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NUMERICAL TAXONOMY OF THE GENUS *EUPHORBIA* L. FROM PUNE, MAHARASHTRA, INDIA

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ABSTRACT:
The morphological parameters of 6 species of genus *Euphorbia* L. were subjected to quantitative analysis in the present study by means of 6 observable variables [viz. length of leaf, width of leaf's middle part, length of petiole, width of the base of leaf and width of leaf's apex] and branch character (internodal length). The cluster analysis obtained the formation of six nodes with the highest correlation being found between *E. hirta* and *E. thymifolia,* while the maximum dissimilarity is observed in *E. neriifolia* which deviated from the rest of the species. The scree plot was achieved with the aid of Eigen values which establish that two foliar characters [viz. length of petiole and width of leaf's apex] are helping in the grouping of the similar species and delimiting the group of similar species from dissimilar species. The current study is found to have a relatively medium variation in Sokal's coefficient of taxonomic distance ranging from 0.3 to 5.017 which helps in grouping and segregating the species accordingly. It also shows the importance of numerical methods for determining taxonomic relationships among species.

Keywords: *Euphorbia*, numerical taxonomy, cluster analysis, scree plot, quantitative foliar characters

INTRODUCTION:

In the world of ever-changing methods to study taxonomy among the plant groups, numerical taxonomy is proving to be a best alternative to examine differences and similarities through statistical methods. This branch of statistical taxonomy deals with grouping by numerical methods of taxonomic units into taxa on the basis of their character state (Sneath and Sokal, 1973). Numerical taxonomy strives to study and distinguish between taxa with the help of computerised means through software which are then classified into various taxa on the basis of their resemblance. The procedures frequently used in numerical studies are cluster analysis and scree plot studies. Cluster analysis furnishes a hierarchical preparation of taxa supported by the Sokal's coefficient of taxonomic distance of the species (Sneath and Sokal, 1973). This helps to combine data from a range of basis such as anatomy, cytology, ecology, genetics, geography, physiology, palynology, biochemistry, chemistry etc. (Soladoye *et al.*, 2010). The numerical studies are considerable for documentation of new morphological character and character states, and many efforts have been made in this view for understanding phenetic relationships in different groups of plants (Sonibare, 2003; Pinheiro and de Barros, 2007; Mulumba and Kakudidi, 2010; Deshmukh, 2011; Rahman and Rahman, 2012).

Euphorbiaceae is one of the most diversified families with 246 genera and 6,300 species which are scattered all around the globe (Govaerts *et al.* 2000, Wurdack & Davis 2009). Among the top ten largest genus of Angiosperms, *Euphorbia* L. is positioned fourth amongst it with the status of being the largest genus in the family Euphorbiaceae (Frodin, 2004, Horn *et al.,* 2012). The genus is characterised by the presence of white milky juice with herb or shrub habit. The leaves are opposite or more or less alternate with monoecious flowers (Cooke, 1901). The genus is well characterized by the presence of special type of inflorescence which is termed as cyathium, a pseudanthial inflorescence exclusive in Angiosperms. It is made up of four or five staminate cymules which surrounds a pistillate flower which is terminal in nature and present within a cup-like involucre created by the union of bracts from the

staminate cymules. The cyathium has glands along its rim, and the glands can sometimes have appendices (Webster, 1994, Radcliffe–Smith, 2001, Horn *et al.* 2012, Yang *et al.* 2012). The cyathium inflorescence is a very important character for the recognition of species and was once used to separate out genera within subtribe Euphorbiineae (Webster, 1994, Radcliffe-Smith, 2001).The male flowers have a stalked stamen without floral envelope while the female flowers have a trilocular ovary with one ovule in each locule and have 3 free connate shaped styles. The seeds are albuminous with broad and flat cotyledons (Cooke, 1901).

The presence of different secondary metabolites like alkaloids, cyanogenic glycosides, diterpenes, glucosinolates, tannins and triterpenes in the Euphorbiaceae family have led to the recent attempt of studying a specific genus of the family in the light of numerical taxonomy with the help of chemical constituents present in their leaves to find affinities among various species (Hegnaeur, 1989, Kolawole *et al.* 2014). In the remark of the multifaceted taxonomic status of *Euphorbia* L. species, this study attempts to use a quantitative set of foliar characters and branch character for screening of the genus *Euphorbia* L. in the Pune, Maharashtra, India with a vision to inspect the taxonomic bond between 6 members of the genus (table 1).

MATERIAL AND METHODS

The different species of this genus were brought to the laboratory and identified with the help of flora. (Sutaria R. N. (1962), Cooke, T. (1901). During the statistical analysis, foliar characters [viz. leaf length, middle (leaf width), width of the base of leaf and width of leaf apex] and branch character (internodal length) were used as variables to point out the differences in the species considered for the examination. The measurements of the following species were done with the help of a line ruler. Cluster analysis was performed on the basis of Farthest Neighbour as the clustering method with Mean Character Distance or Sokal's coefficient of taxonomic distance as the distance matrix type and a dendrogram was built to show the relationship among the species (Sneath and Sokal, 1973). Scree plot and Eigen values are calculated by keeping the data standardised and tolerance of Eigen value at 1E-010. All the statistical evaluations were conducted in the software named as Multivariate Statistical Package v3.2 (MVSP) (Kovach, 1999).

RESULTS AND DISCUSSION

The dendrogram (Fig. 1) prepared shows the morphological relationship between closer related species. It shows the formation of 5 nodes within which the closeness of the species can be seen. The table 2 displays the mean and standard deviation of the respective species considered for numerical analysis. The dendrogram keeps *Euphorbia hirta* and *Euphorbia thymifolia* together which points towards the maximum closeness between the two species with the least Sokal's coefficient of taxonomic distance. *Euphorbia hypericifolia* shows closeness to both *E. hirta* and *E. thymifolia* with its Sokal's coefficient of taxonomic distance below 1. In the meanwhile, *Euphorbia heterophylla*, *Euphorbia tirucalli* and *Euphorbia neriifolia* shows a distinctive gap between each of the species with their Sokal's coefficient of taxonomic distance of above 1 which is illustrated in table 3.

The scree plot (Fig. 2) shows the variables, length of petiole and width of leaf's apex to have Eigen values more than 1 while the other foliar characters and internodal length are all below 1 which is not considered for further explanation of the set of data.

The most significant closeness among the six species are shown between *E. hirta* and *E. thymifolia* which is mainly due similar petiole length and width of leaf apex which is well supported by their prostate nature of herb, presence of small sized leaves and involucres present on limb with gland inconspicuous. (Cooke, 1901)

While *E. hypericifolia* also shares a distinct closeness with both of the *E. hirta* and *E. thymifolia* which is particularly due to the similar petiole length and width of the base that is well hold up by the herbaceous and annual nature of the stem, prostrate stem and presence of glands in involucres with appendices (Cooke, 1901). The three of the species shares common characters such as pollen margin being wavy, lumina being indistinguishable, presence of sunken colpi which lacks a clearly protruding sexine at the os (Perveen and Qaiser, 2005).The species *E. heterophylla* and *E. tirucalli* are somewhat close to each other due to their similar width of apex and the midrib of the leaves are formed by three strands with leaf veins being unornamented (Sehgal and Paliwal, 1973).

E. neriifolia moves away from all the studied species due to its excessive length and width of the foliar characters with the length of leaf being the most noticeable one. It is a perennial shrub with thorns of stipular origin which arises from tubercles which are spirally arranged (Cooke, 1901). The leaves of *E. neriifolia* has three to five strands coming together to form the midrib and the lateral traces of the leaf which joins with the vascular system of the stem shows branching in this case (Sehgal and Paliwal, 1973). And the somatic chromosome number of *E. neriifolia* is 2n = 90 (Mehra and Choda, 1978). These characters state the differences and thus during cluster analysis, it has been kept away from the other species.

The two foliar variables namely, length of petiole and width of leaf's apex are proving instrumental in amalgating similar species together and delimiting the dissimilar species away from the similar set of species by the help of their high Eigen values in Fig. 2 and relationship of variables with Eigen values are displayed in Table 4. The limitations of quantitative taxonomic practices (as in all different kinds of taxonomic practices) a person must not be directed to suppose that "numerical taxonomy is an excursion to futility" as argued by Ross (1964). These numerical taxonomic methods has provided the branch of plant systematics a new approach by examining minute details with lots of potential purposes to integrate or/and isolate most complicated species amongst each other.

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S. No.	Name of the species
1.	*Euphorbia neriifolia* Linn.
2.	*Euphorbia tirucalli* Linn.
3.	*Euphorbia heterophylla* Linn.
4.	*Euphorbia hypericifolia* Linn.
5.	*Euphorbia hirta* Linn.
6.	*Euphorbia thymifolia* Linn.

Table 1: List of species of *Euphorbia* L. studied with their authority.

	Int.	Pt L.	Lf L.	Ap.	Mi.	Ba.
E. neriifolia	5.3 ± 1.02	1.1 ± 0.78	16.6 ± 4.04	1.1 ± 1.54	7.2 ± 1.67	2.1 ± 0.49
E. tirucalli	4.1 ± 0.75	0.1 ± 0.03	0.7 ± 1.34	0.2 ± 1.02	0.3 ± 1.1	0.1 ± 0.04
E. heterophylla	2.5 ± 0.91	1.1 ± 0.76	4.6 ± 0.98	0.4 ± 0.29	2.8 ± 0.59	0.5 ± 0.33
E. hypericifolia	3.1 ± 0.93	0.2 ± 0.32	2.0 ± 1.54	0.2 ± 0.46	1.0 ± 0.62	0.5 ± 0.95
E. hirta	1.5 ± 0.67	0.1 ± 0.08	1.7 ± 0.89	0.4 ± 1.02	0.6 ± 1.03	0.6 ± 0.28
E. thymifolia	1.6 ± 0.85	0.1 ± 0.12	0.5 ± 0.73	0.3 ± 0.38	0.4 ± 0.66	0.4 ± 0.75

Table 2: Mean and Standard deviation values of 6 species of genus *Euphorbia* L.;
Int. = Internodal length, Pt L. = Length of petiole, Lf L. = Length of leaf, Ap. = Width of apex, Mi. = Width of middle part of leaf, Ba. = Width of leaf's base.

Node	Group 1	Group 2	Sokal's coefficient of taxonomic distance	Objects in group
1	*E. hirta*	*E. thymifolia*	0.3	2
2	*E. hypericifolia*	Node 1	0.65	3
3	*E. heterophylla*	Node 2	1.433	4
4	*E. tirucalli*	Node 3	1.6	5

5	*E. neriifolia*	Node 4	5.017	6

Table 3: Sokal's coefficients of taxonomic distances have been displayed with which the dendrogram is built.

Variables	Pt L.	Ap.	Ba.	Mi.	Int.	Lf L.
Eigen values	3.589	1.568	0.546	0.271	0.026	0
Percentage	59.816	26.136	9.106	4.515	0.428	0
Cum. Percentage	59.816	85.951	95.057	99.572	100	100

Table 4: Variables with Eigen values above 1 help to delimit the taxa and compile similar species together by isolating dissimilar species; Int. = Internodal length, Pt L. = Length of petiole, Lf L. = Length of leaf, Ap. = Width of apex, Mi. = Width of middle part of leaf,
Ba. = Width of leaf's base.

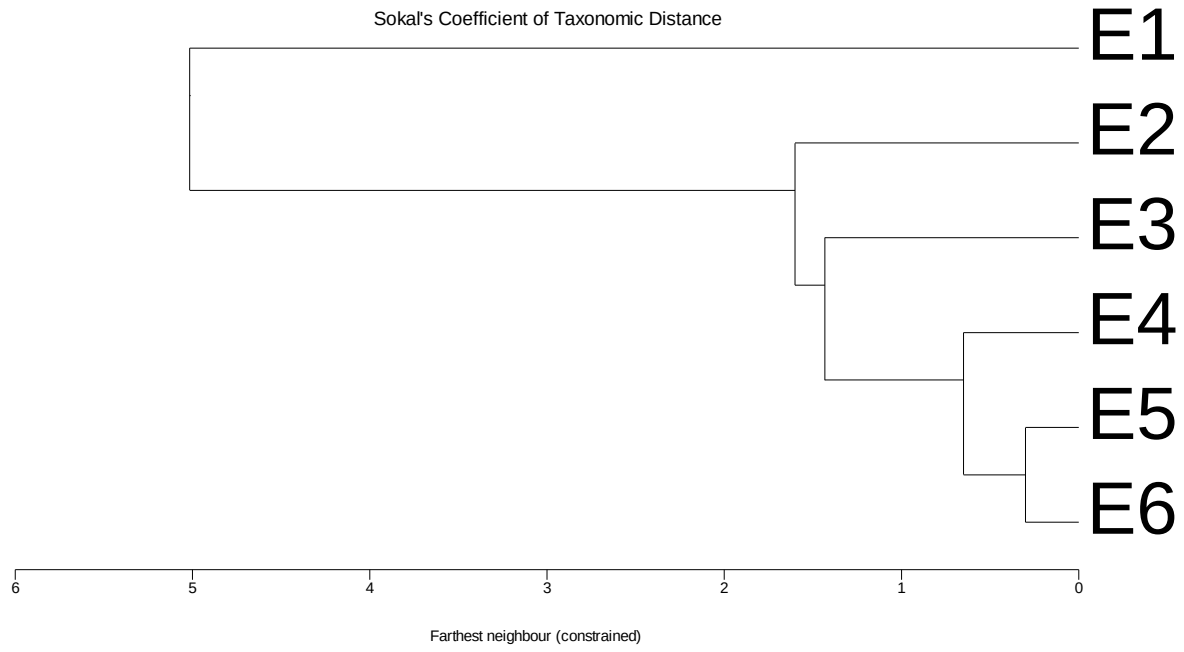

Fig. 1: Dendrogram; E1 = *E. neriifolia*, E2 = *E. tirucalli*, E3 = *E. heterophylla*, E4 = *E. hypericifolia*, E5 = *E. hirta*, E6 = *E. thymifolia*.

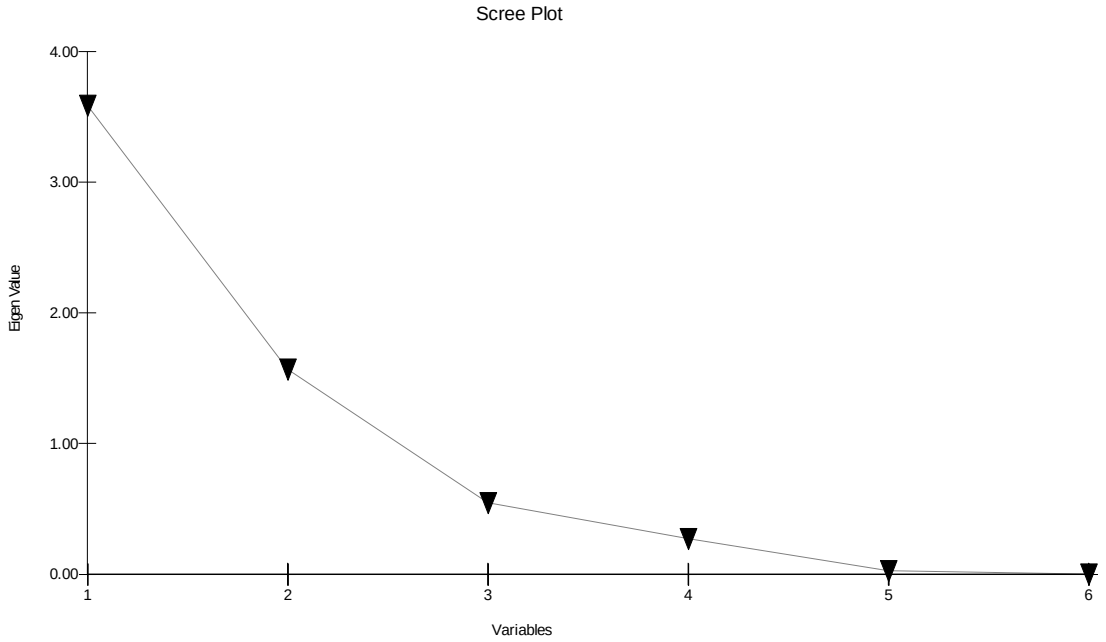

Fig 2: Scree plot with the 6 variables plotted against their respective Eigen values; variables with Eigen value more than 1 are stronger and determinant to delimit the taxa.