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Short Communication: Morphological characterization of five species of *Dendrobium* native to Indonesia for parent selection

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Abstract. *Hartati S, Samanhudi, Cahyono O. 2022. Short Communication: Morphological characterization of five species of* Dendrobium *native to Indonesia for parent selection. Biodiversitas 23: 2648-2654.* As one of the most plentiful orchid genera, *Dendrobium* has a potential genetic resource for crossing programs. Morphological characterization is an important step in determining genetic relationships among orchid species in the same genus. The research aims to identify the morphological characteristics of five species of Indonesian *Dendrobium* in order to assess the potential cross elder candidates. The materials used in this study were *D. mirbelianum* Gaudich., *D. lamellatum* (Blume) Lindl., and *D. anosmum* obtained from Bogor Botanic Gardens; and *D.bracteosum* Rchb.f. and *D. purpureum* obtained from Klaten Speci Gardens. This study recorded 30 morphological characters of *Dendrobium* studied. There were 23 out of the 30 identified morphological characters (76.67%) that showed varying characters in flowers, leaves, pseudobulbs, and roots. Based on the cluster analysis, five species of *Dendrobium* are separated into two clusters and cluster division does not correlate with the section of *Dendrobium.* The species with the highest similarity coefficient has the potential to be used as parental in crosses. *Dendrobium lamellatum* and *D. anosmum* have the highest similarity coefficient of 0.80 and are the most potential as parental species for crossing, followed by *D. bracteosum* and *D. purpureum* with a similarity coefficient of 0.70.

Keywords: Crossing, *Dendrobium,* Indonesia, morphological characters, orchid

INTRODUCTION

Dendrobium is the most plentiful orchid genus in the world with around 1,600 species and is the biggest genus of the Orchidaceae family. It is estimated over 20,000 hybrids of both natural varieties and hybrids from crosses, including single and multi genera (De et al. 2015a). There are 20 sections of *Dendrobium* reported by Schuiteman (2012). The genus is generally sympodial epiphytic, which might be characterized by lengthy pseudobulbs or canes with soft leaves on the entire length or in some species (De et al. 2015a). They are particularly valuable as pot plants or hanging baskets. Some species are hung on the walls or tree branches to cover the bare walls and branches (De et al. 2014). Apart from being an ornamental plant, *Dendrobium* is reported to be used as medicine (Teixeira da Silva et al. 2015; Zeng et al. 2020). For instance, *D. salaccense* leaves for reducing stomach pain (Silalahi and Nisyawati 2015) and *D. crumenatum* for treating acne (Wahyudiningsih et al. 2017).

The genus is morphologically widely diverse and each species has different unique characteristics from one another. To identify the differences in the character of each species, it is necessary to adopt a characterization approach. Characterization based on morphological characters, such as leaves, stems, tubers, fruits, and roots, is expected to be able to determine the type of utilization of the characterized plants (Hidayati et al. 2016). Morphological characters are easy to observe visually, so their diversity can be assessed quickly compared to other characters. Moreover, morphological characterization can be used to assess the relationship of orchids that are important for conservation programs and increase the utility of plant genetic resources (Wang et al. 2009). Although the analysis of genetic relationships based on morphological characters is strongly influenced by the environment, adequate characterization of morphological characters is needed to facilitate the utilization of germplasm by breeders (Tuberosa et al. 2011).

Plant characterization is important for assessing the closeness of genetic relationships among orchid species in the same genus, which determines the success of plant crossing. A closer genetic relationship will increase the success of the cross. This characterization can be used not only to compose plant descriptions, but also to determine the genetic relationship among the species (Purwantoro et al. 2005). In terms of utilization, characterization may be used as the premise for phylogenetic studies to decide patterns of plant diversification (Freudenstein and Chase 2015). Moreover, the characterization results can be used as analytical data for various needs in hybridization, reproduction, germplasm protection, and genetic change (Indraloka et al. 2019).

Indonesia is one of the diversity centers of *Dendrobium*. Unfortunately, only several species of *Dendrobium* native to Indonesia have been characterized, such as Indraloka et al. (2019) have characterized 10 species of *Dendrobium* and Aprilianti et al. (2021) researched *Dendrobium* seed morphology. Some researchers have studied the morphological characterization of other orchids genera, such as *Phalaenopsis* (Fauziah et al. 2014; Pangestu et al. 2014), *Vanda* (De et al. 2015b), *Dendrobium* (Hidayati et al. 2016), and *Phaius* (Hartati et al. 2021a). Therefore, this research aims to characterize the morphology of five species of *Dendrobium* native to Indonesia in order to assess the potential parental candidates for crosses.

MATERIALS AND METHODS

Research site

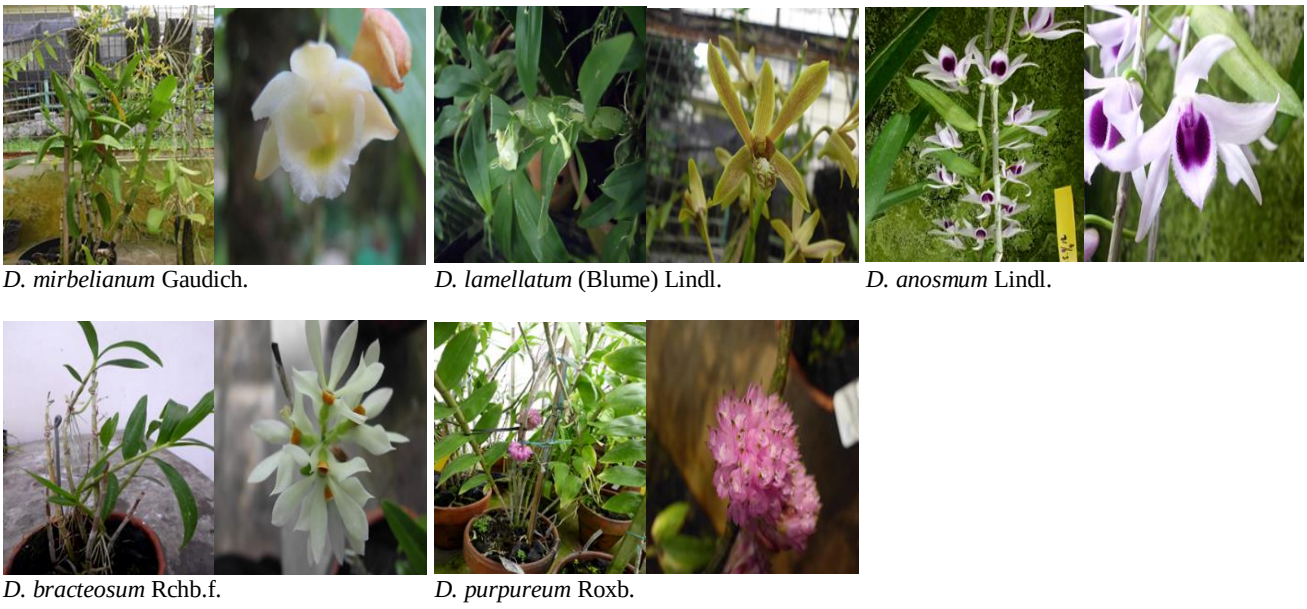
The morphological characterization of the orchids was conducted in Bogor Botanic Gardens, Indonesia and Matesih Screenhouse, Karanganyar, Central Java, in April 2021.

Plant materials

The plant materials used were five species of *Dendrobium*, namely *D. mirbelianum* Gaudich., *D. lamellatum* (Blume) Lindl., and *D. anosmum* Lindl. obtained from the Bogor Botanic Gardens; and *D. bracteosum* Rchb.f. and *D. purpureum* were obtained from Klaten Spesi Garden(Figure 1; Table 1).

Procedures

Identification of morphological characters was carried out descriptively based on direct observation of the parts of the orchids. This study observed 30 morphological characters from five *Dendrobium* species studied belonging to growth types (1 character), leaves (8 characters), flowers (17 characters), pseudobulbs (3 characters), and roots (1 character) by using scoring based on the characteristics of ornamental orchids (BALITHI 2007).



D. mirbelianum Gaudich. *D. lamellatum* (Blume) Lindl. *D. anosmum* Lindl.

D. bracteosum Rchb.f. *D. purpureum* Roxb.

Figure 1. Five species of *Dendrobium* native to Indonesia studied

Table 1. Plant materials used in the study

Species	Section	Distribution	Source	Number of samples observed
D. mirbelianum Gaudich.	Spatulata	Bismarck Archipelago, Caroline Is., Maluku, New Guinea, Queensland, Solomon Is., Sulawesi	Papua	2
D. lamellatum (Blume) Lindl.	Pedilonum	West Java	South Kalimantan	2
D. anosmum Lindl.	Eugenanthe	Borneo, Jawa, Laos, Lesser Sunda Is., Malaya, Maluku, Myanmar, New Guinea, Philippines, Sri Lanka, Sulawesi, Sumatera, Thailand, Vietnam	Sulawesi	2
D. bracteosum Rchb.f.	Pedilonum	Bismarck Archipelago, Maluku, New Guinea	Central Kalimantan	2
D. purpureum Roxb.	Pedilonum	Maluku, New Guinea, Sulawesi	Sulawesi	2

Data analysis

The data were analyzed by score grading the morphological characters into binary data: a score of zero (0) if the trait is not present in a plant and a score of one (1) if the trait is owned by the observed plant. If there are more than one binary data, the most suitable one is chosen. The features were evaluated using the Numerical Taxonomy and Multivariate Analysis System Program (NTSYSpc) version 2.02 (Rohlf 1998). the unweighted pair group method with arithmetic mean (UPGMA) software SIMQUAL (qualitative similarity) was employed to calculate the similarity index of cluster species.

RESULTS AND DISCUSSION

Morphological characters

The structure of an orchid consists of growth types, leaves, flowers, pesudobulbs, and roots. Flowers are the most important organ for species identification. The structure of the flowers of an orchid are mainly petals, sepals, pollen, columnar, and lip petals (Castro and Singer 2019). Based on the morphological observation of five species of *Dendrobium*, 23 out of 30 characters (76.67%) showed varying results on the characteristics of leaves (shape, cross-section, tip, and arrangement); flowers (shape, dorsal sepal shape, the transverse and longitudinal shape of sepal and petal, petal shape, sepal and petal tip shape, type of callus, location of labellum curve, tentacle on labellum, spur, flowering position, pollinia, sepal dorsal color pattern, sepal lateral color pattern, petal color pattern, and floral scent), pseudobulbs (longitude shape and cross-section shape), and root types (Table 2).

Flowers

Almost all flower components in the orchids had varying characters. The general flower appearance of five species of *Dendrobium* showed two flower types, namely star and round shapes (Figure 2). *Dendrobium mirbelianum, D. anosmum,* and *D. bracteosum* had star flower shape, while *D. lamellatum* and *D. purpureum* had round shape. Flowers are markers in distinguishing orchid species in a similar genus because morphological variations are found in flowers (Purwantoro et al. 2005).

Table 2. Morphological characters of species of *Dendrobium* observed in the study

Characters	*D. mirbelianum*	*D. lamellatum*	*D. anosmum*	*D. bracteosum*	*D. purpureum*
Growth type	Sympodial	Sympodial	Sympodial	Sympodial	Sympodial
Leaf shape	Elliptic	Oblong	Oblong	Oblong	Elliptic
Leaf cross section	Plicate	Bilaterally compressed	Bilaterally compressed	Bilaterally compressed	Bilaterally compressed
Leaf tip	Obtuse	Acuminate	Acute	Acuminate	Obtuse
Leaf edge shape	Entire	Entire	Entire	Entire	Entire
Leaf surface texture	Glabrous	Glabrous	Glabrous	Glabrous	Glabrous
Symmetry leaf	Symmetry	Symmetry	Symmetry	Symmetry	Symmetry
Leaf color	Green	Green	Green	Green	Green
Leaf arrangement	Duplicate	Duplicate	Duplicate	Duplicate	Convoluted
Flowers's shape	Star	Round	Star	Star	Round
Resupinate	No	No	No	No	No
Dorsal sepal shape	Oblong	Oblong	Oblong	Elliptic	Oblong
Transverse and longitudinal shape of sepal and petal	Straight	Concave	Convex	Concave	Straight
Petal shape	Oblong	Oblong	Oblong	Spathulate	Elliptic
Sepal and petal tip shape	Acute	Acute	Acute	Mucronate	Apiculate
Location of labellum curve	Middle	Middle	Tip	Tip	Tip
Tentacle on labellum	No	Yes	No	No	Yes
Cross section of the labellum	Flipped in	Flipped in	Flipped in	Flipped in	Flipped in
Spur	No	Yes	No	No	No
Flowering position	Side	Tip	Side	Side	Side
Pollinia	Two	Two	Two	Four	Two
Sepal dorsal color pattern	Striped and speckled	Equally	Equally	Equally	Equally
Sepal lateral color pattern	Striped and speckled	Equally	Equally	Equally	Equally
Petal color pattern	Striped and speckled	Equally	Equally	Equally	Equally
Floral scent	No	Yes	Yes	No	No
Pseudobulb Longitude shape	Linier	Oval	Linear	Ovate	Abovate
Pseudobulb cross section shape	Circular	Elliptic	Circular	Round	Circular
Pseudobulb size	2.5 cm (big)	1.48 cm (medium)	0.9 cm (small)	0.59 cm (small)	0.79 cm (small)
Root type	Sticky	Sticky	Sticky	Ground root	Ground root

According to Buragohain et al. (2015), flowers have a stem structure called a column. At the apical part of the column is an anther where there is pollen called pollinarium. The stigma is located subapical to the column referred to as the rostellum. The area of these organs is important for successful pollination, since it happens when pollinarium is introduced to the rostellum. Orchid is categorized as hermaphrodite (its pollens and pistils are in the flower), and monoandry (female and male genitals are in the same location). Accordingly, orchids are easy to pollinate.

Labellum or lip is a modified petal and a special trait of Orchidaceae with various shapes and colors. Each species in the orchid family has different lip characteristics. The lip of *Paphiopedilum rungsuriyanum* resembles a helmet, which is V-shaped and brown (Grus et al. 2014). In terms of shape, based on the study of 10 species of *Dendrobium*, labellum shape is divided into two kinds, namely (a) elliptic is presented by *D. antennatum*, *D. canaliculatum*, *D. discolor*, *D. lineale*, *D. racieanum*, and *D. sylvanum*; and (b) rounded is presented by *D. lasianthera*, *D. leporinum*, *D. strebloceras*, and *D. strepticeros* (Indraloka et al. 2019). The locations of the labellum curve of the observed *Dendrobium* were in two different positions, i.e. *D. mirbelianum* and *D. lamellatum* were in the middle site, whereas *D. anosmum*, *D. bracteosum*, and *D. purpureum* were in the tip. Nevertheless, the diversity of orchid colors is a key area for plant breeders to produce new hybrids through cross-breeding.

Leaves

Leaf characterization included leaf shape, leaf cross-section, leaf tip shape, leaf edge shape, leaf surface texture, leaf symmetry, and leaf color (Hartati et al. 2021c). Leaves of five *Dendrobium* species showed different characters in leaf shape, leaf cross-section, and leaf tip (Table 2). *Dendrobium mirbelianum* and *D. purpureum* have elliptic leaf shapes, while *D. lamellatum*, *D. anosmum*, and *D. bracteosum* have oblong leaf shapes. Identification of the cross-section of the leaf resulted in two forms, namely plicate on *D. mirbelianum* and bilaterally compressed on the others. There were three shapes of leaf tip among the observed *Dendrobium*, obtuse on the *D. mirbelianum* and *D. purpureum*, acuminate on *D. lamellatum*, and *D. bracteosum*, and acute on *D. anosmum*. Orchid leaves have various shapes, which are elongated circular, roughly circular, and a few leaf bones form a spread grid that is collateral to the leaves. Leaf veins also have many shapes, including thin and fleshy thick (Lokho and Kumar 2012).

Root and pseudobulb

The identification of root types of five *Dendrobium* species showed that *D. mirbelianum*, *D. lamellatum*, and *D. anosmum* had a sticky root type, whereas *D. bracteosum* and *D. purpureum* had a ground root type. The orchid roots are divided into three types, including soil root, air root, and sticky root. They are used to attach the plant to a growing area. Meanwhile, terrestrial orchids have elongated roots and thick furs, which are used to absorb moisture and organic matter from the soil. The rhizome in an orchid is a root similar to a tuber, but it is not one of them. The base of the stem is often thickened to form pseudo tubers that have roots (Khairiah et al. 2012).

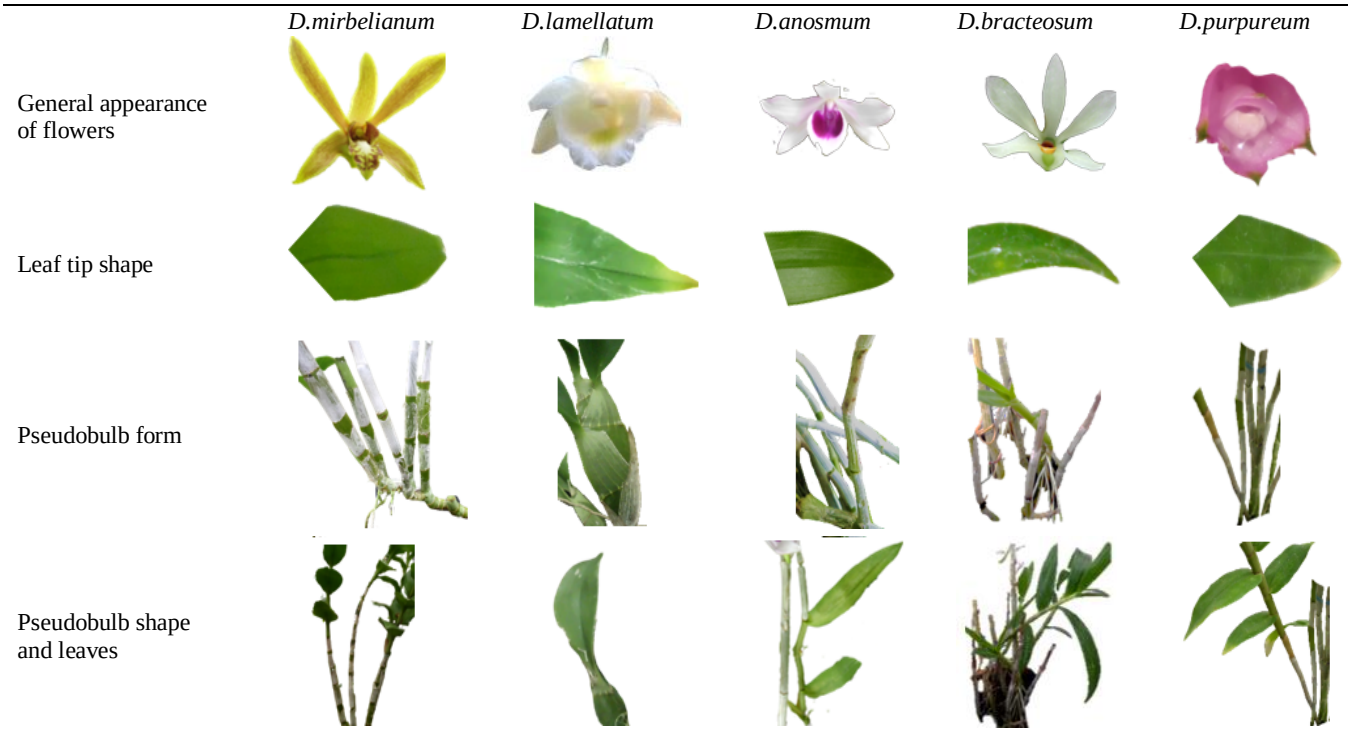


Figure 2. The appearance of the flowers, leaves, and pseudobulb

The pseudobulbs play a role in minimizing water shortages when plants experience drought due to the evaporation of water through leaves (Tay et al. 2015). Pseudobulb is an important organ in identifying the morphological characters of orchids (Miswarti et al. 2021). The identification of pseudobulbs in this study resulted in different forms of pseudobulbs. *D. mirbelianum* has a big size of psudobulb, *D. lemellatum* has a medium size of pseudobulb, whereas the others have a small size of the pseudobulb.

Cluster analysis

Based cluster analysis using 30 morphological characters among five species of *Dendrobium* showed two clusters with a similarity coefficient between 0.30-0.80 (Table 3). Cluster I consists of *D. mirbelianum, D. lamellatum,* and *D. anosmum.* It consists of two subclusters, i.e. subcluster 1 of *D. mirbelianum* and subcluster 2 of *D. lamellatum* - *D. anosmum.* Cluster II consists of *D. bracteosum* and *D. purpureum,* with a similarity coefficient of 0.7 (Figure 3). The similarity coefficient presented in this current study is higher than the similarity coefficient among 10 species of *Dendrobium* presented by Indraloka et al. (2019).

Based on cluster analysis, cluster division does not correlate with the section of *Dendrobium.* However, *D. bracteosum* and *D. pupureum,* members of section Pedilonum were separated into a similar cluster. Meanwhile, *D. anosmum* and *D. bracteosum* belong to different clusters. This is in accordance with the research conducted by Hidayati et al. (2016) where *D. anosmuml* and *D. bracteosum.* have been placed in different clusters. Morphological character data of five *Dendrobium* species can be used to identify closely related species. Crossing between individuals with close relatives or identical relatives has an impact on increasing homozygosity. On the contrary, crossing between individuals with massive genetic distances has an impact on increasing heterozygosity (Hidayati and Saragih 2020).

The most similar coefficient is presented by *D. lamellatum* and *D. anosmum* (0.80). The close relationships of various plant species is used as a source of information for identifying selected parents of two closely related species. The information can be a reference for cross-breeding to obtain new varieties. A study based on qualitative studies on *Phaius* orchids showed 0.80 morphological similarities, namely *P. amboinensis*, *P. tankervilae*, and *P. montanus* (Hartati et al. 2021a). Based on quantitative characterization, Hartati et al. (2021b) reported that *P. indigoferus* and *P. amboinensis* performed 0.87 morphological similarities. Studies have shown that the pedicel length is equivalent to the number of flowers. The greater the number of flowers, the longer the peduncle. *P. indigoferus* has the most elongated pedicel, so it has more flowers than other species.

Table 3. Similarity coefficient matrix based on morphological characters among five *Dendrobium* species

	1	2	3	4	5
1	1.00				
2	0.60	1.00			
3	0.70	0.80	1.00		
4	0.30	0.47	0.37	1.00	
5	0.30	0.43	0.33	0.70	1.00

Note: 1. *D. mirbelianum,* 2. *D. lamellatum,* 3. *D. anosmum,* 4 *D. bracteosum,* and 5. *D. purpureum*

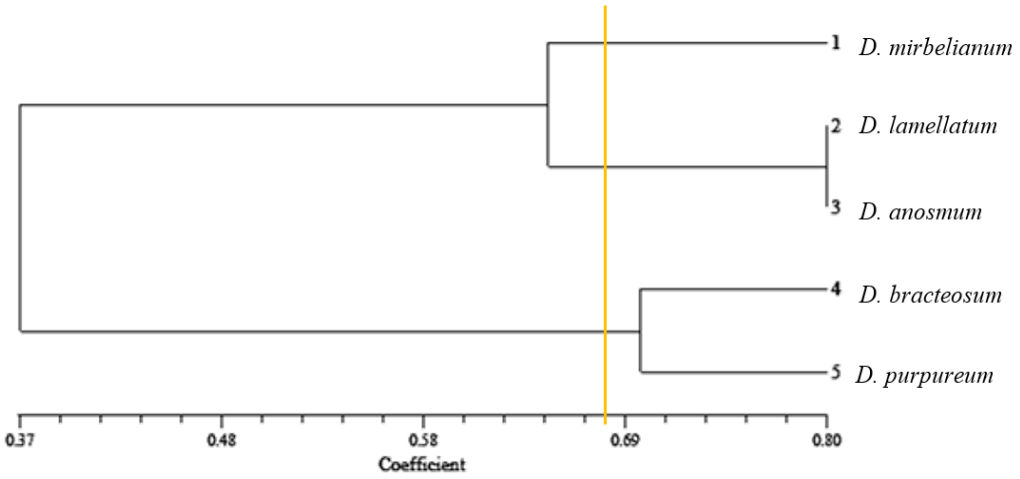


Figure 3. Dendrogram based on morphological characters of the five species of *Dendrobium*

Assessment of the potential parent candidates for crossing

Among the five species of *Dendrobium* studied, *D. lamellatum* and *D. anosmum* present the highest similarity coefficient of 0.80. The closeness of the genetic relationship is very influential on the success of the crosses. The orchids in the same cluster have close relatives and can be used as parents in crosses (Purwantoro et al. 2005). The previous study reported that based on the qualitative characterization of six *Coelogyne* species, *C. pandurata* has a closer genetic relationship to *C. rumphii* with a similarity coefficient of 0.87 (Hartati et al. 2019a). Furthermore, these two species were crossed using a crossing method (♀ *C. pandurata* x ♂ *C. rumphii*), reciprocal method (♀ *C. rumphii* x ♂*C. pandurata*), and selfing method with 100% success (Hartati et al. 2019b). Lokho and Kumar (2012) stated that the morphologic characteristics of orchids are very beneficial to supply control, individual species protection, cross-breeding, germplasm protection, cultivation, and genetic improvement. Kasutjianingati and Firgiyanto (2018) studied the morphological characters of *Vanda* and reported that among the 14 *Vanda* species being observed, there was a high range of similarity values from 0.33 to 1.00. It is divided into two groups, the first group is 0.67 and the second group is 0.39. It was found that the potential *Vanda* to be crossed was *V. helvola* and *V. arades*. Further research conducted by Hartati et al. (2021) showed that there were 3 species of *Phaius* that have the potential to be crossed as parents, namely *P. amboinensis* x *P. tankervilae*, *P. amboinensis* x *P. montanus*, and *P. tankervilae* x *P. montanus*.

In conclusion, 30 morphological characters of five species of *Dendrobium* native to Indonesia were identified, and 23 out of the characters (76.67%) showed varying results on the characteristics of flowers, leaves, pseudobulbs, and roots. Based on the cluster analysis, five species of *Dendrobium* are separated into two clusters. The species with the highest similarity coefficient has the potential to be used as parental in crosses. *Dendrobium lamellatum* and *D. Anosmum* has the highest similarity coefficient of 0.80 and are the most potential as parental species for crossing, followed by *D. bracteosum* and *D. purpureum* with a similarity coefficient of 0.70.

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