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A Numerical Study of Twenty one Taxa of Vernonia (Vernonieae, Asteraceae) in India

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Abstract

The paper presents the result of numerical taxonomic analysis of twenty one species of *Vernonia*. Twenty seven characters were studied of which fifteen are qualitative and others quantitative. Cluster analysis shows that the species fall under four different groups as follows:

- Group 1. Vernonia hookeriana, V. altissima, V. bourneana, V. monosis, V. travancorica, V. indica and V. arborea.
- Group II. V. calycina, V. cinerascens, V. eleagnifolia and V. extensa.
- Group III. V. attenuata, V. cinerea, V. divergens and V. saligna.
- Group IV. V. squarrosa, V. subsessilis var. bracteolata, V. beddomei, V. aspera, V. peninsularis and V. revoluta.

INTRODUCTION

Vernonia is a widely distributed genus with nearly 1000 species. The diversity inherent in this large genus has caused numerous problems in its systematics. Although, a lot of work has been done on various aspects of taxonomy of Vernonia species (Hunter & Austin, 1967; Jones, 1970, 1972, 1979, 1982; Urbatsch, 1972; Faust & Jones, 1973; Kingham, 1976; Keeley & Jones Jr., 1977; Sahu, 1983) numerical studies have not been done so far on this group. Hence the present study was undertaken.

The purpose of this work is to attempt to gain insight into variation patterns within this complex group of plants using numerical technique. The paper presents the result of a numerical taxonomic study of the twenty one species of the genus *Vernonia* occurring in India.

MATERIALS AND METHODS

The taxa (Operational Taxonomic Units, of Sokal & Sneath, 1963) considered in this study and their code number are given in Table I. The characters used and their states are given in Table II. Fifteen of the characters are qualitative and twelve quantitative. At least 500 individuals of each taxon (OTU) were numerically analysed. The measurements for quantitative characters were taken in millimeters and the mean, variance, standard deviation and standard error of the mean were calculated for each of the character in the sample groups. Keul's Multiple Range Test (Woolf, 1968) was

Table I

Name of species considered in taximetric analysis and code numbers given to each OTU.

Species	Code No.
Vernonia squarrosa (D. Don) Less.	1
V. subsessilis var. bracteolata DC.	2
V. beddomei Hook. f.	3
V. attenuata DC.	4
V. aspera BuchHam.	5
V. peninsularis Clarke	6
V. revoluta Ham.	7
V. cinerea Less.	8
V. divergens Benth.	9
V. saligna DC.	10
V. hookeriana Arn.	11
V. calycina Wall.	12
V. cinerascens Schultz-Bip.	13
V. elaeagnifolia DC.	14
V. indica Clarke	15
V. extensa DC.	16
V. arborea Ham.	17
V. monosis Benth.	18
V. <i>travancorica</i> Hook.	19
V. altissima Nutt.	20
V. bourneana Smith	21

performed to measure differences among means, and to find out whether the differences between means of taxa are statistically siginificant or not. The 5% level of confidence was adopted. The results of KMRT was tabulated on charts (Tables III & IV) which compared each OTU with all others on the basis of each of the studied characters. In interpreting these, one needs to know that all means which are over a given line are not significantly different. Only when two means are not over the same continuous line they differ significantly. The percentage of similarity (obtained from the formula "% similarity = number of significantly similar means - number of significantly dissimilar means + the number of significantly similar means") was used to construct a similarity matrix (Fig. 1). In this matrix various symbols were used to

indicate the degree of similarity. Groups of similar taxa can be immediately recognized as triangles made up of high similarity values as shown in Fig. 1. These groups were then represented in the form of dendrogram which shows the degree of relationships and taxonomic distances among the taxa of various groups as well as between the various groups (Fig. 2).

RESULTS AND DISCUSSION

Study of matrix and dendrogram clearly revealed four groups among the considered species of *Vernonia*. The OTU's falling under each group are as follows:

Group	1	-	OTU's 11, 21, 20, 18, 19,
			17 & 15
Group	11	-	OTU's 14, 13, 16 & 12
Group	111	~	OTU's 4, 10, 9 & 8
Group	IV	-	OTU's 6, 7, 2, 5, 1 & 3.

Group I was rather large and contained seven taxa i. e., OTU 11 (V. hookeriana), OTU 21 (V. bourneana), OTU 20 (V. altissima), OTU 18 (V. monosis), OTU 19 (V. travancorica), OTU 17 (V. arborea) and OTU 15 (V. indica). OTU's 11, 21, 20, 18, and 19 formed one cluster and OTU's 17 and 15 another within a group. OTU's of these two clusters joined together at 52% similarity level. Vernonia hookeriana (OTU 11) and V. bourneana (OTU 21) were kept by Hooker (1882) in two different sections i. e., OTU 11 in section 'A' and OTU 21 in section 'B'. In the present study OTU 11 shows close resemblance with considered taxa of section 'B' (OTU's 21, 20, 19, 18, 17 & 15), and maximum similarity i. e. 67% with OTU 21 than the OTU's of section 'A' where it shows only 33-48% similarity level with Hence it is suggested that it may them. be kept in section 'B' along with OTU's 21, 20, 19, 18, 17 and 15. Hooker (1882)

Rheedea 1 (1 & 2) 1991 Numerical study of Vernonia

Table II	
Characters to which numerical values were assigned	

Qua	litative Characters													
1.	Leaf petiolate or not													
2.	Leaf base auriculate or not													
з.	Head stalked or not													
4.	. Receptacle: (a) flat, (b) convex													
5.	. Involucre bracts imbricate or not													
6.	Involucre bracts scarious or not													
7.	Disk floret fertile or not													
8.	Pappus present or absent													
9.	Pappus : (a) hairy, (b) bristle													
10.	Position of anthers in the corolla tube	(a)	included	(b)	exse	rted								
11.	Position of styles in the crolla tube	(a)	included	(b)	exser	ted								
12.	Achene straight or not													
13.	Achene types : (a) cylindrical, (b) obovat	te												
14.	Achene surface hairy or not													
15.	Achene ribbed or not													
Qua	ntitative characters													
1.	Petiole length				2.	Leaf length								
3.	Leaf breadth				4.	Peduncle length								
b. 7	Capitulum length				6.	Capitulum diameter								
/.	Rappus length				8. 10	Corolla tube longth								
9. 11	Achene length				10.	Achene diameter								

Table III

	Results of multiple range test of Qualitative Characters																							
.												× • • •												-
	Characters											10	S	NU	mpe	r								
1.	Leaf: Petiolate	-	1	3	4	6	9	10	1	1	12	14	Ļ	15	16	17	7 ·	18	19	2	20	21		
	not	—	2	5	7	8	13																	
2.	Leaf base : auriculate	—	1	to	2'																			
	not	—	NI	L																				
3.	Head: Stalked		3	4	5	6	7	8	9	10	1	1	12	1	3 1	5	16	1	7	18	1	9 2	20	21
	not		1	2	14																			
4.	Receptacle (a) flat	—	1	3	8	9	11	1	2	18	20) 2	21											
	(b) convex		2	4	5	6	7	10	1	3	14	15	5	16	17	- 19	3							
5.	Inv. bract : imbricate	-	8	18																				
	not	_	1	2	3	4	5	6	7	9	10	1	1	12	13	1	4	15	1	61	7 1	19 2	20	21
6.	Inv. bracts : scarious	_	16																					
	not	—	1	2	3	4	5	6	7	8	9	10)	11	12	13	3 14	41	51	71	8	19	20	21
7.	Disk floret : fertile	_	1	to	2	1																		
	not	_	NI	L																				
8.	Pappus : Present		1	to	2	1																		
	absent	-	NI	L																				
9.	Pappus type : (a) hairy	-	2	3	4	5	6	7	8	9	10) 1	1	12	13	3 14	1 1	51	6 1	7 1	8	19	20	21
	(b) bristle		1																					
10.	Position of anthers in																							
	corolla tube : included		2	4	5	6	7	8	10)														
	exserted	-	1	3	9	11	1:	2	13	14	F 1	5	16	1	7 '	18	19	2	20	21				
11.	Position of style in																							
	corolla tube : included	_	4	5	6	7	8	10																
	exserted	_	1	2	3	9	11	1	2	13	14	1 [.]	15	16	5 1	7 [.]	18	19	9 2	20	21			
12.	Achene : straight		1	3	4	5	6	7	8	9	10) '	12	14	1	5	16	18	3 1	9	20	2	21	
	not		2	11	1	3	17																	
13.	Achene type : cylindrical	_	1	4	5	18	1																	
	obovate	_	2	3	6	7	8	9	10) 1	11	12	1	3	14	15	1	6	18	1	9	20	21	I
14.	Achene surface : hairy	_	1	2	3	4	7	8	11	· ۱	12	13	•	6	18	20) 2	21						
	not	-	5	6	9	10) 1	4	15	1	7	19												
15.	Achene : ribbed	-	1	2	3	4	5	6	9	10	o ·	11	1:	3 1	14	15	16	5	17	18	1	9	20	21
	not		7	8	12	2																		

Table IV

Resuls of mulitiple range test of quantitative characters

Character 1 (Petiole length)

Taxon No.	2	7	13	1	3	5	12	20	14	10	4	8	15	6	16	9		19 7 0	18	<u> </u>	21	11	17 16 0
SE.	0.0	0.0	0.0	0.10	2.0 0.17	2.0 0.27	2.0 0.41	0.25	0.21	0.92	4.0 0.52	4.0 0.64	4.0 0.46	0.61	0.1	, , 71 (.0).73	0.74	10. 1 1.	.27	3.17	1.04	1.38
									Cha	racter	2 (Le	aflen	gth)										
Taxon No.	13	7	8	14	12	10	11	21	19	6	5	15	1	4	9		16	20	3	1	7	2	18
Mean	21.0	29.0	31.0	36.0	38.0	48.0	64.0	64.0	70.0	73.0	75.0	77.0	78.0	84.	0 90	0 9	6.0	96.0	101.	0 1	16.0	126.0	124.0
SE,	1.28	1.01	3.43	2.45		3 3.74	3.5/	11.20	3.94	6.2	3 4.0	6 6.	/6 3.1	18 9.	54 4	79	4.44	5.82	2 5.	02	9.02	5.83	19.7
									Cha	racter	3 (Le	af bre	adth)										
Taxon No.	7	13	10	8	14	20	12	3	1	21	5	4	19	9		16	15	1	1	6	17	2	18
Mean	2.0	7.0	10.0	11.0	13.0) 14.0) 17.0	20.0	22.0	25.0) 26.	0 29	.0 30	.0 3	1.0 3	34.0	35.0) 41	.0 10	42.0	44.0	52.0	69.0
36.	0.20	0.01	1,24	1.44									.05 1			3.04	3.2	.4 2	.10	4.40	3.4		
								С	haract	:er4 (Pedur	ncle le	enght)										
Taxon No.	14	17	18	9	19	5	16	10	13	15	12	21	3	1	4	1	1	8	20		7	6	2
Mean	0.0	1.0	1.5	2.0	2.5	3.0	30	3.0	4.0	4.0	5.0	5.0	5.0	5.0	6.0	7	.5	9.0	10	0.0	14.3	24.0	26.0
SE.	0.0	0.18	0.10	0.16	0.35	0.25	0.29	0.37	0.36	0.40	0.0	0.44	0.53	1.43	1.0	2 (0.89	0.9		1.04	1.50	1.95	2.08
								Ch	aracte	er 5 (C	apitul	um le	ength)										
Taxon No.	8	9	13	21	11	14	10	20	4	17	7	1	5 (6	5	2	1	6	20	1	18	3	12
Mean	5.0	5.0	6.0	6.5	7.5	8.0	8.0	8.0	9.0	10.0	10.	0 10	0.0 1	11.0	13.0	13	.0 1	14.0	15.0	16.0	17.0	18.0	24.0
SE.	0.16	0.20	0.25	0.15	0.45	0.14	0.31	0.45	0.48	0.2	1 0.	23	0.38	0.30	0.4	7 C	0.70	0.30	0.0	0.4	0 0.2	2 20.74	+ 0.65
								Cha	aracter	6 (Ca	ipituli	ım dia	meter))									
Taxon No.	15	18	14	9	11	13	17	16	21	19	20	8	10	4	7	6		5	2	3		1	12
Mean	2.0	2.0	2.0	2.5	3.0	3.0	3.0	3.0	3.5	4·0	4 ∙0	4.5	5.0	5.0	7.0	7.	.0	8.0	9.0	10	.0	12.5	17.5
SE.	0.0	0.0	0.10	0.08	0.0	0.10	0.12	0.18	0.11	0.10	0.21	0.24	0.18	0.39	0.3	4 0	.37	0.36	0.39	0	.53	0.20	0.78

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Sahu Rheedea 1 (1 & 2) 1991

T. R.

Character	7	Involucre	bract	length)
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Taxon No.	14	17	13	11	18	20	15	19	21	9	8	16	4	10	2	1	7		6	5	3	12
Mean	2.0	2.0	2.0	2.0	3.0	3.0	3.0	3.0	3.5	4.0	4.0	4.0	4.0	5.0	6.0	6.5	7.0	0	7.0	7.0	8.0	13.0
SE.	0.15	0.16	0.17	0.27	0.19	0.25	0.26	0.36	0.16	0.20	0.24	0.38	0.43	0.45	0.3	5 0.85	50.	48	0.65	0.70	1.02	1.57
									Chai	acter	8 (Flo	ret len	gth)									
Taxon No.	6	13	9	8	14	11	10	21	20	17	15	7	2	4	3	1	16		5	19	18	12
Mean	4.5	5.0	5.0	5.5	7.0	7.0	7.0	7.0	8.0	8.0	8.0	8.5	9.0	9.0	10.5	13.5	14.0		14.0	14 5	15.0	16.0
SE.	0.05	0.15	0.22	0.23	0.0	0.13	0.45	0.72	0.13	3 0.13	3 0.94	4 0.4	5 0.2	5 0.2	8 0.2	5 0.3	2 0.2	27	0.31	0.27	0.07	0.57
									Char	acter	9 (Pap	pus le	ngth)									
Taxon No.	6	13	14	21	8	9	4	11	20	15	17	10	2	7	18	16	5	5	19	1	3	12
Mean	3.0	4.0	4.5	5.0	5.0) 5.	0 5.0	5.0	5.5	6.0	7.0	7.0	7.0	7.0	8 (8.5	59	0.0	10.0	10.5	12.0	13.0
SE.	0 05	0.10	0.07	0.08	3 0.	19 0.	24 0.3	30 0.0	0 09	0.0	0.10	0 2	1 0 2	5 0.2	8 0.0	8 0.2	9 0	.22	0.41	I 0.15	0.15	0.20
								Ch	aracte	r 10 (Coroll	a tube	tengt	ih)								
Taxon No.	6	13	9	8	14	21	17	15	4	11	10	20	7	2	3	19	18		5	1	16	12
Mean	3.0	3.0	4.0	4.0	5.0	5.0	60	6.0	6.0	6.0	6.0	7.0	7.0	8.0	8.5	9.0	9.0	0	10.0	10.5	12 0	1 3.0
SE.	0.0	0.14	0.17	0.35	0.0	0.10	0.08	0.15	0.18	0.20	0.30	0.17	0.28	0.14	0.21	0.22	6.	.0	0.46	0.32	0.16	0.86
								C	Charac	ter 11	(Ache	ne len	gth)									
Taxon No.	8	9	6	21	20	11	7	2	10	12	14	4	1	3	17	15	3	1	5	16	19	18
Mean	1.0	1.0	1.5	1.5	1.5	1.5	1.5	1.75	1.75	2.0	2.0	2.	0 2	.0	2.0	2.0	2.5	3.0	3.0	3.0	4.75	6.0
SE.	0.07	0.34	0.0	0.0	0.05	0.18	5 0.86	0.07	0.12	0.0	0.0	0.	05 (0.09	0.10	0.11	0.8	0.0	0.0	5 0.9	0.16	0.08
								с	haract	er 12 (Acher	ie diar	neter)									
Taxon No.	2	6	7	9	10	11	13	15	21	8	20	17	4	16	1	12	14	3	3	5	18	19
Mean	0.5	0.5	0.5	0.5	0.2	0.2	0.5	0.5	0.5	0.2	0.75	0.75	0.75	0.75	1.0	1.0	1.0		1.0	1.25	1.5	1.5
SE.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.4	0.05	0.09	0.15	0.15	0.0	0.0	0.0	(0.13	0.07	0.0	0.0

T. R. Sahu



Fig. | Showing Similarity Matrix.

considered V. monosis (OTU 18) as var. wightiana of V. arborea while Clarke (1876) and Fyson (1932) treated V. arborea (OTU 17) and V. monosis (OTU 18) as distinct species. These could easily be separated on the basis of number of florets in the head i. e., one floret in V. monosis (OTU 18) and four to six florets in V. arborea (OTU 17). As only 45% similarity was observed between these two, the view of Clarke and Fyson are supported by the present study and it justified the distinction of them at species level. V. arborea (OTU 17) was found to be nearer to V. indica (OTU 15) than V. monosis (OTU 18). This also supports that V. monosis should

26



Fig. 11 Dendrogram showing the degree of relationship and taxonamic distances among the taxa.

be treated as a distinct species and not as a variety of V. arborea as suggested by Hooker. On the contrary, Sahu (1983) has found that V. arborea and V monosis are closely related in trichome complements (both show aseptate flagellate and achenial hairs) and have a paired affinity index of 100. This supports the treatment of Hooker and do not support the separation of V. arborea and V. monosis as distinct species as done by Clarke and Fyson. At this stage, it is difficult to draw any definite conclusion about the taxonomic status of these species. There is a need to undertake more detailed study involving larger number of characters, particularly phytochemical characters. Only such studies are likely to help us to arrive at any meaningful conclusion.

Group II consists of four taxa (i.e., OTU's 14, 13, 16 and 12) and maximum similarity was observed between OTU 14 (V. elaeagnifolia) and OTU 13 (V. cinerascens). Though they were found to be related in a number of characters, a distinction between them could easily be made. The former is clothed with ashy pubescence and has sessile leaves and OTU 13 and OTU 14 were kept heads, in the same group by Hooker on the basis of much shorter involucral bracts and leaves without cottony hairs. Present analysis also justified the clustering of OTU's 13 and 14 together. Although, OTU 16 (V. extensa) and OTU 12 (V. calycina) were clustered in this group at 50% similarity level, they could easily be separated by the type of involucral bracts, as has been done by Hooker (1882). Therefore the analysis suggests the retention of OTU's 16 and 12 in different groups of the same section.

Group III is a smaller one containing four taxa i. e., OTU's 4, 10, 9 and 8. 61% and 54% similarity was observed among OTU's 4 and 10 and 9 and 8

respectively. OTU 4 (V. attenuata and OTU 10 (V. saligna) were found similar in almost all the qualitative characters, however, they differed in some quantitative characters of leaf, peduncle, capitulum, floret, pappus, corolla tube and diameter of achene. OTU 9 (V. divergens) and OTU 8 (V. cinerea) were found similar in leaf base, stalked head, involucral bracts and pappus type. OTU 4 was kept by Hooker in one of the groups of section 'A' along with OTU's 1, 2, 3, 5, 6 and 7, however, it appeared to be more related with OTU's 10, 9 and 8 of another group of the same section in most of the qualitative and quantitative characters. The present study suggests that it may be kept in a group which contained OTU's 10, 9 and 8 and not with taxa of other group in which it was kept by Hooker.

Group IV is the second largest group which contains six taxa i. e., OTU's 6, 7, 2, 5, 1 and 3. OTU's 6, 7, 2 and 5 formed one cluster and OTU's 1 and 3 another within the group. Analysis revealed 58% similarity between OTU 6 (V. peninsularis), OTU 7 (V. revoluta), OTU 1 (V. Squarrosa) and OTU 3 (V. beddomei), and 55% between OTU 2 (V. subsessilis) and OTU 5 (V. aspera). All the taxa of this group were found similar in most of the qualitative characters, however, they differ markedly from each other in quantitative characters of petiole, leaf, peduncle, capitulum, floret, pappus, corolla tube and achene. Clustering of OTU's 1 - 7 in group IV may be justified as all these taxa belong to the same group of section 'A' of Hooker (1882).

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