

Morphological diversity and phenetic relationship of wild and cultivated *Begonia* based on morphology and leaf venation

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Abstract. Permata DA, Susandarini R. 2022. Morphological diversity and phenetic relationship of wild and cultivated *Begonia* based on morphology and leaf venation. *Biodiversitas* 23: 928-937. *Begonia* is an ornamental plant with intense cultivation and hybridization practices because of the uniqueness and beauty of its leaves. *Begonia* with a very large number of species is interesting to study, especially because Indonesia is one of the resource centers of this genus diversity as indicated by the increasing number of new species found every year. This study aimed to explore the morphological diversity of wild and cultivated *Begonia* and reveal the phenetic relationships of the species and hybrids based on morphology and leaf venation patterns. In this study, we used 19 *Begonia* samples belonging to five species collected from their natural habitat and 14 species and hybrids obtained from the nurseries. Morphological observations of living specimens and examination on microscopic slides of cleared leaf resulted in 28 characters which were used to determine phenetic relationships using cluster analysis. The high variability of leaf venation patterns described in this study disclosed the micromorphological diversity of *Begonia* which has not been widely exposed. The results of morphological observations showed high variabilities in leaf color, leaf shape, and petiole color. The results of cluster analysis and principal component analysis indicated that the grouping of species was mainly determined by the existence of trichomes on leaf surfaces and petiole, leaf venation pattern, leaf variegation, and leaf shape. The grouping of species resulting from cluster analysis can be used in the selection of potential parents to produce new *Begonia* hybrids through crossing experiments.

Keywords: Characters variation, cluster analysis, ornamental plants, taxonomy

INTRODUCTION

Begonia is one of the largest genera in Angiosperms with wide distribution in tropical and subtropical regions of the world except in Australia. Asia is one of the centers of diversity for this genus (Neale et al. 2006). *Begonia* is a popular foliage ornamental plant, but some species are also known to have beautiful flowers. The beauty of *Begonia* is mainly in the unique shape and color pattern of the leaves. *Begonia* leaf shape is generally asymmetrical, but there are also a number of species with symmetrical, peltate, highly dissected, and palmately compound leaves (Tebbutt 2005b).

The variegated leaf on some *Begonia* species is another attractive characteristic. Sheue et al. (2012) defined variegated leaves as the presence of multiple colors on the leaves, which can be in the form of spots or dots, regular patterns, or irregular patterns. The importance of morphology in recognizing variations in *Begonia* was underlined by Borah et al. (2021) that misunderstanding the nature of morphological traits might lead to overlooking them in claiming a new species by giving an example on the case of *Begonia dicressine*. In this case, *B. dicressine*, a new species from Myanmar described by (Wahlsteen 2019), was identified as new species by Maw et al. (2020) under the name *B. putaensis*. The specimens described by these two authors were collected from the same location in northern Myanmar. Later on, it was found that they were the same species. In this regard, Wahlsteen (2021) clarified

that *B. putaensis* was a synonym for *B. dicressine*.

Assessment on morphology of wild and cultivated plants is important for the exploration and effective management of plant diversity, as reported in *Theobroma* (Santos et al. 2012) and *Amaranthus* (Thapa and Blair 2018). Knowledge of plant morphology also has an important role as the basis for determining breeding program strategies, as stated by Rêgo et al. (2020) on the ornamental foliage plant of the genus *Sansevieria*. In its application to ornamental plants, Hartati et al. (2021), based on the characterization of five species of Phaius orchids, noted that morphology was important in selecting suitable parents for experimental crosses to obtain hybrids with desirable traits.

While most *Begonia* species are known as an ornamental plants, a number of species are also used as food and traditional medicine. Several species are known to be edible, as reported by Rajbhandary (2013) that in Nepal there are 10 species of *Begonia* whose stems can be eaten raw or pickled. Similarly, Cao et al. (2020) mentioned three species of *Begonia* as wild edible plants in Southwest China, namely *B. augustinei*, *B. longifolia*, and *B. silletensis* subsp. *mengyangensis*. Meanwhile, the use of *Begonia* as a medicinal plant was reported by Guan et al. (2007) that in China, 24 species of *Begonia* were used for medicine. Several species of *Begonia* in Indonesia were known as medicinal plants, as noted by Girmansyah (2009) that *B. lempuyangensis* was traditionally used to treat coughs,

while *B. lombokensis* and *B. longifolia* were known as both medicinal and food plants. The use of *Begonia* as a medicinal plant is due to the content of secondary metabolites (Suresh et al. 2016). In this regard, Karpova et al. (2019) noted that secondary metabolites in *Begonia* could be found in glandular trichomes and leaf epidermal cells such as those in *B. grandis* subsp. *grandis*. Phytochemical studies on *Begonia palmata*, *B. megaptera* and *B. xanthina* showed that these species contained various secondary metabolites, including phenols, tannins, flavonoids, alkaloids, saponins, and terpenoids (Bhattarai and Rana 2020).

To date, there have been 2,052 species of *Begonia* taxa recorded from around the world (Hughes et al. 2015-continuously updated). The number of species is predicted to continue to grow, considering that there are still many findings of new species reported every year. In Indonesia, wild *Begonia* species grow in a variety of habitats from karst hills to wet tropical forests in the lowlands to highlands up to 2,400 m a.s.l. (Siregar 2017). The discovery of new species in Indonesia in recent years is evidence of the high diversity of natural *Begonia* species. During the last three years, several explorations reported new species, such as four new species from Southeastern Sulawesi (Ardi et al. 2018), one species from Seram Island, Maluku, namely *Begonia mufidakhallae* (Ardaka and Ardi 2019), three new species from Kalimantan (Hughes et al. 2020), and the discovery of *Begonia daunhitam* from West Kalimantan (Wang et al. 2020). The high species diversity in this genus makes studying taxonomy and its potential development as an ornamental plant very interesting.

The high diversity in *Begonia* is known to be caused by hybridization and polyploidy (Dewitte et al. 2011). The existence of natural hybrids of *Begonia*, among others, was reported by Tian et al. (2017) that in China, there were 50 populations consisting of 31 natural hybrids from 29 species of *Begonia*. A natural hybrid between *B. crispipila* and *B. balangcodiae* was discovered by Liu et al. (2019), which was then given a name as *Begonia* × *kapangan*. The natural variation in morphology and hybridization ability of

Begonia is beneficial for this genus which was used by breeders for creating new hybrids (Neale et al. 2006). A number of hybridization experiments have been carried out on various *Begonia* species. Interspecific hybridization through a cross between two native *Begonia* species of Indonesia, namely *Begonia natunaensis* and *B. puspitae* resulted in four new varieties (Siregar 2016). Another hybrid produced from an artificial cross between two other native Indonesian species, *B. sudjanae* and *B. puspitae*, was *Begonia* 'Crested', which have beautiful yellow-green exotic leaves (Siregar et al. 2021). In this regard, the inventory and knowledge of wild *Begonia* diversity are very important since wild species have the potential to be developed as materials for experimental hybridization to produce exotic cultivars with the desired character combinations. This study aimed to reveal the morphological diversity of wild and cultivated *Begonia* species and hybrids, as well as determine their phenetic relationship, which can be used as the basis for developing their potential as foliage ornamental plants.

MATERIALS AND METHODS

Plant materials used in this study were collected in April - June 2021. A total of 19 *Begonia* samples were obtained (Table 1), consisting of 5 wild species collected from natural habitats in the adjacent area of Baturraden Botanical Garden, and 14 cultivated species, varieties, and hybrids purchased from two nurseries in West Java. Identification of plant specimens was done by comparison to keys, descriptions, drawings, and photographs from Doorenbos et al. (1998), Siregar (2005), Tebbitt (2005a), Tebbitt (2005b), and online database Begonia Resource Centre of the Royal Botanic Garden Edinburgh (<http://padme.rbge.org.uk/begonia/>). Verification of species names was carried out by referring to Plants of the World Online (<http://www.plantsoftheworldonline.org/>).

Table 1. *Begonia* species and hybrids used in this study

Sample code	Scientific name	Collection site
BW1	<i>Begonia hirtella</i> Link	Baturraden Botanical Garden, Central Java
BW2	<i>Begonia atricha</i> (Miq.) Miq. ex A.DC.	Baturraden Botanical Garden, Central Java
BW3	<i>Begonia multangula</i> Blume	Baturraden Botanical Garden, Central Java
BW4	<i>Begonia longifolia</i> Blume	Baturraden Botanical Garden, Central Java
BW5	<i>Begonia muricata</i> Blume	Baturraden Botanical Garden, Central Java
BC1	<i>Begonia acetosa</i> Vell.	Ornamental Nursery, West Java
BC2	<i>Begonia heracleifolia</i> Schltld. & Cham. 'Black Falcon'	Ornamental Nursery, West Java
BC3	<i>Begonia bowerae</i> Ziesenh. 'Bethlehem Star'	Ornamental Nursery, West Java
BC4	<i>Begonia rex</i> Putz. 'Rosy Morn'	Ornamental Nursery, West Java
BC5	<i>Begonia</i> 'Kimbrook'	Ornamental Nursery, West Java
BC6	<i>Begonia listada</i> L.B.Sm. & Wassh.	Ornamental Nursery, West Java
BC7	<i>Begonia coccinea</i> Hook.	Ornamental Nursery, West Java
BC8	<i>Begonia</i> 'Argenteo-guttata' Fanfare	Ornamental Nursery, West Java
BC9	<i>Begonia maculatta</i> var. <i>wightii</i> Fotsch	Ornamental Nursery, West Java
BC10	<i>Begonia cucullata</i> Willd. 'Tinkerbell'	Taman Bunga Nusantara Nursery, West Java
BC11	<i>Begonia cucullata</i> Willd. 'Thousand Wonders'	Taman Bunga Nusantara Nursery, West Java
BC12	<i>Begonia</i> 'Arabian Sunset'	Taman Bunga Nusantara Nursery, West Java
BC13	<i>Begonia brevirimosa</i> subsp. <i>exotica</i> Tebbitt	Taman Bunga Nusantara Nursery, West Java
BC14	<i>Begonia masoniana</i> Irmsch. ex Ziesenh.	Taman Bunga Nusantara Nursery, West Java

Note: BW: wild *Begonia*; BC: cultivated *Begonia*

Data on morphological characters were collected based on observation of plant habits, petiole, leaves, and stipules of living specimens. Leaf venation patterns were examined based on microscopic slides of cleared leaf-cutting prepared using the method described by Ruzin (1999) and Lu et al. (2012) with some modifications. Horticultural nomenclature for plant habit referred to Tebbitt (2005b), while the classification of leaf variegation referred to Zhang et al. (2020). Terminologies used in describing venation patterns followed those of Leaf Architecture Working Group (1999). The morphological and venation data were subjected to cluster analysis and principal component analysis. A dendrogram generated from cluster analysis was constructed based on Gower coefficient of similarity and unweighted pair group method using arithmetic average (UPGMA) clustering method. Cluster analysis and principal component analysis were performed using PAST 3.2 (Hammer et al. 2001).

RESULTS AND DISCUSSION

Observation on the morphology of 19 samples showed high inter-species variability (Figures 1 and 2). For the assessment of morphological variation, a total of 28 characters were examined (Table 2), consisting of 21 macro-morphological characters and 7 micro-morphological characters. Based on the plant habit, there were five types of *Begonia* recognized, namely rhizomatous, shrub, cane, semperflorens, and rex. Of the 15

leaf morphological characters, the highest variation was found on leaf color. There were nine variants found on the color of leaf adaxial surface, namely light green, dark green, reddish-green, green and pink, brownish-green, purplish-green, dark purple, brownish red, and dark red. The color of leaf abaxial surface also varied greatly with eight different colors, consisting of light green, dark green, reddish-green, red, dark red, greenish-red, greenish-brown, and dark purple. High variation also found in leaf shapes from oblique-ovate, star-shaped, ovate, grape-leaf, lance-shaped, angel wing, to viviparous. Leaves of *Begonia* showed various forms of leaf margin, which can be classified as entire, undulate, crenate, dentate, serrate, and lobate.

Leaf variegation which was one of the attractive features of *Begonia* as foliage ornamental plant, also showed considerable variation. Variegation is the presence of multiple colors on the leaves, either forming regular or irregular patterns or spots (Sheue et al. 2012). Leaf variegations found in this study were blotched, spotted, striped, and reticulated. A study on the diversity of leaf variegation in *Begonia* reported by Cui and Guan (2013) showed ten types of variegations in Chinese *Begonia* that could be grouped into vein type and non-vein type. In terms of leaf variegation, Wang et al. (2019) used an appraisal system to evaluate the quality of *Begonia* ornamental foliage based on four criteria and resulted in recognition of three categories, namely excellent, good, and general. Two of the four criteria used in the appraisal were color of leaf upper side and leaf variegation.

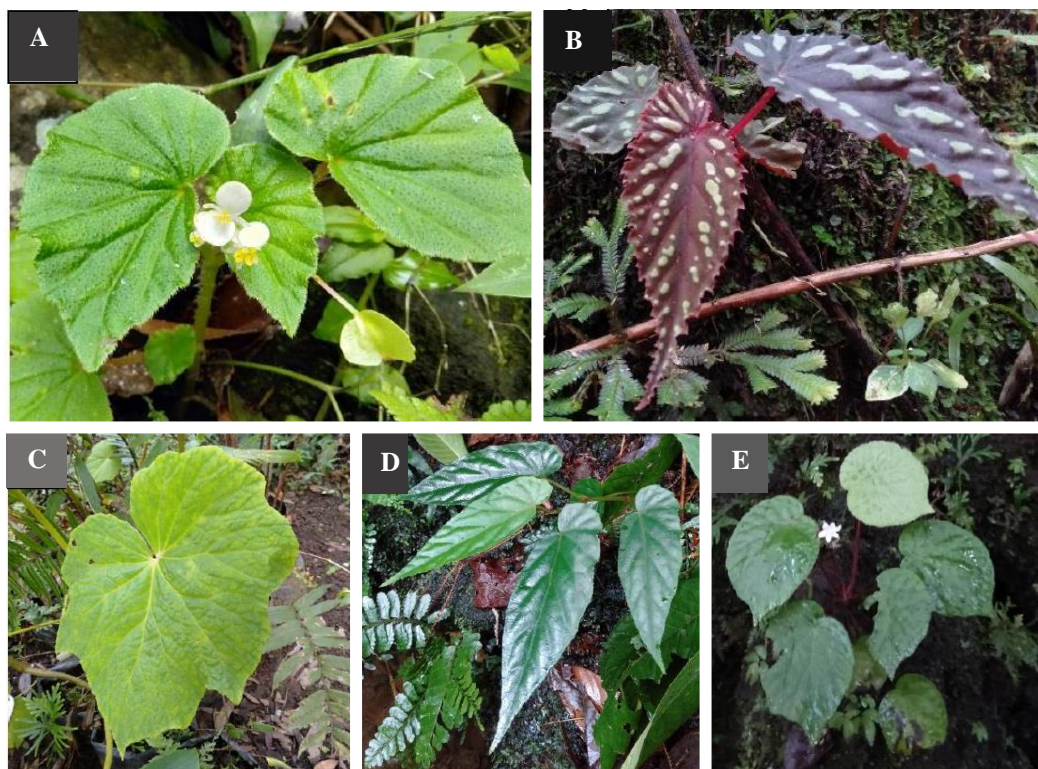


Figure 1. Morphology of wild *Begonia* species used in this study, *B. hirtella* (A); *B. atricha* (B); *B. multangula* (C); *B. longifolia* (D); *B. muricata* (E)



Figure 2. Morphology of cultivated *Begonia* species and hybrids used in this study: *B. bowerae* (A); *B. acetosa* (B); *B. 'Kimbroke'* (C); *B. listada* (D); *B. coccinea* (E); *B. 'Argenteo-guttata'* (F); *B. 'Arabian Sunset'* (G); *B. masoniana* (H); *B. brevirimosa* subsp. *exotica* (I); *B. maculata* var. *wightii* (J); *B. rex* (K); *B. cucullata* 'Thousand Wonders' (L); *B. cucullata* 'Tinkerbelle' (M); *B. heracleifolia* (N)

The high morphological diversity in *Begonia* has an advantage in terms of its use as an ornamental plant. As mentioned by Neale et al. (2006), great diversity in *Begonia* is beneficial to breeders to create new hybrids. Moreover, Dewitte et al. (2011) noted that the high morphological diversity of vegetative organs in *Begonia* was related to the ability to adapt to various ecological

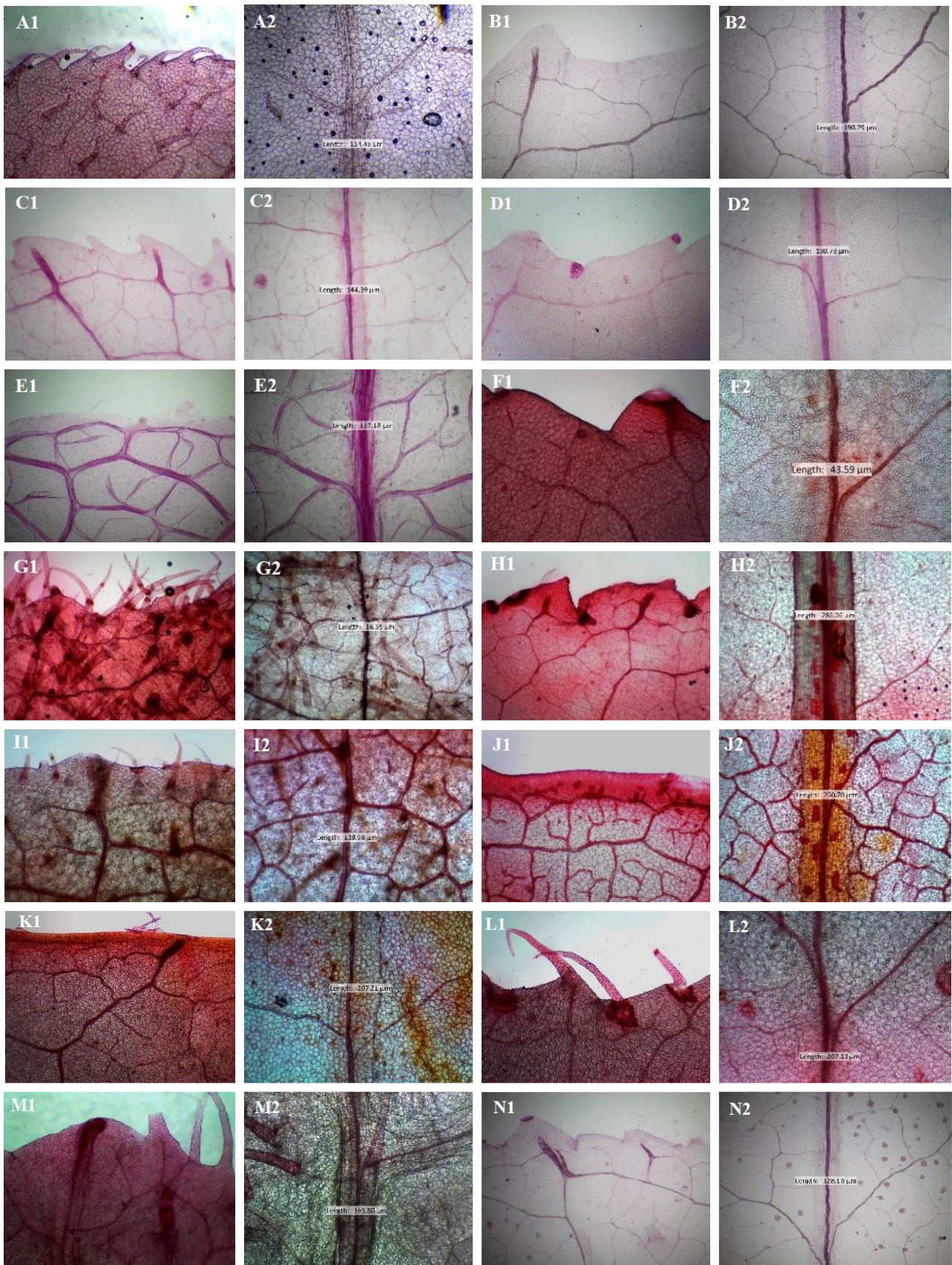
conditions. Most of *Begonia* species and hybrids used in this study belong to the category of ornamental foliage begonias or leafy begonias, and only a few are classified as flowering begonias. In this case, *Begonia brevirimosa* and *B. rex* represent species in the category of leafy begonias, while *B. cucullata* is a popular exotic species for its beautiful flowers (Siregar 2017).

Table 2. List of morphological and leaf venation characters of *Begonia* taxa based on the performed analysis

Character	Character code	Character states
Begonia type	BEHT	rhizomatous; rex; shrub-like; cane-like; semperflorens
Lamina length	LMAL	measurement (cm)
Lamina width	LMAW	measurement (cm)
Lamina shape	LMAS	oblique-ovate; star-shaped; ovate; grape leaf; lance-shaped; angel wing; viviparous
Lamina margin	LMAM	entire; undulate; crenate; dentate; serrate; lobate
Lamina apex	LMAA	acute; acuminate; obtuse; truncate
Lamina base	LMAB	obtuse; cordate
Lamina symmetry	LMSY	symmetrical; asymmetrical
Lamina major venation pattern	LVEN	palmate; pinnate; radiate
Lamina surface texture	LMST	flat; undulate; bullate
Leaf variegation	LMMO	non-variegated; blotched; spotted; stripped; reticulate
Colour of leaf adaxial surface	LMDC	light green; dark green; reddish green; green and pink; brownish green; purplish green; dark purple; brownish red; dark red
Colour of leaf abaxial surface	LMBC	light green; dark green; reddish green; red; dark red; greenish red; greenish brown; dark purple
Hairs on leaf adaxial surface	HLDS	no hairs; sparse; dense; very dense
Hairs on leaf margin	HLMM	no hairs; sparse; dense; very dense
Hairs on leaf abaxial surface	HLBS	no hairs; sparse; dense; very dense
Hairs on petiole	HPTS	no hairs; sparse; dense; very dense
Petiole colour	PTLC	light green; brownish green; greenish brown; light brown; reddish brown; red; brownish red
Petiole variegation	PTLM	non-variegated; red dotted
The nature of stipules	STPL	persistent; deciduous
Stipule shape	STPS	triangular; rounded-triangular; linear
1° veins	ODVE	basal actinodromous; pinnate; flabellate
2° veins	TDVE	semi-craspedrodromous; reticulodromous
3° veins	SDVE	alternate percurrent; random reticulate; regular polygonal reticulate; mixed opposite alternate percurrent
4° veins	FDVE	regular polygonal reticulate; not formed
Areoles	ARLV	well developed; moderately developed; paxillaate; lacking
Free ending ultimate veins	FEVS	absent; unbranched; 1-branched; 2-branched; >2-branched
Midrib width	MIDW	measurement (µm)

In addition to macromorphological characters the venation pattern was observed in revealing interspecies variability of anatomical or micromorphological characters in this study. The results showed that leaf venation patterns of 19 *Begonia* samples were highly variable (Figure 3). The use of leaf venation as a taxonomic character was very rarely explored in the genus *Begonia*. Since variation in leaf venation is an interesting aspect in foliage ornamental plants, Fujita and Mochizuki (2006) used some species of *Begonia* for modeling the origin and diversity of leaf venation. Seven species of *Begonia* were examined, and the results showed that venation was influenced by leaf shape and leaf expansion. Moreover, the role of anatomical characters in the taxonomy of *Begonia* was revealed by Zhang et al. (2008) based on a study of 52 species which showed that at the species level, there were variations in the shape of epidermal cells, trichomes, stomata shapes, and crystal types. In addition, Indrakumar et al. (2013) mentioned that the anatomical characters of *Begonia* leaves, including the leaf venation pattern, were proved to be useful to confirm the taxonomic identity of *B. dipetala* as a distinct species and not a synonym of *B. malabarica*.

Based on micromorphological characters, notable variations were found in the trichomes on lamina and leaf margin. Variations of trichomes on *Begonia* leaves and petiole showed an important role in species identification both in the field and in herbarium specimens (Maity et al. 2006). The presence of trichomes on stems and adaxial leaf surface was reported to be one of the diagnostic characters used to distinguish *B. crassitepala* and *B. dryadis*, which have similar leaf morphology (Maw et al. 2020). Meanwhile, a micromorphometric study on the leaves of five *Begonia* species by Suffan et al. (2021) showed that there were variations in the characters of the epidermis, hypodermis and trichomes, which were useful for exploring the potential of the species as a materials breeding program through crossing experiments. In addition to its role as a diagnostic character for species identification, trichomes have an important function for plants in protecting against herbivores and increasing resistance to abiotic stresses, especially to drought (Dalin et al. 2008). Trichomes on leaves also function to protect plants from exposure to ultraviolet light, pathogen attack, and excessive transpiration (Wang et al. 2021).



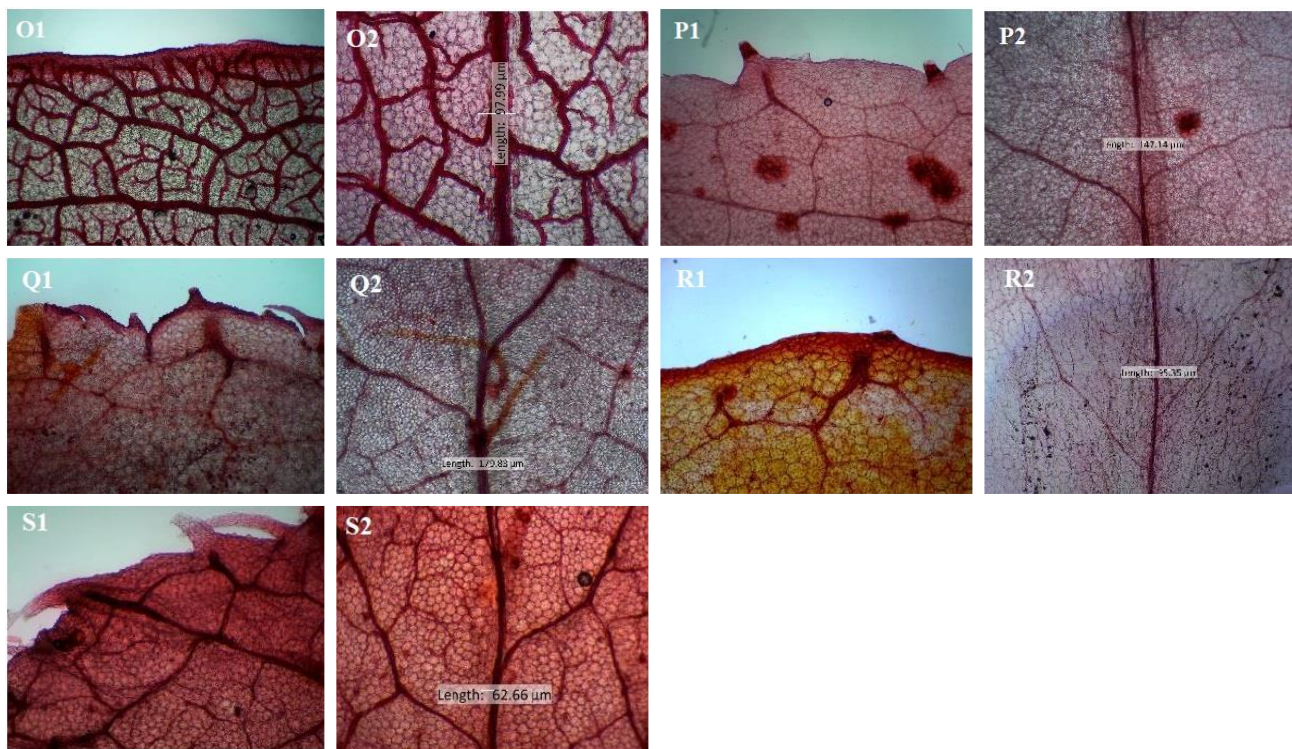


Figure 3. A variation on leaf venation patterns on 19 samples of *Begonia* (1: marginal veins; 2: midrib width and 1° to 4° veins)

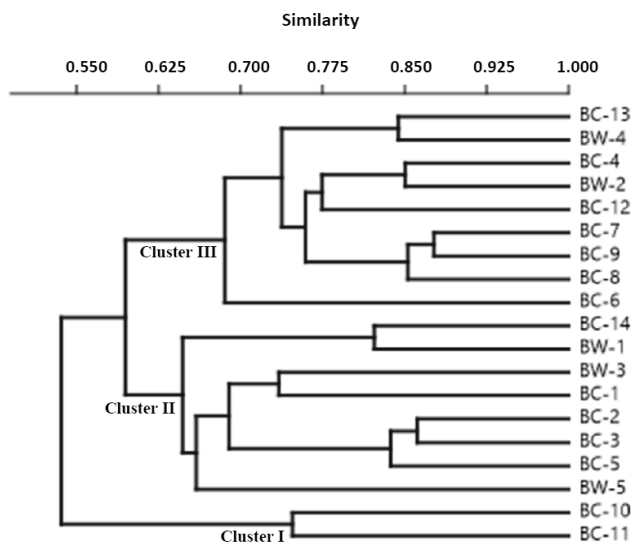


Figure 4. Dendrogram of taxonomic relationships of wild and cultivated *Begonia* species, with a cophenetic correlation coefficient of 0.85

The results of cluster analysis to determine the phenetic relationship of 19 *Begonia* samples based on 28 macro- and micro-morphological characters showed the formation of three clusters (Figure 4). This dendrogram was very well in representing the similarities between samples as indicated by the cophenetic correlation coefficient of 0.85. The cophenetic correlation coefficient is a measure of the goodness of fit for a dendrogram, and thus this coefficient is used to verify the grouping of samples resulting from the

cluster analysis (Carvalho et al. 2017). The three clusters in the dendrogram displayed a considerable degree of morphological diversity reflected in the similarity coefficients in the branching points of each cluster.

The first cluster consisted of only two samples, namely *B. cucullata* 'Tinkerbelle' and *B. cucullata* 'Thousand Wonders'. These two hybrids have a nearly rounded leaf with radial venation spreading from the base to the apex, and both their leaf shape and venation pattern are clearly different from other species which have asymmetrical leaves. The second cluster consisted of eight species characterized by oblique-ovate, ovate, ear-shape, and grape-leaf leaves, dense trichomes on their leaf surfaces, and the color pattern of the lamina varied from non-variegated to striped and reticulated variegations. The eight species in cluster two were a mixture of wild and cultivated *Begonia*. In this cluster, there were only two samples with grape-leaf shape, namely *B. heracleifolia* and *B. 'Kimbrook'*. The close relationship between these two samples was due to parent and hybrid relation. In this case, *B. 'Kimbrook'* is known to be a hybrid of *B. heracleifolia* var. *heracleifolia* × *B. 'Locheil'*. The later has leaf shape similar to that of *B. bowerae*, and therefore it was quite reasonable that the position of *B. heracleifolia* and *B. 'Kimbrook'* in the dendrogram was close to *B. bowerae*.

The third cluster consisted of nine species which can be clearly distinguished from the members of the second cluster, especially by the leaf shape, which tended to be long. The leaves of species in this cluster were lance-shaped, angel wing, and viviparous, the lamina with sparse trichomes or glabrous leaf surfaces, and the lamina with blotched or spotted variegations. Similar to the second cluster, the third cluster was also comprised of a mixture of

wild, cultivated, and hybrid *Begonia*. Based on the grouping patterns in the dendrogram, there is no clear distinction between the morphology of wild and cultivated *Begonia* species and their hybrids. A previous study on *Begonia* that used cluster analysis was reported by Li et al. (2021) on *B. grandis* using 33 morphological characters to examine phenotypic variation. The results showed that the cluster analysis of 39 populations of *B. grandis* resulted in the division of samples into four groups based on male flower size, leaf size, plant size, and leaf color. Meanwhile, the use of cluster analysis for the appraisal and classification of the ornamental foliage of *Begonia* was carried out by Wang et al. (2019), which mentioned that the results could be used as the basis for selecting species with excellent character combinations as ornamental plants.

In this study, the combination of cluster analysis and principal component analysis was useful in the assessment of morphological diversity as well as the determination of characters' contribution in the grouping of samples. The result of principal component analysis (Table 3) showed the existence of eight characters that contributed greatly to the grouping of *Begonia* species, as indicated by character loading of > 0.2 on the first principal component. These eight characters were leaf shape, major leaf venation pattern, leaf variegation, the color of leaf abaxial surface, trichomes on leaf adaxial surface, trichomes on leaf margin, trichomes on leaf abaxial surface, and trichomes on the petiole. These characters played an important role in distinguishing between species with morphological similarities. In this regard Sands (2009) noted that the shape and size of lamina were greatly varied between species of *Begonia* from New Guinea, and that the size and shape basal lobes of leaf and unequal lobes of leaf base were an important diagnostic character. Meanwhile, the occurrence of trichomes on stem, petiole, and adaxial leaf surfaces were reported to be the distinguishing characters between *B. crassitepala* and *B. dryadis* (Maw et al. 2020).

Results of cluster analysis and principal component analysis showed that the grouping of samples based on morphological similarities, especially leaves, can be used to create hybrids with combinations of characters through artificial crosses. In relation to the horticultural application, hybrids with high variety of desirable characters could be generated by selecting parents, which showed some degree of genetic distance. In this regard, cluster analysis on morphological characters is of the method useful for the evaluation of genotypic diversity and the selection of potential candidates for hybridization by providing an estimation of relationships between parents to be used in crossing (Khodadadi et al. 2011). The application of cluster analysis to help breeders in selecting appropriate parents by looking at the grouping of candidate genotypes has been reported by Kojj and Saba (2015). Meanwhile, principal component analysis is an appropriate method for the identification of character contribution in the discrimination of samples for selection in a breeding program (Shen et al. 2019). The complementary nature of cluster analysis and principal component analysis made these two methods were commonly used in combination in plant systematics studies (Matheri et al. 2016; Mulima et al. 2018).

Table 3. Eigenvalue, percent variance, and characters loading on the first two principal components

Character code	Character loading	
	PC 1	PC 2
BEHT	0.168	-0.389
LMAL	0.110	0.100
LMAW	-0.097	0.043
LMAS	0.263	0.285
LMAM	0.247	0.043
LMAA	-0.088	-0.333
LMAB	-0.005	-0.127
LMSY	0.212	0.041
LVEN	0.274	0.056
LMST	-0.103	0.142
LMMO	0.278	0.190
LMDC	0.132	0.376
LMBC	0.259	0.313
HLDS	-0.257	0.109
HLMM	-0.333	0.136
HLBS	-0.300	0.232
HPTS	-0.348	0.246
PTLC	-0.135	0.244
PTLM	-0.023	0.101
STPL	-0.018	-0.138
STPS	-0.063	-0.003
ODVE	0.185	-0.189
TDVE	-0.005	-0.127
SDVE	-0.120	0.002
FDVE	-0.077	-0.059
ARLV	-0.170	-0.177
FEVS	0.150	0.077
MIDW	0.060	-0.020
Eigenvalue	0.310	0.228
Variance (%)	23.268	17.089
Cumulative variance (%)	23.268	40.357

To summarize, this study revealed that wild and cultivated *Begonia* species showed high diversity in both macromorphological characters and venation patterns. Variability of leaf venation patterns reported in this study added the knowledge on the high diversity of micromorphological characters of *Begonia*, which was fewer studies and therefore have not been clearly revealed. The use of numerical taxonomic methods in this study, namely cluster analysis and principal component analysis, contributed to revealing the relationship between *Begonia* species. The clustering pattern resulting from the cluster analysis can be considered in selecting prospective species as parents for crossing experiments to produce hybrids with the desired combination of characters.

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