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MORPHOMETRIC ANALYSIS OF *DESMODIUM* DESV. IN BANGLADESH

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Abstract

Phenetic analysis based on morphological characters is presented for 14 species of *Desmodium* Desv. in Bangladesh. This study examines patterns of morphological similarity and variation within *Desmodium* using 36 floral and vegetative characters. *D. heterophyllum* shows highest similarity with *D. triflorum* among the species employed. UPGMA dendrogram is constructed based on cluster analysis which reveals two major clusters, the first of which consists of seven species while the second cluster comprises six species, and *D. microphyllum* is found far from all other species. The presence of winged petioles distinguishes *D. alatum* and *D. auriculatum* from the other species. The present study shows the application of morphometric analysis for understanding the phenetic relationships among the species of *Desmodium.*

Introduction

The genus *Desmodium* Desv. (Fabaceae) consists of approximately 280 species mostly distributed in subtropical and tropical regions (Puhua and Ohashi 2010). Very recently Hyde *et al*. (2012) report the distribution of 450 species of *Desmodium* in warm regions, especially in East Asia, Brazil and Mexico. *Desmodium* and its allied genera are mainly native to the tropics and subtropics. Ohashi (1973) records two centers of geographic distribution and differentiation, South-east Asia and Mexico. Williams (1983) states that South-east Asia is a centre of legume diversity, while Schubert (1980) considers Mexico and Brazil as the centers of diversity of *Desmodium*. The genus *Desmodium* can be recognized by uni- or tri-foliolate leaves, simple raceme or panicle inflorescence and distinctly jointed pods. The systematics of the genus *Desmodium* is confusing and not yet resolved completely. For example, several species of *Desmodium* have been transferred to the genera *Dendrolobium*, *Hylodesmum*, *Lespedeza* and *Phyllodium*, and some species of other genera such as *Hedysarum* and *Uraria* are still included to *Desmodium* (Puhua *et al.* 2010). Ohashi and Mill (2000) based on morphological characteristics, proposed to split 14 species out of *Desmodium* and placed them in the newly described genus *Hylodesmum*. Although several taxonomic treatments on the genus *Desmodium* were carried out based on morphological characters (Liu and Chang 1962, Ohashi 1973, Pedley and Rudd 1996, Shaheeen 2008), however, in Bangladesh no detailed study has been completed on this important and complicated genus, except listing its few species (Prain 1903, Khan *et al.* 1996, Ahmed *et al.* 2009).

Morphometric is the study of covariances between patterns of morphological variation and patterns of variation in other associated or causal variables (Bookstein 1991). Morphometric methods can be instrumental in discovering, documenting and analyzing morphological character and character states, and have become important tools for understanding similarities and inferring relationships in different groups of plants. Morphometric and cladistic analyses based on morphological characters have been carried out in a number of genera and families (Michelangeli 2000, Roalson *et al*. 2002, Li and Conran 2003, Sonibare *et al*. 2004, Gomes-da-Silva *et al*. 2012).

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Despite morphometric studies were carried out in some legume genera (Chandler and Crisp 1998, de La Estrella *et al*. 2009, Soladoye *et al.* 2010), there has been no such study on *Desmodium* so far. The aims of this study are to examine the patterns of morphological variation and phenetic relationships in the genus *Desmodium* in Bangladesh.

Materials and Methods

Fourteen species of *Desmodium viz., D. alatum, D. auriculatum, D. concinnum, D. dichotomum, D. gangeticum, D. heterocarpon, D. heterophyllum, D. laxiflorum, D. microphyllum, D. oblongum, D. sequax, D. styracifolium, D. triflorum* and *D. velutinum* were employed in the present study. Among them nine species along with representative specimens have been mentioned in Table 1. For the remaining five species, namely *D. concinnum, D. dichotomum, D. microphyllum, D. sequax* and *D. auriculatum* neither herbarium nor living specimens were available; consequently character states for these taxa were selected from the relevant literature (Baker 1876, Liu and Chang 1962, Schubert 1980, Pedley and Rudd 1996, Ahmed *et al.* 2009). Both fresh materials collected from different parts of the country, and herbarium specimens deposited in the herbaria DUSH (Dhaka University Salar Khan Herbarium), DACB (Bangladesh National Herbarium), HCU (Chittagong University Herbarium) and BFRIH (Bangladesh Forest Research Institute Herbarium) were examined for this study (Table 1).

Table 1. List of nine *Desmodium* species employed in the present study with their sources.

No.	Species	Representative specimens
1.	*Desmodium alatum* DC.	Zahid 73 (DUSH); M.S. Khan K 69 (DUSH); M.A. Rahman & M. Hossain 2389 (HCU).
2.	*D. gangeticum* (L.) DC.	Zahid 85 (DUSH); Khan & Huq K 6177 (DACB); M.A. Rahman 571 (HCU).
3.	*D. heterocarpon* (L.) DC.	Zahid 91 (DUSH); M.S. Khan K 7113 (DACB); M.S. Islam 125 (HCU).
4.	*D. heterophyllum* (Willd.) DC.	Zahid 74 (DUSH); Hassan 132 (DUSH); M.K. Alam W 14 (BFRIH).
5.	*D. laxiflorum* DC.	M.S. Khan K 6717 (DACB); Huq 8558 (DACB); M.S. Khan K 7867 (DACB).
6.	*D. oblongum* Wall. *ex* Benth.	M.S. Khan K 6441 (DACB); M. Mohiuddin & Md. Mezanul Huq 7537 (BFRIH).
7.	*D. styracifolium* (Osbeck) Merr.	Zahid 27 (DUSH); M.S. Khan K 3374 (DACB); Huq 9013 (DACB).
8.	*D. triflorum* (L.) DC.	Zahid 63 (DUSH); M.S. Khan K 6567 (DACB); M.A. Rahman 4671 (HCU).
9.	*D. velutinum* (Willd.) DC.	M.S. Khan K 6577 (DACB); M.K. Alam 4803 (BFRIH).

A data matrix based on the coded binary states of characters was used in the analysis. Cluster analyses using the UPGMA method (unweighted pair-group method with arithmetical averages) were carried out (Sneath and Sokal 1973), from which a dendogram representing the phenetic relationships among the species was constructed. All analyses were carried out using the software Statistica (version 9).

Results and Discussion

Thirty six floral and vegetative characters were identified and examined. The characters and their binary states used in the morphometric analyses of 14 species of *Desmodium* are depicted in Table 2.

Table 2. Morphological characters and their binary character states used for morphometric analysis of *Desmodium*.

No.	Characters attributes	Character states
1.	Habit	Herb (0); Shrub (1).
2.	Stem	Glabrous (0); Hairy (1).
3.	Triquetrous branch	Absent (0); Present (1).
4.	Leaf	Uni-foliolate (0); Tri-foliolate (1).
5.	Leaf attachment	Opposite (0); Alternate (1).
6.	Petiole length	>2.5 cm (0); 0.1 - 2.5 cm (1).
7.	Petiole outline	Slender (0); Cylindrical (1).
8.	Winged petiole	Absent (0); Present (1).
9.	Laminar shape	Ovate to lanceolate (0); Obovate to oblong (1).
10.	Base angle	Obtuse (0); Acute (1).
11.	Apex angle	Obtuse (0); Acute (1).
12.	Apex shape	Obtuse or emerginate (0); Acute (1).
13.	Base shape	Obtuse or rounded (0); Attenuate (1).
14.	Leaf surface	Glabrous (0); Hairy (1).
15.	Leaf margin	Undulate (0); Entire (1).
16.	Vein lobation	Absent (0); Present (1).
17.	Stipule	Ovate or lanceolate (0); Triangular (1).
18.	Flowers	Solitary (0); Fasciculated (1).
19.	Inflorescence	Terminal (0); Axillary and terminal (1).
20.	Length of inflorescence	5-30 cm (0); > 30 cm (1).
21.	Corolla colour	Whitish to yellow (0); Pink to purple (1).
22.	Pedicel length	15-20 mm (0); 1-12 mm (1).
23.	Calyx shape	Tubular or funnel shaped (0); Campanulate (1).
24.	Calyx teeth	Ovate or lanceolate (0); Triangular (1).
25.	Calyx lobe	5-lobed (0); 4-lobed (1).
26.	Bract	Absent (0); Present (1).
27.	Shape of bract	Ovate (0); Linear to lanceolate (1).
28.	Secondary bract	Absent (0); Present (1).
29.	Bracteole	Absent (0); Present (1).
30.	Stamens	Monadelphous (0); Diadelphous (1).
31.	Ovary	Glabrous (0); Pubescent (1).
32.	Pod shape	Straight or linear (0); Falcate (1).
33.	Indent of pod	One side (0); Both sides (1).
34.	Surface of pod	Glabrous (0); Hairy (1).
35.	Joint of pod	2-4 joints (0); 6-10 joints (1).
36.	Number of seeds/pod	5-10 seeds (0); 2-4 seeds (1).

The morphometric analysis reveals the extent of phenetic relationships among 14 species of *Desmodium*. Two major clusters are found in the UPGMA dendrogram constructed through cluster analysis. The first cluster consists of seven species, *viz*., *D. alatum*, *D. auriculatum*, *D. sequax*, *D. velutinum*, *D. gangeticum*, *D. laxiflorum* and *D. oblongum*, while the second cluster comprises six species, i.e., *D. concinnum*, *D. styracifolium*, *D. dichotomum*, *D. heterocarpon*, *D. heterophyllum* and *D. triflorum*. *D. microphyllum* is found to be most far from all other species (Fig. 1).

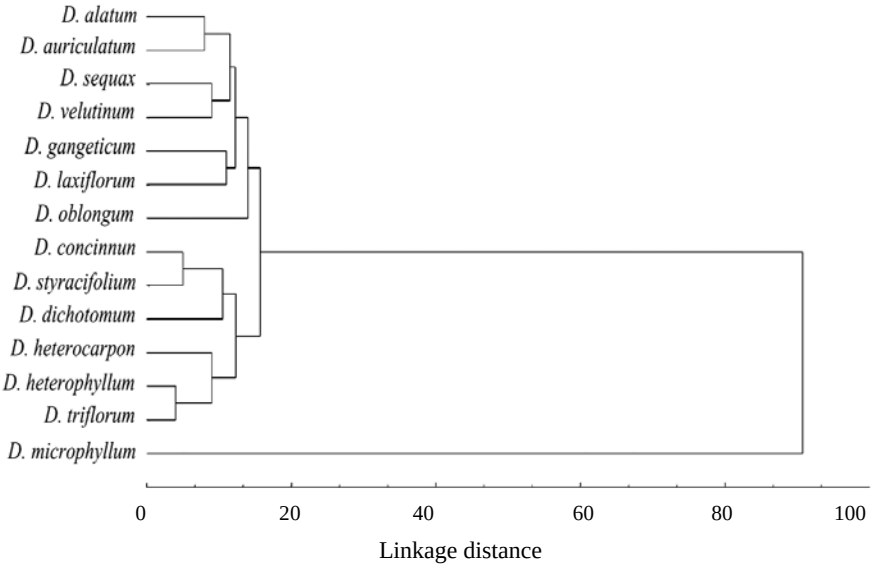

Fig. 1. UPGMA dendrogram showing the relationships among *Desmodium* species based on morphological characters.

In the first cluster *D. alatum* is grouped with *D. auriculatum*, *D. sequax* with *D. velutinum* and *D. gangeticum* with *D. laxiflorum* indicating that the members of each of these three groups are more close to each other than they are to the members of other groups (Fig. 1). The closeness between *D. alatum* and *D. auriculatum* is supported by their lanceolate leaves and presence of wings on the petioles. The close association between *D. sequax* and *D. velutinum* is supported by their 4-lobed campanulate calyx and moniliform pods. This finding is consistent with pollen morphology of these species wherein the pollen is without microperforation, the endoapertures are lalongate, the tectum is finely reticulate and the simple columellae have no granular interstitia (Chen and Huang 1993). The sub-cluster of *D. gangeticum* and *D. laxiflorum* is attested by the characters of hairy stem, absence of bracteoles, pubescent calyx and incurved style.

In the second major cluster two distinct sub-clusters have been found. The first one consists of *D. concinnum*, *D. styracifolium* and *D. dichotomum*. The common characters shared by these species include rounded leaf apex, diadelphous stamens and capitate stigma. In this sub-cluster *D. concinnum* and *D. styracifolium* are found to be more close to each other than they are to *D. dichotomum*. The close relationship between *D. concinnum* and *D. styracifolium* is evidenced by their axillary and terminal inflorescence, pink corolla and pubescent ovary. *D. heterocarpon*, *D. heterophyllum* and *D. triflorum* form another sub-cluster and their close association is supported

by presence of tri-foliolate leaf, obovate to oblong lamina, hairy stem and lobed venation. Within this sub-cluster *D. heterophyllum* and *D. triflorum* are found to share the highest similarity which is supported by the characters: prostrate herbs, leaves tri-foliolate, leaflets chartaceous, terminal leaflet larger than lateral leaflets, stipules lanceolate, primary bracts ovate, acuminate, flower solitary and standard petal obovate. This finding is congruent with Chen and Huang (1993) who placed *D. heterophyllum* and *D. triflorum* in the same group and demonstrated that the pollens of these species are semi-angular in polar view, with thick, psilate tectum, reduced columella and substituted with granular interstitia. Our result is also supported by anatomical data (unpublished). In the dendrogram, *D. microphyllum* has been found morphologically most distant from all other species investigated in this study.

Finally, it is concluded that the morphometric analysis could be used for understanding the phenetic relationships among different species of *Desmodium*. Use of more taxa and additional tools would help for better understanding of systematics and relationships of the genus *Desmodium*.

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References

Ahmed ZU, Hassan MA, Begum ZNT, Khondker M, Kabir SMH, Ahmed M, Ahmed ATA, Rahman AKA and Haque EU (Eds) 2009. Encyclopedia of Flora and Fauna of Bangladesh, Vol. **8**. Angiosprems: Dicotyledons (Fabaceae-Lythraceae). Asiatic Society of Bangladesh, Dhaka. pp. 73-87.

Baker JG 1876. Fabaceae. *In*: Hooker JD (Ed.), Flora of British India **2**. L. Reeve & Co. Ltd. England. pp. 161-175.

Bookstein FL 1991. Morphometric tools for landmark data: Geometry and biology. Cambridge University Press.

Chandler GT and Crisp MD 1998. Morphometric and phylogenetic analysis of the *Daviesia ulicifolia* complex (Fabaceae, Mirbelieae). Plant Syst. Evol. **209**(1-2): 93-122.

Chen S-J and Huang T-C 1993. Pollen morphology of the tribe Desmodieae (Leguminosae) in Taiwan. Taiwania **38**: 67-89.

de La Estrella M, Aedo C and Velayos M 2009. A morphometric analysis of *Daniellia* (Fabaceae - Caesalpinioideae). Botanical J. Linn. Soc. **159**(2): 268-279.

Gomes-da-Silva J, da Costa Vargens FA, de Oliveira Arruda RC and da Costa AF 2012. A morphological cladistic analysis of the *Vriesea corcovadensis* group (Bromeliaceae : Tillandsiodeae), with anatomical descriptions: new evidence of the non-monophyly of the genus. Systematic Botany **37**(3): 641-654.

Hyde MA, Wursten BT and Ballings P 2012. Flora of Zimbabwe. Genus page *Desmodium.* http://www.zimbabweflora.co.zw/speciesdata/genus.php?genus_id=744, retrieved 22 September, 2012.

Khan MS, Khatun BMR and Rahman MM 1996. A preliminary account of legume diversity in Bangladesh. Bangladesh J. Plant Taxon. **3**(1): 1-33.

Li J and Conran JG 2003. Phylogenetic relationships in Magnoliaceae subfam. Magnolioideae: A morphological cladistic analysis. Plant Syst. Evol. **242**: 33-47.

Liu TS and Chang CC 1962. On the Taiwan species of *Desmodium*. Taiwania **8**: 67-126.

Michelangeli FA 2000. A cladistic analysis of the genus *Tococa* (Melastomataceae) based on morphological data. Systematic Botany **25**(2): 211-234.

Ohashi H 1973. The Asiatic species of *Desmodium* and its allied genera (Leguminosae) Gingoana No. **1**: 1-138.

Ohashi H and Mill RR 2000. *Hylodesmum*, a new name for *Podocarpium* (Leguminosae). Edinburgh J. Bot. **57**: 171-188.

Pedley L and Rudd VE 1996. Fabaceae, Tribe Desmodieae. *In:* Dassanayake MD and Clayton WD (Eds), Flora of Ceylon. Vol. **10**. Oxford & IBH publishing Co. Pvt. Ltd., New Delhi. pp. 149-198.

Prain D 1903. Bengal Plants. Vol. **1**. Botanical Survey of India. pp. 301-305.

Puhua H and Ohashi H 2010. *Desmodium* Desv. *In*: Wu ZY, Raven PH and Hong DY (Eds), Flora of China. Vol. **10** (Fabaceae). Science Press, Beijing, and Missouri Botanical Garden Press, St. Louis. pp. 268-278.

Puhua H, Ohashi H, Iokawa Y and Nemoto T 2010. Tribe Desmodieae. *In*: Wu ZY, Raven PH and Hong DY (Eds), Flora of China. Vol. **10** (Fabaceae). Science Press, Beijing, and Missouri Botanical Garden Press, St. Louis. pp. 262-311.

Roalson EH, Senters AE, Skog LE and Zimmer EA 2002. A morphological cladistic analysis of the Neotropical flowering plant genus *Gasteranthus* (Gesneriaceae). Systematic Botany **27**(3): 573-591.

Schubert BG 1980. Flora of Panama. Part V, Fascicle 5. Family 83. Leguminosae, Subfamily Papilionoidae (Conclusion). 18. *Desmodium*. Ann. Miss. Bot. Gard. **67**: 622-662.

Shaheen ASM 2008. Morphological and anatomical investigation in *Desmodium tortuosum* (SW.) DC. (Fabaceae): A new addition to the Egyptian flora. Bangladesh J. Plant Taxon. **15**(1): 21-29.

Sneath PHA and Sokal RR 1973. Numerical Taxonomy. W.H. Freeman and Co. San Francisco, California

Soladoye MO, Onakoya MA, Chukwuma EC and Sonibare MA 2010. Morphometric study of the genus *Senna* Mill. in south-western Nigeria. African J. Plant Sci. **4**(3): 44-52.

Sonibare MA, Jayeola AA and Egunyomi A 2004. A morphometric analysis of the genus *Ficus* Linn. (Moraceae). African J. Biotechnol. **3**(4): 229-235.

Williams RJ 1983. Tropical Legumes. *In:* McIvor JG and Bray RA (Eds), Genetic resources of forage plants. CSIRO, Melbourne, Australia. pp. 17-31.

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