Morphological characterization of natural orchids

Dendrobium spp.

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Abstract. Dendrobium is characterized by long pseudobulbs or canes with soft leaves over the entire length, or in some species short or swollen pseudobulbs with two leathery leaves. The inflorescence is composed from dozens of flowers of different sizes and colors. This study aimed to identify the quantitative morphological character of five species of Dendrobium spp. namely D. mirbelianum, D. lamellatum from Java, D. anosmum from South Kalimantan, D. bracteosum from Papua, and D. purpureum from North Sumatera. The resulted dendrogram based on the similarity matrix were divided into two clusters, among the five species the value of similarity coefficient is 1.50. The first cluster is only composed from D. mirbelianum, the second cluster is D. lamellatum, D. purpureum, D. bracteosum, and D. anosmum which have more distant relationship with the other three orchids. Moreover, D. lamellatum and D. purpureum have the closest similarity coefficient with 0.81 value, which have bigger chance to use as the parents for hybridization. There are many Dendrobiums spp. distribution which based on the relationship area. In addition to quantitative properties, it also needs to be expanded to qualitative, anatomy, cytology, and also molecular characteristic to have more comprehensive data.

1. Introduction

Due to the wide variety of orchids in the world, currently orchids are rapidly developed as ornamental plants in Indonesia. Most of the orchids species are coming from Indonesian. Until now, these genetic resources have not been optimally used as parents to produce offspring according to the characteristics required by consumers. Characterization itself is a method for qualitatively and quantitatively determining the plant traits. The changes in the properties of orchid plants were used to identify the genetic components related to orchid morphology and flowering time, this usually caused by changes in the protein activity and gene expression [1].

Dendrobium is composed of 1600 kinds of sympodial epiphytic orchids. The genus is characterized by long pseudobulbs or canes with soft leaves over the entire length, or in some species, short or swollen pseudobulbs, ending in two bearish leaves. The inflorescence is terminal or near terminal, arranged into one to dozens of flowers with extremely different sizes and color ranges. Dendrobium is very popular as cut flowers and interior scenes. They are also valuable as potted plants and hanging pots. Many orchid
species are hang on the branches or walls to cover the exposed branches and walls [2].

Morphological identification is the process of determining the phenotypic characteristics of plants by inspecting the leaves, stems, and flowers of plants, covering all the morphologies of plants, and understanding the genetic relation among some species. One method that can be used to determine the genetic relationship between individual plants is to identify the characteristics of each plant. When formulating a conservation strategy for cultivating, using, and managing plant genetic resources in a sustainable manner, it is necessary to understand plant genetic diversity information at the level of individual species or populations as a basis consideration. The diversity of orchids can be seen in the diversity of colors, shapes and sizes of orchids. In addition to looking at the diversity of flower shapes and sizes, the diversity of flowers can also be seen from the pollination process of the flowers themselves [3].

The study of morphological characteristics in the current study aimed to determine the morphological characteristics and relationships of the five orchids in the genus Dendrobium in Indonesia. Due to its high economic value, there must be an act to save that Dendrobium from the extinction. The orchid cultivation process takes long time, therefore faster cultivation process and mass production are required [4]. The most important factor for the success of inter-species plant hybridization programs is the genetically related species. Hybridization between closely related species will increase successful hybridization changes. The morphological characteristics can be use as reference to study the genetic relationship of biological populations, hence the knowledge of the morphological diversity of orchids is of great significance to determine the protection or commercial purpose of orchids hybrid plant [5].

2. Materials and methods

The study of morphological characterization was conducted at Bogor Botanic Gardens (Center for Plant Conservation - Botanic Gardens) currently operated by Indonesian Institute of Sciences (LIPI). Five kinds of Dendrobium spp. (D. mirbelianum, D. lamellatum, D. anosmum, D. bracteosum, and D. purpureum) were explored in this study. All the Dendrobium are the collections of The Bogor Botanic Gardens.

The quantitative observation of Dendrobium spp. consisted of 20 characters that are length, width, and thickness of the leaves, then the length, width, and thickness of the pseudobulb, in the flower part including length and width, in sepal part are length of dorsal, width of dorsal, length of lateral, width of lateral, in petal part are length and its width. The length of flower stalk, structure flower length, flower stalk diameter, flowers bloom duration, flower bud amount, and flower stalk amount also measured in this study. To characterize the morphological feature, scoring data which developed by BALITHI (Indonesian Research Institute of Decorative Plants) were applied [6].

The similarity of the morphological data derived from the score data of each orchid plant was processed using the quantitative data Similarity of Interval (SimInt). The next method used is Sequential Hierarchical and Nested Clustering (SAHN), and the result is based on the input matrix data. The Unweighted Pair Group Method Arithmetic Average (UPGMA) method was used for group analysis of plant samples, and the NTSYSpc 2.02i version (Numerical Classification and Multivariate Analysis System Program) also used to analyze the obtained data [7].

3. Results and discussion

Characterization is the activity in germplasm preservation to determine the morphological characteristics that can be used to distinguish germplasm, assess the degree of genetic diversity, identify the species, and to evaluate the number of germplasm [5]. The dissimilarities in vegetation characteristics are affected by environmental components and the germplasm ancestor habitats [8].

According to Table 1, among other orchids, D. mirbelianum seems to have highest average of leaves length, width, and thickness of pseudobulb, but the average number of florets (14) of this species is smaller than that of D. anosmum. The average number of D. anosmum florets is 26, which is the most compared to other orchid varieties. Similarly, the flower size of D. anosmum is often larger than that of D. mirbelianum, D. lamellatum, D. bracteosum and D. purpureum, and its dorsal sepal area and lateral
sepal length × width are the largest in average compared with other orchids. This indicates the leaf area does not determine the size and number of flowers. Dendrobium differs from the others in that it has lateral lip flowers and sepals. The elders’ characteristics and diversity are needed as a source of superior qualities to be merged in an effort to increase plant quality through hybridization [9].

Table 1. Morphological characters based on qualitative data.

| Character                      | Quantitative data |
|--------------------------------|-------------------|
|                                | *D. mirbelianum*   | *D. lamellatum*   | *D. anosmum*   | *D. bracteosum* | *D. purpureum* |
| Leaf length                    | 19 cm             | 9.13 cm           | 7.8 cm         | 7.8 cm          | 11.4 cm        |
| Leaf width                     | 5.5 cm            | 2.4 cm            | 1.9 cm         | 1.1 cm          | 3 cm           |
| Leaf thickness                 | 0.1 cm            | 0.1 cm            | 0.1 cm         | 0.1 cm          | 0.1 cm         |
| Pseudobulb length              | 17 cm             | 2.5 cm            | 11 cm          | 5.5 cm          | 3 cm           |
| Pseudobulb width               | 2.5 cm, 0.9 cm    | 1.48 cm           | 0.9 cm         | 0.59 cm         | 0.79 cm        |
| Pseudobulb thickness           | 2.5 cm, 0.8 cm    | 0.5 cm            | 0.8 cm         | 0.54 cm         | 0.76 cm        |
| Flower length                  | 3.2 cm            | 1.5 cm            | 6 cm           | 2.3 cm          | 1.4 cm         |
| Flower width                   | 4.9 cm, 1.35 cm   | 5.5 cm            | 2.5 cm         | 0.5 cm          |                |
| Length of dorsal sepal         | 2.3 cm, 0.9 cm    | 3.8 cm            | 1.5 cm         | 0.5 cm          |                |
| Width of dorsal sepal          | 0.8 cm, 0.6 cm    | 0.7 cm            | 0.4 cm         | 0.2 cm          |                |
| Length of lateral sepal        | 2 cm, 1.2 cm      | 3.8 cm            | 1.7 cm         | 1 cm            |                |
| Width of lateral sepal         | 0.7 cm, 0.7 cm    | 0.8 cm            | 0.4 cm         | 0.4 cm          |                |
| Length of petal                | 2.5 cm, 0.8 cm    | 3.5 cm            | 1.2 cm         | 0.5 cm          |                |
| Width of petal                 | 0.7 cm, 0.4 cm    | 1 cm              | 0.25 cm        | 0.2 cm          |                |
| Length of flower stalk         | 23 cm, 0.2 cm     | 3 cm              | 0.2 cm         | 0.2 cm          |                |
| Length of structure flower     | 21 cm, 0.2 cm     | 3.3 cm            | 3 cm           | 0.5 cm          |                |
| Diameter of flower stalk       | 0.35 cm           | 0.08 cm           | 0.3 cm         | 0.1 cm          | 0.2 cm         |
| Flowers bloom duration         | 60 days           | 14 days           | 9 days         | 40 days         | 30 days        |
| Number of flower bud           | 14                | 6                 | 26             | 8               | 22             |
| Number of flower stalk         | 3                 | 5                 | 1              | 1               | 7              |

Table 1 shows the length × width of the dorsal sepal, lateral sepal, and lip of *Dendrobium* spp. orchids. It is determined that they have diversity with each other. *D. mirbelianum* has dorsal and lateral sepals’ cross section, respectively $2.3 \times 0.8$ cm and $2 \times 0.7$ cm, *D. lamellatum* has $0.9 \times 0.6$ cm and $1.2 \times 0.7$ cm, *D. anosmum* has $3.8 \times 0.7$ cm and $3.8 \times 0.8$ cm, *D. bracteosum* has $1.5 \times 0.4$ cm and $1.7 \times 0.4$ cm, and *D. purpureum* has $0.5 \times 0.2$ cm and $0.2 \times 1$ cm. The largest dorsal and lateral sepals’ cross section are *D. anosmum*, and the smallest dorsal and lateral sepals’ cross section are *D. purpureum*. There are dissimilarities in the size of the dorsal and lateral sepals of the *Dendrobium* orchid species. The dissimilarities that exist going to make particularities in vegetation’s.

Leaves amount per plant is greatly affected by the diversifications. Leaf is the primary organ that absorb the sun’s rays when forming substrates during photosynthesis. The bigger number of leaves, the total value of the leaves area will increase, which will act on the growth of vegetation. Leaves area ratio and net assimilation ratio have relations with the leaves area, and an increase in leaves area lead to the improvement of assimilation ratio and affected to the high amount of dry weight [10]. Moreover, the leaf anatomical features can be used to determine the relationship between plants [11].

Five kinds of *Dendrobium* orchids were identified as germplasms, have different flowering duration. The flowering period of *D. mirbelianum* is the longest flowering duration which up to 2 months (60 days) blooming flowers. While the flowering period of *D. bracteosum* was 40 days, *D. purpureum* was 30 days, and *D. lamellatum* was 14 days. The *D. anosmum* has the shortest flowering duration that is 9 days of blooming flower. The long blossom on the flower is one of the traits that orchid farmers and hobbyists also paid in attention. Blooming flowers with long-lasting endurance trend to be more popular [12]. Morphological observations in order to identify the species level show that the use of labels improves the accuracy of identification compared with the use of flowers (without labellum) [13]. Each orchid exhibits different characteristics. This difference is due to the difference in habitats where orchid plants originate. The indigenous habitat of orchid plants affects the growing of orchids thru the effect of
sun’s rays, humidity, air, weather (climatic conditions), temperature, and the presences of nutritive substances infiltrated by orchid plants, thereby affecting the quantity and quality of orchid plants, also generated flowers.

The thickness of *Dendrobium* spp. pseudobulbs which are recognized is different. From the data on Table 1 the morphologic traits are based on the *Dendrobium* spp data of quantitative. *D. mirbelianum* has the bulkiest pseudobulb, with the median thickness of 2.5 cm, while *D. lamellatum* has the thinner pseudobulb, with the median of 0.5 cm on pseudobulb thickness. In the looked form, the configuration of *D. lamellatum* pseudobulb looks round, which is different from *D. mirbelianum*’s pseudobulbs in that it has an elongated javelin shape. The pseudobulbs characteristics is directly proportional to the leaves characteristics from each orchids. The bigger pseudobulbs had by the orchids, the area of the orchids leaves also get wider. The pseudobulbs in orchids even play a part in meeting the vigor requirements of the plant. The chloroplast constructed in pseudobulbs enables intensive photosynthesize processes other than leaves. As a storage medium for nutrition, pseudobulbs play a very important role in the survival and growth of orchids [14].

![Figure 1. Dendrobium spp. dendrogram based on quantitative morphological characters.](image)

Based on the *Dendrobium* spp. dendrogram, quantitative and morphological features is shown in Figure 1. The dendrogram shows that the dissimilarities coefficient value between five species of orchids are between 0.81-1.65. The genotypes of *D. mirbelianum* with other orchids showed similarity coefficient 1.65, while the similarity coefficient between *D. lamellatum* and *D. purpureum* is 0.81 as the closest relationship orchids. The similarity coefficient between germplasm shows the genetic relationship between the tested germplasms. Consistent with the previous study from Hartati et al. [15] on the hybridization of *Ceologyne pandurata* and *Ceologyne rumphii*, all hybridization results have 100% compatible results. The *C. pandurata* and *C. rumphii* plants used in this study have the highest coefficients compared to the four *Ceologyne* spp. other. Even so, the hybridization of different species of orchids can still be done, just like the successful hybridization of *Phalaenopsis* spp. and *Vanda tricolor* although these two plants belong to different genera [15].

Five species with 1.50 similarity coefficient value produced two clusters. The first cluster was composed of *D. mirbelianum* only. The second group was composed of *D. lamellatum*, *D. purpureum*, *D. bracteosum* and *D. anosmum* which have more distant relationship with other three orchids on the second cluster. The earlier study performed by Hartati and Darsana [16] showed that several general of orchids have 50 - 100% similarity in morphology. Crossbreeding on plants in the paired cluster resulted higher success rate than different vegetation’s in the cluster. Since the closer the parents are, the greater the chance of successful hybridization [17]. The current study deduces that between the five species
observed, two couples of parents have the biggest opportunity of successful hybridization.

Plant compatibility happens by reason of there is an assembly among the stamen and the pistil, thus the fruits shall be formed normally. There are plentiful of components that influenced the success percentage of hybridization, one of that is the compatibility of the pollen applied. Cross compatibility is the capability of plant to produce the fruits. The cross that produces fruit is called suitable. The overall shape of the orchids is a bit complicated. It has a stem structure called a column, and there is an anther on the top of the column, which contains a pollen called pollinarium. The stigma is located at the sub-shoots in the column called rostellum. When pollen can be inserted into the beak, pollination will be successful [18].

The orchids depend on the other plants and their biological ecosystems to survive. In the climate change era, there is still an urgent need for intensive monitoring of the diversity of this area to detect changes in the status and use of this precious forest in terms of its plant diversity. Therefore, providing baseline information on plant and orchid diversity data is a basic step in planning, and the Indonesian conservation authority should give priority to it [19].

Generally speaking, the morphological characteristics and shapes of plants are the optimum data to strict the taxonomy [8]. Right classification restrictions are accomplished by using easy-to-see characters instead of ulterior characteristics, so morphologic features may be utilized as a resource of the taxonomy. The output and the analysis of these observations using morphologic features (phenotypical features) show that morphological features as taxonomic proof are indeed good utilized to recognize and analyze the variety of nearby relations among the orchids. The above quantitative morphologic observation is the result of kinship, so environmental components and age components able to influence these plants development. Therefore, it is necessary to directly understand the characteristics of plants from the visual data information of plant morphology. The outputs of observatory data may be utilized as a resource of variety tips or means to cultivate Dendrobium orchids in the future.

4. Conclusion
The dendrogram results based on the similarity matrix are divided into two clusters and that five species have 1.50 value of similarity coefficient. The first cluster is composed of D. mirbelianum only, the second cluster is composed of D. lamellatum, D. purpureum, D. bracteosum and D. anosmum which have more distant relationship with other three orchids on the second cluster. The D. lamellatum and D. purpureum have the closest similarity coefficient with 0.81 value, hence both have bigger chance to be used as parents in hybridization. Many Dendrobium spp. classification were based on the relationship of the distribution area. In addition to quantitative traits, it also needs to expand through traits, from qualitative, anatomical, cytological, and molecular levels to get more comprehensive data.

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