PRELIMINARY STUDY ON MORPHOLOGICAL CHARACTERISTICS OF ARACEAE SPECIES USING PHENETIC APPROACH

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Abstract

Araceae is a large family consisting Aroids or Arums. It is a monocot plants characterised by the inflorescence consisting of spadix subtending a spathe. The aim of the study was to determine the relationship of 13 species from seven genera of Araceae using phenetic approach. The seven genera are *Anthurium, Spathyphyllum, Monstera, Philodendron, Syngonium, Alocasia* and *Caladium*. A cluster analysis was performed using the Multivariate Statistical Procedures Version 2.2 (MVSP) on 22 morphological characters of selected species. Based on the similarity of morphological characters, these 13 species are clustered into three groups: (1) *Anthurium forgetii* and *A. leuconeurum*, (2) *M. oblique expilata, P. scandens oxycardium* and *Monstera* sp. 1 and, (3) *M. deliciosa, P. scandens* and *Philodendron* sp. 1. The cluster analysis indicates *Caladium* sp. 1 had the lowest similarities (5.6%) compared to other 12 species. Meanwhile, *M. deliciosa* and *P. scandens* exhibit the highest similarity (68.4%) for both analyses.

Keyword: Araceae, MVSP, phenetic approach.

Introduction

Phenetics also recognized as taximetrics, is an approach of classifying organisms based on overall similarity, generally in morphology or other observable traits, without regarding to their phylogeny or evolutionary relation (Sneath and Sokal, 1973; Sokal. 1986). Araceae, or aroids, are plants which are very familiar to everyone but paradoxically little known. This family is one of the common monocotyledon plants and also a monophyletic family comprising about 117 genera and 3790 species (Boyce and Croat, 2011). The Araceae is one of the largest plant families in the world that comes after orchids, grasses and also been acknowledged as the seventh largest of all flowering plants after Asteraceae, Fabaceae, Rubiaceae, and Lamiaceae (Mayo, Bogner and Boyce, 1997). This family has worldwide distribution extending from tropical dry to pluvial rainforest. It also has a wide range of climate tolerance but many species will not tolerate to any degree frost or cold such as *Anthurium brownie* (Croat, 1988). There are approximately 23 genera with 123 species of Araceae have been recorded in Peninsular Malaysia (Sulaiman and Mansor, 2001). The Araceae abundance basically depends on availability of water and atmospheric humidity (Oraphan, Marod, Thanompun, 2018). Most species in this family are utilized for cooking especially the native dishes, as medicinal uses and as ornamental plants. *Monstera deliciosa, Philodendron scandens, Dieffenbachia maculata* and *Aglaonema commutatum* may be counted as among the world's most popular house plants. Morphological characteristics are fundamental for species identification. The family of Araceae is most readily defined by characters of the inflorescence: small flowers borne on a fleshy axis (the spadix) subtended by a modified leaf (the spathe) (Boyce and Wong, 2012), flower and leaf shape (Klimko, Wawrzyńska and Wiland-Szymańsk, 2014). However, due to the unequal distribution of

Araceae throughout the world, species of this family are poorly studied for its phenetic relationships. Therefore, this study aimed to determine the relationship of 13 species of Araceae based on morphological characteristics by using cluster analysis.

Materials and Methods

Plant specimen

Araceae specimens were bought from nurseries at Sungai Buloh, Selangor. Only adult specimens with complete morphological characteristics were chosen. The specimens were identified by referring to "The genera of Araceae" (Mayo, Bogner and Boyce, 2007). Specimens was then prepared and deposited in the herbarium. The identified specimens were listed in **Table 1**.

Table 1 List of specimens from nurseries at Sungai Buloh, Selangor.

Subfamily	Tribe	Genus	Species
Pothoideae	Anthurieae	*Anthurium*	*Anthurium forgetii*
			Anthurium leuconeurum
Mosteroideae	Spathiphylleae	*Spathiphyllum*	*Spathiphyllum commutatum*
	Monstereae	*Monstera*	*Monstera deliciosa*
			Monstera oblique expilata
			Monstera sp. 1
Aroideae	Philodendreae	*Philodendron*	*Philodendron erubescens*
			Philodendron scanden oxycardium
			Philodendron scandens
			Philodendron sp. 1
	Colocasieae	*Alocasia*	*Alocasia* sp. 1
	Caladieae	*Caladium*	*Caladium*
		Syngonium	*Syngonium* sp. 1

The habit of the stem was noted, whether it is creeper or epiphyte. Then the identification focuses on leaves, stem, root and inflorescences. Details characteristics on each part of the specimen were examined. For leaves characteristics, three largest leaves on each specimen were chosen for further examination. Length and width of petiole and lamina were measured on the most accessible and complete leaf of each specimen to ensure that ratios to compare these measurements are accurate. Lamina morphology (texture and shape) and petiole morphology were also recorded.

Data Analysis

This study was using numerical analyses software; Multivariate Statistical Procedures (MVSP plus Version 2.2) software (Kovach, 1995). The analyses used were nearest neighbour cluster analysis and farthest neighbour cluster analysis. With the aim of generating the similarity matrices on morphological characteristics, Gower general similarity coefficient (GGSc) was used. By using this coefficient, the absolute similarity is marked by the GGSc in percentage.

Result and Discussion

For this study, a total of 22 morphological characters were listed (**Appendix 1**). The character matrices are given in **Appendix 2**. In order to create standardization, some of the quantitative characters that vary most in the data set are converted to logs. Standardisation of the measurements ensures all species have equal weight in the analyses and would not tend to

dominate to avoid bias in the analyses. Dendogram resulting from the farthest neighbour cluster analysis were shown in **Figure 1**. Meanwhile, **Figure 2** shows the dendogram resulting from the nearest neighbour cluster analysis. In both figure, the absolute similarity is marked by GGSc in percentage.

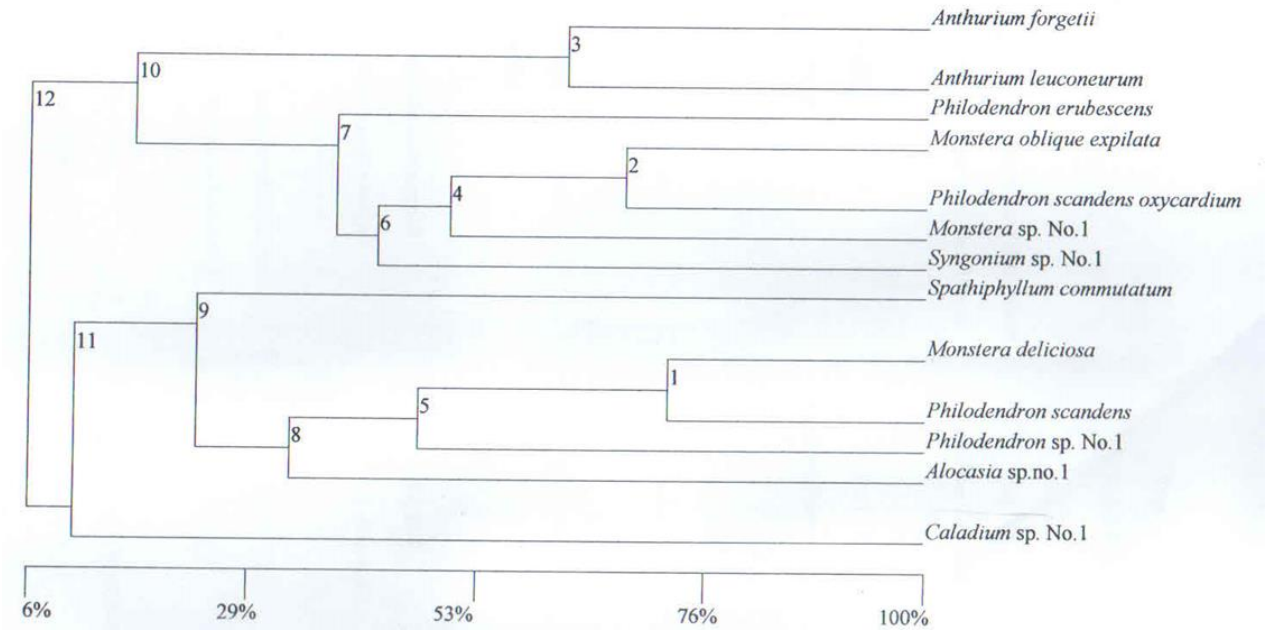

Figure 1 Dendogram of 13 species resulting from farthest neighbour cluster analysis

In farthest neighbour cluster analysis, *Anthurium forgetii* clustered to *A. leuconeurum* with 62.5% similarity. Both species are similar in their habit (epiphyte), petiole colour (green), spot on the leaves (yellow), leaf texture (smooth), leaf shape (pedatisect), leaf margin (smooth), leaf blade (cuneate) and leaf arrangement (spiral). Mayo, Bogner & Boyce (1997) findings showed that the similarities of *Anthurium* species are cuneate leaf blade and variable of leaf shape. Findings by Sousa dos Santos (2014), confirmed that *A. leuconerum* most similar to *A. wendlingeri* based on DNA studies. *M. oblique expilata, P. scandens oxycardium* and *Monstera* sp. 1 with 50.0 % similarity form a constant cluster in the dendograms. These species are similar in habit (epiphyte), petiole texture (smooth), leaf colour (green), leaf (adaxial) texture (smooth), leaf (abaxial) colour (green), leaf arrangement (alternate). Other anatomical characteristics that confirm both genera (*Monstera* and *Philodendron*) are similar is the collenchyma cells in feeder roots (Hinchee, 1981), organisation of vascular tissues (Mayo, Bogner & Boyce, 1997) and absence of epidermal cells (Grayum, 1984). This study shows that *M. deliciosa, P. scandens* and *Philodendron* sp. 1 are similar with each other with 47.4 % similarity. The similarities are their habit (epiphyte), stem colour (brownish green), stem texture (segmented), petiole colour (green), spot on the leaves (none) and leaf base (cordate). *M. deliciosa* has a very high similarity to *P. scandens* with 68.4%, followed by *Philodendron* sp. 1 with 47.4%.

In nearest neighbour cluster analysis (**Figure 2**), *Caladium* sp.1 appears to be the most isolated species. The abaxial colour in *Caladium* sp.1 which is clearly transparent, significantly distinguished *Caladium* sp.1 from the rest of the Araceae species studied. Leaf spots and vein colours represent the major traits in *Caladium* (Deng, Goktepe, and Harbaugh, 2008). However, in farthest neighbour cluster analysis (**Figure 1**), *Caladium* sp.1 are clustered to *M. deliciosa, P. scandens* and *Philodendron* sp. 1*, Alocasia* sp. 1 and *S. commutatum.*

The overall similarity relationships between the 13 species of Araceae are significantly correlated with the growth habit and other morphological characteristics studied. The characters of the groups have a high similarity, especially *M. deliciosa* and *P. scandens* with 68.4% similarities that are similar in vegetative morphological qualitative characters.

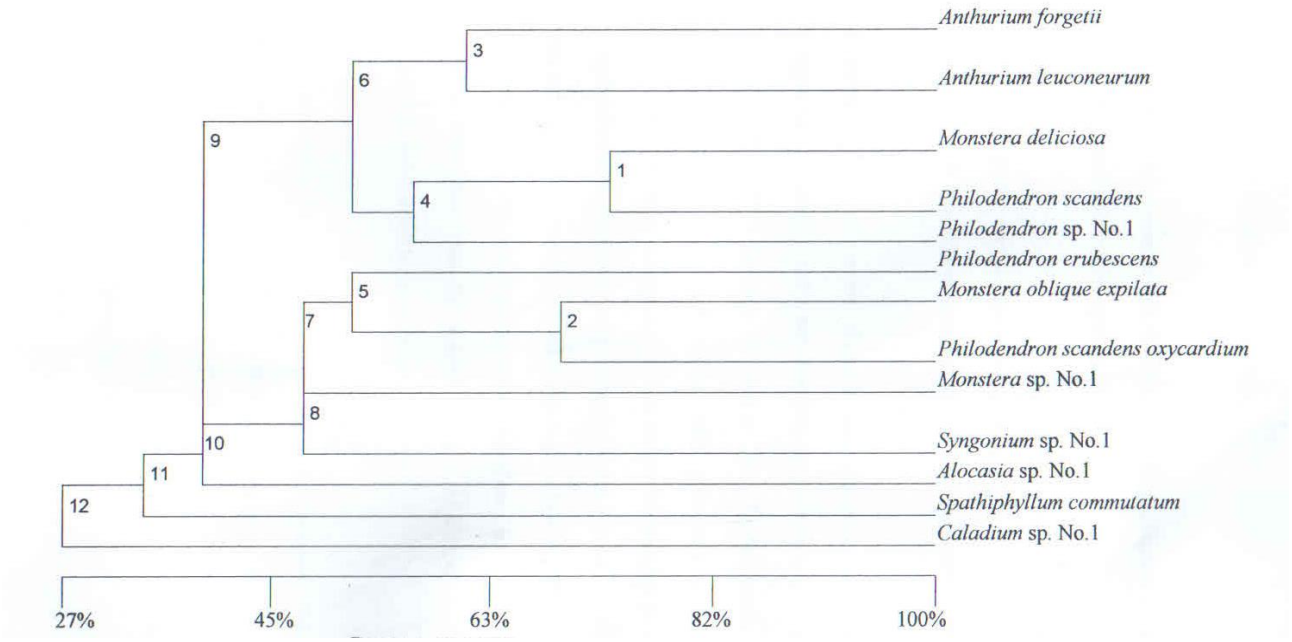

Figure 2 Dendogram of 13 species resulting from nearest neighbour cluster analysis

Conclusion

This study concluded that, based on the similarity of its morphological characteristics, these 13 selected species of Araceae can be clustered into three constant groups. These groups are: (1) *Anthurium forgetii* and *A. leuconeurum*, (2) *M. oblique expilata, P. scandens oxycardium* and *Monstera* sp. 1 and, (3) *M. deliciosa, P. scandens* and *Philodendron* sp. 1. Additionally, *M. deliciosa* and *P. scandens* share a wealth of vegetative morphology characters. Therefore, in future, detail studies can be done especially on anatomy, embryology, palynology, ecology, physiology, cytology, genetics, etc. to prove the affinities of Araceae species. It is hoped that this study will also increase public interest in systematics studies on this family for more complete understanding of this remarkable group of plants.

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Conflict of interests

Author hereby declares that there is no conflict of interests with any organization or financial body for supporting this research.

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Appendix 1 : Character coding of 13 species for numerical analyses.

Morphological characters
1. Growth habit: creepers (0), epiphytes (1),
2. Stem color: green (0), dark green (1), brownish green (2), brown (3), none (4)
3. Stem structure: with climbing root (0), segmented (1), climbing root and segmented (2), segmented with fine line (3), none (4)
4. Petiole colour: green (0), dark green (1), brownish green (2), yellowish green (3), purple (4)
5. Petiole texture: smooth (0), rough (1).
6. Leaf color: green (0), dark green (1), shiny dark green (2), yellowish green (3), greyish green (4)
7. Spot on the leaves: yellow (0), transverse/reticulate (1).
8. Leaf texture (adaxial): smooth (0), rough (1).
9. Leaf colour (abaxial): green (0), shiny and green (1), dark green (2), yellowish green (3), greyish green (4), whitish (5)
10. Leaf shape: sagittate (0), linear (1). Cordate (2), ovate (3), ovate and peltate (4), elliptic (5), pedatisect (6), pinnatifid (7)
11. Leaf margin: smooth (0), wavy (1).
12. Leaf apex: acute (0), acuminate (1), apiculate(2).
13. Leaf blade: cordate (0), cuneate (1):
14. Leaf arrangement: alternate (0), spiral (1), equitant (2)
15. Height (cm): less than 100 (0), more than 100 (1)
16. Stem length (cm): less than 80 (0), more than 80 (1), none (2)
17. Stem diameter (cm): less than 10 (0), more than 10 (1), none (2)
18. Petiole length (cm): less than 40 (0), more than 40 (1),
19. Petiole diameter (cm): less than 4 (0), more than 4 (1), none (2)
20. Petiole number (cm): less than 10 (0), more than 10 (1),:
21. Leaf length (cm): less than 25 (0), more than 25 (1).
22. Leaf width (cm): less than 20 (0), more than 20 (1).

Appendix 2: Character matrices of 13 species of Araceae for numerical analyses

	Species												
Character	A	B	C	D	E	F	G	H	I	J	K	L	M
1	0	0	0	1	1	1	1	1	0	0	0	0	0
2	0	1	3	3	0	2	3	0	3	3	3	3	4
3	0	0	1	2	1	1	3	1	4	1	0	1	5
4	0	1	1	4	0	2	0	3	3	1	0	1	1
5	0	1	1	0	0	0	0	0	0	0	1	0	0
6	0	1	2	1	0	3	0	0	3	1	1	4	1
7	0	2	2	2	2	0	0	2	2	2	0	2	1
8	0	1	0	0	0	0	0	0	0	0	0	0	1
9	3	0	2	2	0	3	0	0	3	2	1	4	5
10	2	1	2	4	5	6	3	0	3	7	2	4	0
11	0	0	1	0	0	0	1	1	0	1	0	0	0
12	1	0	2	1	0	1	1	0	1	0	0	0	1
13	0	1	0	0	0	0	1	0	1	0	0	0	0
14	1	1	1	0	0	0	0	1	2	2	1	0	2
15	0	0	1	1	1	1	1	0	0	0	1	0	0
16	0	0	0	0	1	1	1	0	0	0	0	0	2
17	0	1	0	0	0	0	0	0	1	0	0	1	2
18	0	0	1	0	0	0	0	0	0	1	0	0	0
19	0	0	1	0	0	0	0	0	1	1	0	1	0
20	0	1	1	0	1	1	1	1	1	0	1	0	0
21	1	0	1	0	0	1	1	1	1	1	1	1	0
22	1	0	1	0	0	0	1	0	1	1	1	0	0

*Note: A- Anthurium forgetii, B- Spathiphyllum commutatum, C- Monstera deliciosa, D- Philodendron erubescens, E- Monstera oblique expilata, F- Syngonium sp 1, G- Monstera sp 1, H- Philodendron scanden oxycardium, I- Alocasia sp 1, J- Philodendron scandens, K- Anthurium leuconeurum, L- Philodendron sp 1, M- Caladium sp No.1