Morphological characterization of natural orchids *Phaius* spp.

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Abstract. *Phaius* spp. is an orchid plant that has a large plant size with dark and striking flower color which is an attraction for *Phaius* spp. Morphological characterization of orchids is needed for the preservation of germplasm and selecting a variety of natural orchid germplasm that has superior plant and hash surface properties to be used in crossing. The study aims to identify the quantitative morphological character of 5 species *Phaius* spp. The materials used were Sulawesi *Phaius tankervilliae* and *P. indigoferus*, Papua was *P. montanus*, and Bali *P. amboinensis* and *P. callosus* which were the collection of the Bogor Botanical Garden. The result showed that the dendogram based on similarity the five species in the similarity of 1.32 produces two groups, the first group consists of *P. amboinensis*, *P. indigoferus*, *P. montanus*. The second group consist of *P. callosus* and *P. tankervilliae*. Genotype *P. amboinensis* and *P. indigoferus* showed similiarity (87%) compared to the other genotypes and have opportunity to be used as parents for crossing.

1. Introduction
Orchid is an ornamental plant that is popular with people. Orchids are recognized as an important commodity that have a huge potential, either as cut flower or potted plants [1]. Orchids belong to one group of cosmopolitan plants that are spread in almost all parts of the world, especially in the tropics. Around the world, there are about 12 countries that have made the country's natural orchids a national flower.

The *Phaius* genus orchid is considered very decorative because it has a large ornamental value with long inflorescence, larger flower sizes, and a large number of buds and different colors making it suitable for cultivation in the room [2].

The superiority of orchids is determined by the color, size, shape, and composition, a number of flower buds, length, and flower resistance [3]. *Phaius* genus orchid is one of the orchidaceae family which consists of about 30 species. *Phaius* spp. orchid plant has a large enough plant size and the dark and striking color of the flower that is an attraction for the genus *Phaius* spp.

An Orchid breeding is strived to expand genetic diversity in unique shapes and colors, favored by consumers, high-frequency flowering and resistant to disease-causing pathogens and environmental stress. Characterization is the initial activity to determine variations in vegetative and generative growth traits as well as plant morphological characteristics that aim to produce plant descriptions.
2. Materials and methods
Morphological characterization of orchids was carried out at the Bogor Botanical Gardens Conservation Center. The study was conducted from April to July 2020. The materials used were five species of Phaius spp. (P.amboinensis, P.callosus, P.tankervilliae, P.montanus, P.indigoferas) which were the collection of the Bogor Botanical Garden. Morphological characterization consisted of 30 characters using scoring data developed by Balith [4]. Data analysis was performed using the NTSYSYS program. NTSYSpc (Numerical Taxonomy and Multivariate Analysis System) version 2.02i to determine genetic distance [5].

3. Results and discussion
Genetic relationship among cultivars is a very important factor for the success of a plant crossing program. Crossing between closely related species will increase the chances of success of crossing [6]. The kinship of a population of organisms can be studied using morphological characters as a reference for characterization. According to Kasutjiananingati and Firgiyanto [7] based on the knowledge about the diversity of orchid morphology is important in determining plant breeding activities for conservation or business purposes.

Table 1. Morphological character based on quantitative data

| No | Character              | P.amboinensis | P.callosus | P.tankervilliae | P.montanus | P.indigoferas |
|----|-----------------------|---------------|------------|-----------------|------------|---------------|
| 1  | Leaf length           | 40            | 110        | 120             | 70.5       | 16.3          |
| 2  | Leaf width            | 11            | 25         | 10.3            | 10.6       | 12            |
| 3  | Leaf thickness        | 0.4           | 0.8        | 0.6             | 0.4        | 0.4           |
| 4  | Pseudobulb length     | 3.4           | 10         | 4.2             | 4.6        | 26            |
| 5  | Pseudobulb width      | 2             | 4.1        | 2.6             | 1.5        | 1.0           |
| 6  | Pseudobulb thickness  | 2             | 3.8        | 2.6             | 1.5        | 0.7           |
| 7  | Flower length         | 2.4           | 6.7        | 6.3             | 3.3        | 3.9           |
| 8  | Flower width          | 3.8           | 6          | 8.4             | 8.1        | 3.9           |
| 9  | Length of dorsal sepal| 2.3           | 5          | 5.6             | 4.9        | 2.6           |
| 10 | Width of dorsal sepal | 0.8           | 2          | 1.4             | 1.2        | 0.6           |
| 11 | Length of lateral sepal| 2.1         | 5          | 5.5             | 5.1        | 2.4           |
| 12 | Width of lateral sepal| 0.8           | 1.8        | 1.4             | 1.2        | 0.7           |
| 13 | Length of petal       | 2.2           | 5          | 5               | 4.9        | 3.2           |
| 14 | Width of petal        | 0.6           | 1.8        | 1.1             | 0.9        | 0.5           |
| 15 | Number of flower bud  | 15            | 10         | 18              | 13         | 22            |
| 16 | Length of flower stalk| 85            | 5          | 155             | 31         | 59            |
| 17 | Length of structure flower| 37       | 15         | 35              | 45         | 22.4          |
| 18 | Diameter of flower stalk| 0.9        | 1.8        | 1.9             | 1.1        | 0.2           |
| 19 | Longtime flowers bloom| 1             | 5          | 1               | 10         | 5             |
| 20 | Number of flower stalk| 2             | 1          | 3               | 1          | 2             |

Quantitative observations on the Phaius orchid species were observed as quantitative parameters: leaf length, leaf width, flower stalk length, flower arrangement length, flower stalk diameter, pseudobulb length.

Based on the table, it appears that P. callosus has the highest average leaf length, leaf width, and pseudobulb thickness among other orchids, but the average number of flower buds (10) of this species is smaller than P.indigoferas. The average number of flower buds is 47, the most compared to other orchid species. Likewise, the flower size of P. callosus tends to be greater than P.amboinensis, P. tankervilliae, P. montanus, P. indigoferas with length × width of dorsal sepal and length × width of lateral sepal which have the largest average number compared to other orchid. 

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This shows that the length and width of the leaves do not determine the size of the flower and the number of flowers [6].

Table 1, showed length × width dorsal sepals, lateral sepals, and lip (labellum) orchid _Phaius_ spp. Identified as having diversity with one another. _P.amboinensis_ has a broad dorsal and lateral sepals of 2.3 × 0.8 cm and 2.1 × 0.8 cm, _P. callosus_ 5 × 2 cm and 5 × 1.8 cm, _P. tankervilliae_ with 5.6 × 1.4 cm and 5.5 × 1.4 cm, _P. montanus_ 4.9 × 1.2 cm and 5.1 × 1.2 cm, _P. indigoferus_ 2.6 × 0.6 cm and 2.4 × 0.7 cm. The largest dorsal and lateral sepal size is owned by _P. tankervilliae_ and the smallest dorsal and lateral sepal size is _P. amboinensis_. There is a difference in size between the dorsal and lateral sepals in the orchid species _Phaius_ spp. The differences that exist will create peculiarities in plants.

Table thicknesses of pseudobulb orchid _Phaius_ spp, which are identified vary from one another. Based on the quantitative character data table 1 morphological character based on quantitative data of the _Phaius_ spp. species has an average pseudobulb thickness of 3.7 cm, _P. callosus_ has the thickest pseudobulb with an average of 3.8 cm, and _P. indigoferus_ has the thinnest pseudobulb thickness an average of 0.7 cm. In appearance, the shape of _P. montanus_ pseudobulb resembles _P. tankervilliae_ with a longitudinal cross- shaped javelin shape.

The number of leaves in each plant is strongly influenced by the variety. Leaves are the main organ that captures sunlight in the formation of substrates in the process of photosynthesis. The greater the number of leaves which also increases the total value of leaf area will affect plants' development. According to Buntoro et al [8] states that the leaf area ratio and net assimilation rate are related to leaf area, where an increase in leaf area value will cause an assimilation rate increase and result in high dry weight. The length of the flower stalk is directly proportional to the number of flower buds, the more the number of flowers the size of the flower stalk will be greater _P. indigoferus_ has the size and number of flower stalks higher than other orchids.

As a storage medium for water, carbohydrates and minerals, pseudobulb occupies a very important position for the growth and survival of orchid plants [9]. Pseudobulb in orchids also plays a role in fulfilling the energy needed by plants. The chlorophyll found in pseudobulb allows intensive photosynthesis to occur in addition to leaves [10].

_Phaius_ spp. of the 5 accessions identified as having different flowering duration for one accession. _P. indigoferus_ and _P. montanus_ have a flowering period of 10 days, while _P.amboinensis_, _P.tankervilliae_ has the same blooming period of 1 day. Long blooms on flowers are one of the characteristics that orchid collectors also notice. Flowers that have long durability tend to be more desirable [3]. To identify to species level morphological observations according to Apriyanti et al [11] suggest that using labellum increases the level of accuracy in identification compared to using flowers (without labellum). Each type of orchid shows a different character from one another. The difference occurs because of differences in habitat from the origin of the orchid plant. The original habitat of the orchid plant influences the growth of the orchid through the influence of sunlight, weather or climatic conditions, temperature, air, humidity and the availability of nutrients absorbed by the orchid plant, which in turn affects the quality and quantity of flowers produced. Hardiyanto [12] states that differences in plant properties are influenced by environmental factors and the origin of their habitat.

The dendrogram of _Phaius_ spp. based on quantitative morphology characters is presented in the Figure 1. The dendrogram shows similarities among the ten orchids are between 0.87–1.38 Genotypes of _P. amboinensis_ and _P. indigoferus_ showed similarity (87%) compared to the other genotypes. This is indicated by the similarity of the properties on the number of leaves, the length, and width of leaf size and shape of the pseudobulb. Crosses between individuals who are distantly related are likely to be small and difficult to succeed.

The five species in the similarity of 1.32 produces two groups, the first group consists of _P. amboinensis_, _P. indigoferus_, _P. montanus_. The second group consist of _P. callosus_ and _P. tankervilliae_. The study of Hartati et al [13] show that there are qualitative morphological similarities in several genera of orchids from 50–100%. According to Purwantoro et al [6] stated that the crossing carried out on
plants that are in the same cluster group will have a high success rate compared to the different plants of the group. According to Hartati et al [14] stated that the similarity of 87% in C. pandurata orchids with C. rumpeii and C. mayeriana with C. asperata have a similarity between accessions. Since the closer the parent’s genetic relationship the greater the chance of success in crossing [6,15], this study found that among the 6 species being studied, there are two pairs of parents that have most successful chance to be crossed.

![Figure 1. Dendrogram of Phaius spp. based on quantitative morphological characters](image)

Compatibility in plants occurs because there is a match between the pistil and stamens so that the fruit can form properly. Many factors can affect the success rate of crossing, one of which is the condition of the pollen used and the level of compatibility. Cross compatibility is the ability to form fruit. Crosses that produce fruit are called compatible.

Morphological characters and shape in plants in general are the best data to limit a taxon [12]. Good taxon restriction is done by using characters that are easily seen not hidden characters, therefore morphological characters can be used as a source of taxonomy. The results of the study using morphological characters (phenotypic characters) as conducted on the results and analysis of these observations indicate that morphological characters are as taxonomic evidence very well indeed used to identify and analyze the diversity of close kinship relationships between species in orchids. The quantitative morphological observations described above are the results for kinship relationships so that environmental factors and age factors can affect these plants. So that information about visual data from plant morphology is needed to know the character of the plant directly. The results of the observational data can be used as a source of diversity information for efforts to breed the Phaius spp.

4. Conclusion
Dendogram results based on similarity matrix resulted in two groups: the five species in the similarity of 1.32 produces two groups, the first group consists of P. amboinensis, P. indigoferus, P. montanus. The second group consist of P. callosus and P. tankervillae.

Genotypes of P. amboinensis and P. indigoferus showed similarity (87%) compared to the other genotypes.

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