

MORPHOMETRICS OF THE TRIBE *MERREMIEAE* AUSTIN (CONVOLVULACAE) FROM INDIA

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Abstract

Sixteen species of the tribe *Merremieae* Austin (Convolvulaceae) from India were morphometrically analyzed with the help of Principal component analysis (PCA) and cluster analysis to explain the relationship between them. PCA showed that quantitative characters like corolla breadth, fruit breadth and length of paracot leaf play important role in bringing together all the species in the same tribe while the characters like leaf length, leaf breadth, petiole length, pedicel length, calyx length and calyx breadth play vital role in the delimitation of taxa within the tribe *Merremieae*. Cluster analysis and dendrogram revealed that, the genus *Operculina* S. Manso is segregated from *Merremia* Denns. ex Endlich.; genus *Hewittia* Wight. & Arn. is very close to *Merremia*, probably originated from *M. aegyptia* (L.) Urban and *M. dissecta* (Jacq.) Hall. f. cluster and genus *Xenostegia* Austin & Staples is isolated in the separate cluster.

Introduction

The Convolvulaceae is one of the largest families of angiosperms consist of 52 genera and 1650 species (Mabberley, 2008) and mainly distributed in the tropical and subtropical regions of the world. Some members of the family Convolvulaceae are medicinally as well as economically important (Austin, 1982; Chopra *et al.*, 1995; Kamalutheen *et al.*, 2009; Sahu and Gupta, 2014).

The tribe *Merremieae* Austin is a diverse tribe in the family Convolvulaceae. Due to many overlapping characters in the members of tribe *Merremieae*, their proper identification is confusing, which may be due to the lack of sound morphological characters to define it and increase in the number of published species in this tribe. The tribe possesses four genera, *viz.*, *Hewittia* R. Wight & Arnott, *Merremia* Dennst. ex Endl., *Operculina* Silva Manso and *Xenostegia* Austin & Staples. The genus *Hewittia* is represented by a single species, *Merremia* by 70 species, *Operculina* by 15 species and *Xenostegia* by only two species in the world (Mabberley, 2008). The present study reveals that, in India the genus *Hewittia* is represented by a single species, while the genera *Operculina* and *Xenostegia* consist of two species each, and the genus *Merremia* is represented by 11 species.

Numerical taxonomy plays important role in segregation of taxa. Cluster analysis (CA) and Principal component analysis (PCA) techniques are commonly used in determining the phylogenetic relationships among different taxa. Applying various methods of numerical taxonomy many authors, e.g. Sneath and Sokal (1973), Chiapella (2000), Gomez-Campo *et al.* (2001), Sonibare *et al.* (2004), Henderson (2006), Soladoye *et al.* (2010), Rahman *et al.* (2013) and many others have interpreted interrelationship among different genera and families of flowering plants. According to Sonibare *et al.* (2004) cluster analysis provides a hierarchical classification of entities (taxa) based on the similarity matrix, while PCA is a second method used for reducing the dimensions of the original data which allows visual interpretation of the relationships.

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Using macromorphological data and seedling character variations the present study aims to delimit the following 16 species of the tribe *Merremieae* and to evaluate systematic relationships within the tribe.

Materials and Methods

Plant specimens:

Sixteen species of the tribe *Merremieae* are listed in Table 1. Freshly collected as well as herbarium specimens deposited in BSI, BAMU, PBL, SUK and herbarium of the The New College, Kolhapur were used in this study. Fresh specimens were collected from different localities of India during 2005 to 2011. Some morphological characters are based on herbarium specimens (Table 1). The species were identified and authenticated with the help of relevant literature (Hooker, 1885; Cooke, 1958; Austin and Staples, 1980; Johari, 1983; Gamble, 1986; Bhandari, 1995; Biju, 1997; Almeida and Almeida, 2001; Singh *et al.*, 2001; Bhagat *et al.*, 2009). All the specimens are deposited in the herbarium of The New College, Kolhapur (NCK), India.

Table 1. List of species of the tribe *Merremieae* along with voucher specimens.

No.	Species	Specimens examined
1	<i>Hewittia malabarica</i> (L.) Suresh	Maharashtra: Ratnagiri, Bhatia beach, 2.11.2011, Shimpale 9835 (NCK)
2	<i>Merremia aegyptia</i> (L.) Urban	Maharashtra: Sangali, Miraj, 8.11.2006, Shimpale 3998 (NCK)
3	<i>M. dissecta</i> (Jacq.) Hall. f.	Maharashtra: Osmanabad, Kasabe Tadawale, 25.1.2009, Shimpale 4098 (NCK)
4	<i>M. gangetica</i> (L.) Cuford.	Maharashtra: Kolhapur, Rankala, 12.12.2012, Shimpale 5620 (NCK)
5	<i>M. hederacea</i> (Burm. f.) Hall. f.	Maharashtra: Pune, Baramati, 12.11.2008, Shimpale 2209 (NCK)
6	<i>M. peltata</i> (L.) Merr.	Great Nicobar Island: Dwivedi 17024 without date (PBL)
7	<i>M. quinquefolia</i> (L.) Hall. f.	Maharashtra: Kolhapur, Sarnobatwadi, 9.2.2010, Shimpale 5629 (NCK); Karnataka Belgaum district, Nipani, 23.3.2010, VBS 63 (SUK)
8	<i>M. rajasthanensis</i> Bhandari	Rajasthan: Jodhpur, Sardarsamand, 29.8.1975, Bhandari 1976 (CAL)
9	<i>M. rhyncorhiza</i> (Dalz.) Hall. f.	Karnataka: Belgaum, Kankumbi, 17.8.2008, Shimpale 3342 (NCK)
10	<i>M. tuberosa</i> (L.) Rendle	Maharashtra: Kolhapur, Tarabai Park, 29.12.2009, Shimpale 2629 (NCK)
11	<i>M. umbellata</i> (L.) Hall. f.	Maharashtra: Kolhapur, Dajipur, 22.3.2006, Shimpale 269 (NCK)
12	<i>M. vitifolia</i> (Burm.f.) Hall. f.	Maharashtra: Kolhapur, Dajipur, 22.3.2006 Shimpale 276 (NCK)
13	<i>Operculina tansaensis</i> Sant. & Patel	Maharashtra: Thane, Thansa lake, 28.11.2010, Shimpale 3229 (NCK)
14	<i>O. turpethum</i> (L.) S. Manso	Maharashtra: Ratnagiri, Dapoli, 16.1.2008, Shimpale 998 (NCK)
15	<i>Xenostegia filiformis</i> (Thunb.) Almeida	Karnataka: Khanapur, 2.1.2001, Shimpale 794 (NCK)
16	<i>X. tridentata</i> (L.) Hall. f.	Maharashtra: Sindhudurg, Malvan, 12.11.2009, Shimpale 754 (NCK); Nanded District, Dharmabad, 12.12.1993 Madhukar 6716 (BAMU)

Morphometric studies:

Morphometric studies were carried out on freshly collected as well as herbarium specimens that are deposited in BSI, BAMU, PBL, SUK and The New College, Kolhapur (NCK). Measurements were taken for 19 selected quantitative characters e.g. leaf length, leaf breadth, petiole length, pedicel length, calyx length, calyx breadth, corolla length, corolla breadth, stamen length, filament length, anther length, ovary length, style length, fruit length, fruit breadth, seed length, seed breadth, apical notch length, paracot length, and recorded on record sheets using as many as numbers of specimens were available for each taxonomic operational unit (OTU). The mean and standard deviation values for all the 19 quantitative characters were calculated and processed for PCA and CA (Kovach, 1999) by keeping data standardized at similarity matrix and tolerance of Eigen analysis set at 1E-010.

Results and Discussion

Nineteen parameters of 16 species of the tribe *Merremieae* from India were examined using numerical methods. The morphological features employed for delimitation of the 16 species with their means and standard deviations are shown in Table 2.

Similarity matrix based on correlation of *Merremieae* species (Table 3) shows that close resemblance of species could be observed when certain characters are employed. It is observed that, there is significant correlation between leaf length and corolla breadth, leaf length and corolla length, leaf breadth and petiole length, leaf breadth and calyx length, petiole length and calyx length, petiole length and corolla breadth, pedicel length and paracot length, calyx length and calyx breadth, calyx breadth and fruit breadth, corolla length and corolla breadth, corolla length and style length, corolla breadth and style length, stamen length and paracot length, filament length and paracot length, style length and fruit breadth, style length and seed length, fruit length and seed length, fruit length and fruit breadth.

Cluster analysis shows that *Xenostegia tridentata* distinctly differs from *Hewittia malabarica* and *Merremia aegyptia* while both the species of the genus *Xenostegia*, distinctly differs from *M. dissecta*, *M. hederacea*, *M. peltata*, *M. quenquifolia*, *M. rajsthanensis*, *M. rhyncorhiza*, *M. tuberosa*, *M. vitifolia*, *Operculina tansaensis* and *O. turpethum* (Table 4). *Merremia tuberosa* distinctly differs with *H. malabarica*, *M. aegyptia*, *M. gangetica*, *M. quenquifolia*, *M. rajsthanensis* and *M. umbellata*. It was also determined that *Operculina turpethum* is closely related with the *O. tansaensis*, *M. vitifolia*, *M. rhyncorhiza*, *M. dissecta* and *M. aegyptia*, while *M. vitifolia* closely relate with *M. umbellata*, *M. rajsthanensis*, *M. quenquifolia*, *M. dissecta* and *H. malabarica*. The relationships among the species of the tribe *Merremieae* is shown in Figure 1.

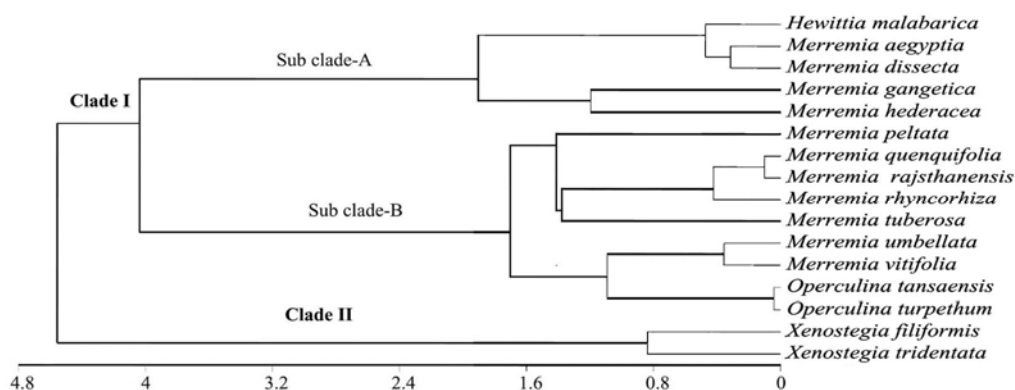


Fig. 1. Dendrogram showing relationship among the species of tribe *Merremieae*

Table 2. Quantitative characters of Tribe *Merremieae* species with Mean and Standard Deviation

Characters	H1	M1	M2	M3	M4	M5	M6	M7	M8	M9	M10	M11	O1	O2	X1	X2
Leaf length	7.8±0.57	8±1.2	8±2.25	1.3±0.69	5.5±1.3	18.2±6.4	3.8±1.1	3.7±1.15	10±4.77	13.9±5.49	7±2.5	7±2.8	11±3.4	9±3.7	6±2.4	1.2±0.66
Leaf breadth	3.3±0.91	3.2±0.9	10±3.4	1.8±0.78	4.8±0.98	17.4±5.2	6.5±2.4	6.7±2.2	4.5±2.1	12.9±4.15	3±0.55	9±3.5	8±2.7	8.5±2.9	0.9±0.1	0.35±0.11
Petiole length	2.8±0.12	6±2	4.5±1.8	1.8±0.57	4.7±1.25	11±3.4	4.5±1.7	8.9±3.77	9±2.75	11.4±1.9	1±0.2	3±1.15	10±2.9	7±2.5	0.2±0.01	0.2±0.05
Pedicle length	0.8±0.05	4±0.75	1.8±0.9	0.2±0.07	0.45±0.21	2±1.1	0.7±0.2	1.1±0.22	0.5±0.1	1.7±0.69	0.9±0.31	0.9±0.21	1.8±0.88	1.7±0.61	7±2.15	0.6±0.2
Calyx length	1.0±0.65	2±0.18	2.5±0.18	0.5±0.05	5.5±1.3	1.9±0.9	0.7±0.18	1.1±0.18	1±0.3	2.2±0.9	1±0.5	1.4±0.28	1.8±0.75	1.7±0.82	0.9±0.2	0.5±0.11
Calyx breadth	0.6±0.12	0.6±0.02	1.2±0.88	0.3±0.04	3.2±0.95	1.3±0.88	0.6±0.22	0.7±0.1	0.6±0.25	2.1±0.87	0.8±0.34	0.7±0.08	1.2±0.3	1.3±0.4	0.4±0.03	0.35±0.07
Corolla length	2.5±0.18	2.6±0.16	3±0.92	0.6±0.045	0.8±0.05	5.5±1.57	1.8±0.99	1.4±0.33	4±0.15	5.5±2.2	2.4±1.75	2.7±1.23	4.4±0.6	4±1	2±0.07	0.8±0.06
Corolla breadth	3.8±0.2	2.4±0.16	3.2±0.90	0.4±0.035	1.1±0.7	10±4.11	1.8±0.87	2±0.8	4.5±1.27	5.5±1.85	2.5±0.99	4±1.8	5.1±1.1	4.2±0.92	1±0.04	1±0.05
Stamen length	0.8±0.06	1.9±0.69	1.7±0.69	0.5±0.02	1.1±0.09	2±0.69	1.2±0.72	1.3±0.06	1.2±0.8	1.1±0.3	1.5±0.07	1.5±0.2	2.3±0.4	2.2±0.7	0.9±0.08	0.9±0.07
Filament Length	0.6±0.15	1.5±0.57	1±0.4	0.3±0.023	0.9±0.08	1.7±0.77	0.9±0.32	1±0.6	0.4±0.16	0.8±0.13	1.3±0.09	0.9±0.1	0.8±0.03	0.7±0.05	0.6±0.07	0.6±0.07
Anther length	0.2±0.16	0.4±0.01	0.7±0.02	0.2±0.017	0.2±0.01	0.3±0.07	0.3±0.02	0.3±0.04	0.8±0.17	0.3±0.02	0.3±0.03	0.6±0.05	1.6±0.04	1.5±0.07	0.3±0.02	0.3±0.01
Ovary length	1.0±0.7	0.2±0.01	0.3±0.01	0.1±0.09	0.1±0.01	0.2±0.09	0.2±0.018	0.2±0.03	0.2±0.01	0.2±0.04	0.2±0.011	0.1±0.02	0.2±0.01	0.1±0.01	0.2±0.01	0.2±0.02
Style length	0.9±0.28	1±0.08	1.4±0.09	0.2±0.08	0.5±0.04	2.3±0.15	1±0.09	1.1±0.6	1.3±0.67	2.8±1.2	1.2±0.05	1.1±0.08	2.1±0.09	1.9±0.2	1±0.02	1.1±0.05
Fruit length	0.9±0.35	1±0.08	0.9±0.08	0.2±0.07	0.6±0.07	1.5±0.95	0.8±0.08	0.6±0.2	1±0.4	3.6±0.85	1.3±0.88	1.4±0.08	0.8±0.03	0.75±0.01	0.6±0.03	0.5±0.02
Fruit breadth	0.6±0.14	1±0.07	1.2±0.08	0.4±0.04	0.7±0.065	1.7±0.67	1±0.22	0.7±0.15	0.9±0.38	3.2±1.05	0.8±0.44	1.5±0.05	1.7±0.04	1.5±0.52	0.6±0.04	0.3±0.01
Seed length	0.4±0.1	0.4±0.008	0.6±0.07	0.2±0.015	0.26±0.017	0.6±0.05	0.4±0.1	0.5±0.2	0.5±0.19	1.6±0.3	0.58±0.17	0.66±0.07	0.75±0.04	0.6±0.02	0.28±0.02	0.22±0.01
Seed breadth	0.3±0.7	0.4±0.011	0.4±0.01	0.2±0.011	0.22±0.01	0.4±0.22	0.3±0.05	0.4±0.06	0.4±0.19	1.2±0.24	0.39±0.06	0.51±0.04	0.73±0.06	0.64±0.02	0.3±0.01	0.2±0.02
Apical notch length	0.7±0.4	0.64±0.02	0.7±0.02	0.17±0.01	0.36±0.07	0.51±0.18	0.22±0.05	0.18±0.01	0.1±0.04	0.11±0.02	0.29±0.04	0.47±0.05	0.8±0.02	0.9±0.01	0.94±0.04	0.8±0.04
Paracot length	1.3±0.88	1.7±0.47	1.6±0.51	0.46±0.025	0.7±0.67	1.37±0.6	0.97±0.14	0.9±0.3	0.8±0.22	1.1±0.92	0.88±0.03	1.86±0.03	1.6±0.09	1.7±0.08	1.1±0.52	0.9±0.03

H1 = *Hemitelia malabarica*, M1 = *Merremia aegyptia*, M2 = *M. dissecta*, M3 = *M. gangetica*, M4 = *M. hederacea*, M5 = *M. peltata*, M6 = *M. quinquefolia*, M7 = *M. rajasthanensis*, M8 = *M. rhyncorhiza*, M9 = *M. tuberosa*, M10 = *M. umbellata*, M11 = *M. vitifolia*, O1 = *Operculina tansanensis*, O2 = *O. turpethum*, X1 = *Xenostegia filiformis*, X2 = *X. tridentata*

Table 3. Principal component analysis (PCA) in Tribe Merremieae

Similarity matrix	Leaf length	Leaf breadth	Petiole length	Pedicle length	Calyx length	Pediceal length	Calyx length	Calyx breadth	Corolla length	Corolla breadth	Stamen length	Filament length	Anther length	Ovary length	Style length	Fruit length	Fruit breadth	Seed length	Seed breadth	Apical notch length	Paracot length	
Leaf length	1																					
Leaf breadth	0.714	1																				
Petiole length	0.634	0.839	1																			
Pedicle length	0.422	0.011	-0.028	1																		
Calyx length	0.516	0.517	0.486	0.145	1																	
Calyx breadth	0.514	0.6	0.531	-0.036	0.905	1																
Corolla length	0.917	0.692	0.617	0.392	0.237	0.299	1															
Corolla breadth	0.881	0.78	0.685	0.169	0.284	0.355	0.929	1														
Stamen length	0.643	0.614	0.546	0.373	0.426	0.348	0.653	0.66	1													
Filament length	0.467	0.463	0.3	0.358	0.423	0.318	0.333	0.425	0.647	1												
Anther length	0.376	0.347	0.392	0.151	0.143	0.137	0.521	0.437	0.693	-0.097	1											
Ovary length	0.147	-0.089	-0.073	-0.011	-0.155	-0.179	0.113	0.193	-0.228	-0.082	-0.214	1										
Style length	0.741	0.623	0.534	0.372	0.209	0.364	0.879	0.831	0.648	0.37	0.484	-0.007	1									
Fruit length	0.703	0.589	0.435	0.189	0.297	0.435	0.728	0.694	0.284	0.393	-0.006	0.06	0.723	1								
Fruit breadth	0.773	0.826	0.691	0.262	0.441	0.565	0.832	0.773	0.575	0.356	0.409	-0.16	0.82	0.828	1							
Seed length	0.677	0.706	0.589	0.16	0.293	0.473	0.774	0.71	0.408	0.247	0.307	-0.02	0.813	0.889	0.922	1						
Seed breadth	0.354	0.34	0.369	0.158	0.186	0.31	0.478	0.307	0.251	-0.127	0.471	-0.083	0.526	0.567	0.669	0.789	1					
Apical notch length	0.085	-0.219	-0.32	0.551	0.071	-0.097	0.091	0.042	0.342	0.09	0.379	0.216	0.147	-0.265	-0.102	-0.231	-0.103	1				
Paracot length	0.58	0.464	0.287	0.533	0.271	0.11	0.627	0.613	0.741	0.448	0.556	0.146	0.557	0.346	0.539	0.397	0.327	0.327	0.611			

UPGMA dendrogram based on cluster analysis, mean character difference and constrained clustering strategy reveals that, greater affinity exists in between *Operculina tansaensis* and *O. turpethum* (Fig. 1). It is also pointed out that, in dendrogram, 16 species clearly forms distinct two clades i.e. I and II. Clade I is divided into subclade A and subclade B. Subclade A comprises *Hewittia malabarica*, *M. aegyptia*, *M. dissecta*, *M. gangetica* and *M. hederacea*, while subclade B comprises *M. peltata*, *M. quenquifolia*, *M. rajsthanensis*, *M. rhyncorhiza*, *M. tuberosa*, *M. umbellata*, *M. vitifolia*, *O. tansaensis* and *O. turpethum*. Clade II comprises *Xenostegia filiformis* and *X. tridentata*. On the basis of dendrogram it is clear that both the *Xenostegia* species distantly differs with the remaining species of tribe *Merremieae*, which supports Austin and Staples (1980) segregation of the genus *Xenostegia* from *Merremia*. The present study is the first report depicting correlation between the members of the tribe *Merremieae* from India and also predicts the phylogenetic relationship within the members of the tribe.

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