. 10(2): 60-66
[27] Apriani R 2010 Ants diversity on Hoya multiflora in Bodogol, Gunung Gede Pangrango National Park (in Indonesian) [Thesis] (Bogor: Institut Pertanian Bogor)
[28] Kiew R and Anthonysamy 1996 Ant-garden and ant-tree association involving *Dischidia* species (Asclepiadaceae) in Peninsular Malaysia *Proceedings of Botany 2000 ASIA Intern Seminar and Workshop*. Malacca pp 95-102

[29] Kleijn D and van Donkelaar R 2001 Notes on the taxonomy and ecology of the genus Hoya (Asclepiadaceae) in Central Sulawesi *Blumea* 46: 457-483

[30] Weissflog A, Moog J, Federle W, Wernr M, Hashim R and Maschwitz U 1999 *Hoya mitrata* Kerr. (Asclepiadaceae): a new myrmecotropic epiphyte from Southeast Asia with a unique multi-leaved domatium *Ecotropica* 5: 221-25

[31] Forster P I 1992 Pollination of *Hoya australis* (Asclepiadaceae) by *Ocibadistes walkeri* Sotis (Lepidoptera: Hesperiidae) *Austr Entomol Mag* 19: 39-43

[32] Meve U and Liede S 1994 Pollination in Stapeliads-new results and a literature review *Plant Systematics and Evolution* 192: 99-116

[33] Frankel O H and Soul M E 1991 *Conservation and Evolution* (Cambridge: Cambr. Univ. Press)

[34] Perda Kab_Beltim No. 8 Tahun 2016 Penyelenggaraan Kebun Raya Daerah [Online] accessed from https://peraturan.bpk.go.id/Home/Details/11878/perda-kab-belitung-timur-no-8-tahun2016.

[35] Dinas Kebudayaan dan Pariwisata 2018 Recent *Recent report on Geopark in Pulau Bangka dan Belitung (in Indonesian)* [Bangka: Pemerintah Provinsi Kepulauan Bangka Belitung]