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Significance of Numerical Taxonomy in Plant Classification Studies using some Species of Euphorbiaceae as Case Study

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Abstract
Numerical taxonomy is a veritable and useful tool in plant classification and identification studies. However the potentials and opportunities offered by this field have not been maximally harnessed in plant systematics. This study demonstrated the significance of numerical taxonomy in plant classification studies by using species of Euphorbiaceae as a case study. Numerical taxonomy differs from conventional taxonomy in the sense that the later equate taxonomic relationships with evolutionary relationships whereas the former views and treats them in three ways which includes: Phenetic- based on overall similarities; Cladistic- based on a common line of descents and Chronistic- based on temporal relation among various evolutionary branches. Usually, the species to be classified are called Operational Taxonomic Units (OTUs). In this report, characters were spotted out and then codified numerically. These numerically coded characters were recorded in the form of appropriate numbers in a manner that indicate that the differences among them are proportional to their dissimilarities. Seven species of Euphorbiaceae were subjected to cluster analysis using 60 diagnostic characters as it is already an established concept among taxonomists that the more characters used in numerical taxonomic studies, the more efficient the result would be. The Numerical taxonomic methods adopted to analyze these characters drawn from morphological, epidermal and anatomical lines of evidence proved effective as results validated previous systematics. This is because all operational taxonomic units (OTUs) belonging to same genus were clustered as a group indicating that they are more related to each other. Recommendation was made for numerical taxonomy to be applied to other groups of plant for classification studies.

Keywords: Diagnostic characters; Euphorbiaceae; Numerical Taxonomy; Operational Taxonomic Unit; Phenetic; Cladistic; Chronistic

Introduction

Michel Adanson, a French botanist was the first to put forward a plan for assigning numerical values to the similarity between organisms. He proposed that equal weighting be apportioned to all the characters while classifying plants in his book *familles des plantes*; his work however, did not come to public notice until late 1963 on the occasion of a major conference organized to mark the bicentenary of the book's publication [1]. Furthermore, the origin of this movement (numerical taxonomy) can be credited to P. H. Sneath who rediscovered the natural classification proposed by Adanson and observed that the classification was suitable for the application of electronic calculators in taxonomy [1]. It was at the bicentenary of the publication of the book *familles des plantes* that the pioneering treatise on phenetics, *Principles of Numerical Taxonomy* by P. H. Sneath and R. R. Sokal appeared in the same year [2, 3]. Since then, the application of Numerical Taxonomy is greeted with warmth reception, especially in the field of biological sciences [4]. Currently, Numerical taxonomy has a wider sense of meaning and usage than it was originally intended and developed because all systematics to an extent adopts numerical approach: computer and numerical taxonomic programs are presently made standard resources for museums and systematics laboratory [3].

Modern Numerical Taxonomy takes into cognizance phenetic, cladistic and chronistic taxonomic relationships. Based on this trend, it was suggested that workers in all branches of systematics and comparative biology be acquainted with phenetic and cladistic methods because these methods are very essential for lots of classification problems [3]. Numerical taxonomy in its broad sense is believed to be the greatest advance in systematics since Darwin or perhaps since Linnaeus and it has stimulated several new areas of growth, including numerical phylogenetics, molecular taxonomy, morphometrics, and numerical identification [4]. Presently Numerical Taxonomy has wide application outside systematics biology [3, 4]. In microbiology, the program of numerical taxonomy has been successful, as indicated by the preponderance of papers describing numerical relationships in the International Journal of Systematic Bacteriology [4].

Although remarkable achievements are made in the field of microbiology as regards numerical Taxonomy, not much is achieved in Plant taxonomy as there are pockets of arguments regarding its authenticity. Be that as it may, numerical taxonomy is of great significance in plant systematics as conventional taxonomic data collected from sources like morphology, physiology, chemistry, anatomy, cytology etc can be improved by numerical taxonomy as it utilizes better and more number of described characters [2, 5].

A number of researchers have demonstrated the importance of numerical taxonomic methods in plant classification and delimitation. For instance, [5] adopted numerical methods to conduct a comparative study, explaining and establishing the taxonomic relationship between some species of Euphorbiaceae using 21 morphological characters, also [6] in their work used numerical taxonomic methods to show the differences and similarities in the morphological characters of several species of the genus *Jatropha* belonging to the family Euphorbiaceae. Others like [7] also utilized numerical methods to establish the taxonomic relationship among some species of

Euphorbiaceae within Ambrose Alli University campus using 35 morphological characters. Few other research work involving numerical methods also exist among other plant family as found in [8] who made use of numerical taxonomic techniques in classification of *Magnifera indica* [9-11]. However, it must be stated clearly that more work needs to be done using numerical taxonomic methods to better expatiate the pattern of relationship existing in the family Euphorbiaceae just as suggested by [7]. Hence the need of the choice of using some selected Species of family Euphorbiaceae as a case study to demonstrate the significance of numerical taxonomy. One distinct aspect of this current research publication of ours from previous reports is the fact that 60 diagnostic characters drawn from three taxonomic lines of evidence including morphology, anatomy and leaf epidermis were adopted with reason being that, it is an already established fact among numerical taxonomists that the more characters spotted out and adopted to conduct a study in numerical taxonomy, the more effective the result will be.

The family Euphorbiaceae is among the largest of the families of plant [12] and contains over 300 genera and species numbering more than 8000 [13]. They are of great economic importance as species of Euphorbiaceae can be used for timber, food and fodder, medicine, landscape and beautification, hedges, superstitious use and some others [5]. This study was aimed at the characterization and application of numerical methods to establish a taxonomic relationship of species within the family Euphorbiaceae.

Materials and Methods

Collection and Identification of Plant Materials

Collection and identification of samples were done according to the method described by [14]. Samples that were fresh and at the same time healthy from species of study from four different genera in the family Euphorbiaceae were collected in separate bags from Rivers, Delta, Abia, Bayelsa and Imo state all from the Niger Delta region of Nigeria. The location of collection sites, ecological conditions like Altitude, Longitude, and Latitude were recorded (figure 1). The plant specimens were identified at the herbarium of the Department of Plant Science and Biotechnology, Rivers State University. Identified pressed plant samples were deposited at the Rivers State University Herbarium for reference and further studies.

Morphological Characterization Study

Examinations of the taxonomic morphological features of study species of the family Euphorbiaceae were done in matured living plants samples. References were made to several books and Floras including Flora of West tropical Africa [15], Useful Plants of West Africa [16]. Morphological studies involved visual observation of the vegetative and reproductive parts of the species. Quantitative morphological studies included the measurement of the leaf length, leaf width, petiole length and plant height using a meter rule and measuring tape [17]. While qualitative morphological plant features studied include the leaf shape, leaf base, leaf apex, leaf margin, leaf type, leaf venation, Presence/absence of petals, phyllotaxy and plant habit. Others include flower symmetry, terminal flower, flower color, stipules, sexuality and type of bracts.

Leaf Epidermal Characterization Study

Leaf epidermal study was done according to the method described by [18] with little modification. Foliar materials for the epidermal studies were collected fresh from studied plants samples. Blades were used to peel the upper and lower epidermal surfaces and at times, depending on the genus involved, the peeled samples were soaked in concentrated Nitric acid or Trioxonitrate (v) acid, rinsed in distilled water and then stained in 1% aqueous safranin solution

and mounted in glycerin. Thereafter, the cover slips were placed over the peels and then sealed with nail varnish to prevent dehydration [18]. The observation of the slides was made and photographs that were of interest to the study were taken with the aid of an XSZ-N107 Microscope with (MA88-900) camera.

Anatomical Characterization Study

An anatomical study was done according to the method of [19] with little modification. The Stem and the leaf midrib anatomy were studied for taxonomic characters and photographs that were of interest to the study were taking with the use of an XSZ-N107 Microscope with (MA88-900) camera.

Numerical Taxonomy and Statistical Evaluation

Taxonomic characters obtained from the morphological and anatomical investigations of the species of study were codified numerically: recorded in the form of appropriate numbers (table 4) and inputted into the computer which were grouped by cluster analysis using the single linkage method based on similarity matrix of Euclidean distances of morphological and anatomical characters. The species studied are the Operational Taxonomic Units (OUT's). The characters of each species studied were codified appropriately in numerals according to the number of 'Character State' adopted for each character. This statistical analysis was done using the Paleontological statistics (PAST) software.

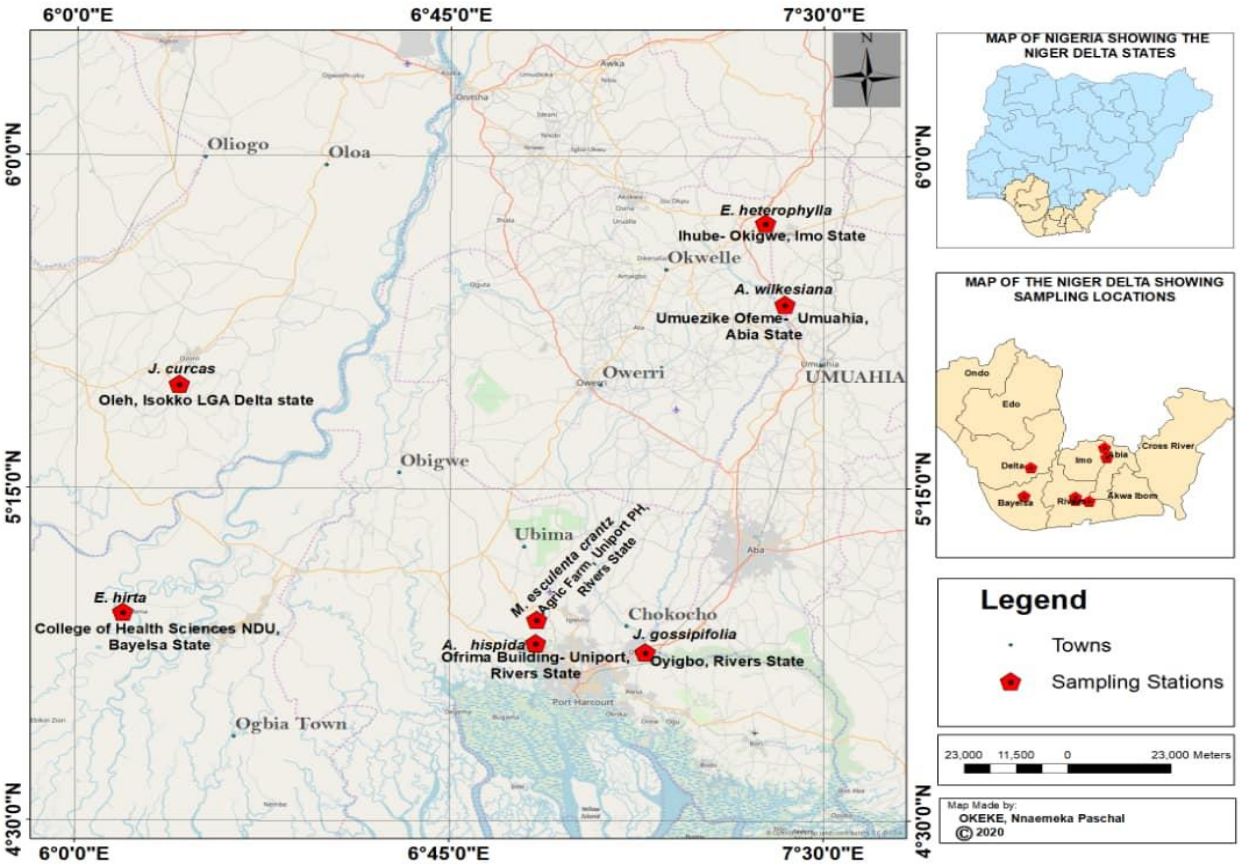

Figure 1: Map of Nigeria showing the collection sites of the species of Euphorbiaceae used in the study

Results

Morphological Study

Morphological features showing the differences and similarities observed among the species of Euphorbiaceae studied are summarized in Table 1

Table 1: Summary of the Morphological Characters of Species Studied

S/N	Characters	*A. hispida*	*A. wilkesiana*	*E. heterophylla*	*E. hirta*	*J. curcas*	*J. gossipifolia*	*M. esculenta*
1	Leaf Shape	Cordate	Cordate	Obovate/Lanceolate	Oblong/Lanceolate	Cordate	Cordate	Lanceolate
2	Leaf Apex	Acuminate	Acuminate	Acute	Acute	Acute	Acuminate	Acute
3	Leaf Base	Cuneate	Cuneate	Cuneate	Round	Cordate	Cordate	Cuneate
4	Leaf Margin	Dentate	Dentate	Entire	Dentate	Entire	Entire	Lobed
5	Leaf length	Up to 20 cm long	Up to 12 cm long	Up to 8 cm long	Up to 3 cm long	Up to 12cm long	Up to 9 cm long	Up to 15.cm long
6	Leaf width	15 cm broad	7 cm broad	5 cm broad	and 1.5 cm broad	and 10 broad	and 8 cm broad	and 13.0cm broad
7	Petiole length	Up to 15 cm long	Up to 60 cm long	Up to 1.5 cm long	Up to 0.6 cm long	Up to 16cm long	Up to 6 cm long	Up to 20 cm long
8	Plant height	450 cm long	350 cm long	80 cm long	60 cm long	300 cm long	220 cm long	300 cm long
9	Phylotaxy	Alternate	Alternate	Alternate	Opposite	Whorled	Whorled	Alternate
10	Leaf Surface	Pubescent	Pubescent	Glabrous	Pubescent	Glabrous	Pubescent	Glabrous
11	Habitat	Cultivated	Cultivated	Wild	Wild	Cultivated	Cultivated	Cultivated
12	Habit	Shrub	Shrub	Herb	Herb	Shrub	Shrub	Shrub
13	Venation	Reticulate	Reticulate	Reticulate	Reticulate	Reticulate	Reticulate	Reticulate
14	Sexuality	Dioecious	Monoecious	Monoecious	Dioecious	Monoecious to Andromonoecious	Monoecious	Dioecious
15	Stipules	Absent	Absent	Absent	Present	Absent	Absent	Absent
16	Leaf type	Compound	Compound	Simple	Simple	Compound	Compound	Compound
17	Types of bract	Bracteate	Bracteate	Leafy-bracted infloresce	Leafy-bracted infloresce	Bracteate	Bracteate	Bracteate

				nces	nces			
18	Inflorescence	Indeterminate	Indeterminate	Determinate	Determinate	Determinate	Determinate	Indeterminate
19	Presence/ Absence of petals	Absent	Absent	Absent	Absent	Present	Present	Present
20	Floral symmetry	Actinomorphic	Actinomorphic	Actinomorphic	Actinomorphic	Actinomorphic	Actinomorphic	Actinomorphic
21	Flower colour	Reddish	Reddish	Greenish-yellowish	Greenish	Yellowish-green	Purple red	Golden yellow

Leaf Epidermal Study

A summary of the epidermal characters as observed under the microscope showing the similarities and dissimilarities in the characters of the seven species of family Euphorbiaceae studied is shown in Table 2.

Table 2: Summary of the Leaf Epidermal Characters of Species Studied.

S/N	Character	*A. hispida*	*A. wilkesiana*	*E. heterophylla*	*E. hirta*	*J. curcas*	*J. gossipifolia*	*M. esculenta*
1	Stomatal index (%) (U.E)	2.27	Nill	23.68	25.00	2.25	5.41	48.4 (1.3)
	(L.E)	32.61	37.5	55.17	78.43	57.89	25.49	67.5
2	Epidermal Cell shape (U.E)	Irregular to polygonal	Irregular to polygonal	Rectangular, Irregular to Polygonal	Polygonal	Polygonal	Irregular	Irregular to polygonal
	(L.E)	Irregular to polygonal	Irregular to polygonal	Irregular	Irregular	Polygonal	Irregular	Polygonal to Irregular
3	Stomatal type (U.E)	Paracytic	Absent	Tetracytic, Anisocytic	Paracytic, Diacytic	Anomocytic, Tetracytic	Anomocytic, Tetracytic	Anomocytic
	(L.E)	Anisocytic and Paracytic	Anisocytic, Actinocytic and Paracytic	Actinocytic, Paracytic	Anisocytic,Tetracytic, Anomocytic and Paracytic	Anisocytic, Paracytic	Anisocytic, Paracytic	Paracytic
4	Trichomes (U.E)	Absent	Present	Absent	Present	Absent	Absent	Absent
	(L.E)	Absent	Present	Absent	Present	Absent	Present	Absent
5	Papillae (U.E)	Absent	Absent	Present	Absent	Absent	Absent	Absent
		Absent	Absent	Present	Absent	Absent	Absent	Absent

	(L.E)							
6	Anticlinal cell wall (U.E)	Wavy	Undulating	Straight to wavy	Undulating	Straight to Undulating	Undulating	Undulating
	(L.E)	Undulating	Undulating	Wavy	Wavy	Straight to Undulating	Undulating	Straight to Undulating
7	Stomatal distribution	Amphistomatic	Hypostomatic	Amphistomatic	Amphistomatic	Amphistomatic	Amphistomatic	Amphistomatic

Anatomical Study

Midrib Anatomical Study

A summary of the important observable leaf midrib anatomical characters, showing differences and similarities of the seven species studied is shown in Table 3.

Table 3: Summary of the Leaf Midrib anatomical Characters of Species Studied.

S/N	Character	*A. hispida*	*A. wilkesiana*	*E. heterophylla*	*E. hirta*	*J. curcas*	*J. gossipifolia*	*M. esculenta*
1	Nature of epidermis (Midrib)	Uniseriate	Uniseriate	Uniseriate	Uniseriate	Uniseriate	Uniseriate	Uniseriate
2	Nature of xylem cells within midrib	5 -6 layers	3-4 layers	4-5 layers	5-6 layers	2-3 layers	2-4 layers	2-3 layers
3	Nature of Cortical tissue (midrib)	Collenchyma and parenchyma cell	Collenchyma and parenchyma cell	Collenchyma and parenchyma cell	Collenchyma and parenchyma cell	Collenchyma and parenchyma cell	Collenchyma and parenchyma cell	Collenchyma and parenchyma cell
4	Nature of intercellular spaces	Small	Small	Small	Small	Small	Small	Small
5	Nature of parenchyma cells in (Midrib) cortex	10 – 13 layers	10 – 11 layers	7 – 8 layers	7-8 layers	12-14 layers	8-9 layers	6-7 layers
6	Nature of collenchyma cells (Midrib)	1 -3 layers	1 -2 layers	2-3 layers	3-4 layers	2-5 layers	2-3 layers	3-4 layers
7	Cell inclusions in midrib	Present	Present	Absent	Absent	Present	Present	Present
8	Pith tissue (midrib)	Parenchyma	Parenchyma	Parenchyma	Parenchyma	Parenchyma	Parenchyma	Parenchyma
9	Midrib shape in Transverse section	Arc	Arc	Rounded	Rounded	Rounded	Arc	Crescent
10	Vascular bundles arrangement (Midrib)	Crescent	Crescent	Rounded	Rounded	Crescent	Rounded	Rounded
11	Number of vascular bundle (Midrib)	2	2	1	1	1	1	2
12	Nature of Vascular bundle (Midrib)	Separated	Separated	Compacted	Compacted	Compacted	Compacted	Separated
13	Shape of vascular bundles in midrib	Arc	Arc	Rounded	Rounded	Rounded	Rounded	Rounded
14	Trichomes in midrib	Absent	Absent	Absent	Present	Absent	Absent	Absent

15	Protuberance or Ridges and furrows	Absent	Absent	Absent	Present	Absent	Absent	Absent

Stem anatomical study

A summary of the stem anatomical characters showing similarities and dissimilarities of the seven species of Euphorbiaceae studied is shown in Table 4.

Table 4: Summary of the Stem anatomical Characters of Species Studied.

S/N	Character	*A. hispida*	*A. wilkesiana*	*E. heterophylla*	*E. hirta*	*J. curcas*	*J. gossipifolia*	*M. esculenta*
1	Shape of stem tranverse section	Rounded	Rounded	Rounded	Rounded	Rounded	Rounded	Rounded
2	Cortex tissue	Collenchyma and Parenchyma	Collenchyma and Parenchyma	Collenchyma and Parenchyma	Collenchyma and Parenchyma	Collenchyma and Parenchyma	Collenchyma and Parenchyma	Collenchyma, Parenchyma and Sclerenchyma
3	Cell inclusion	Present	Present	Absent	Absent	Present	Absent	Absent
4	Protuberance	Absent	Absent	Present	Present	Absent	Absent	Absent
5	Pith tissue	Parenchyma	Parenchyma	Hollow pith	Parenchyma	Parenchyma	Parenchyma	Parenchyma
6	Epidermis	Uniseriate	Uniseriate	Uniseriate	Uniseriate	Uniseriate	Uniseriate	Uniseriate
7	Conjugative tissue in vascular cylinder	Parenchyma	Parenchyma	Parenchyma	Parenchyma	Parenchyma	Parenchyma	Parenchyma
8	Nature of cortical parenchyma cells	6 -7 layers	6 -7 layers	5-6 layers	5-6 layers	30-31 layers	30-31 layers	40-45 layers
9	Nature of cortical collenchyma cells	2- 3 layers	2- 3 layers	1-2 layers	1-2 layers	1-2 layers	1-2 layers	7-8 layers
10	Trichomes	Present	Present	Present	Present	Absent	Absent	Absent
11	Intercellular spaces	Small	Small	Small	Small	Small	Small	Small
12	No. of collateral vascular bundles in stem	16-18	19-20	21-22	16-18	23-24	23-24	26-27

Numerical Taxonomy and Statistical Analysis of Morphological, Epidermal and Anatomical Characters

Table 5 showed the collection of all 60 characters of the selected species of Euphorbiaceae drawn from the morphological, epidermal and anatomical lines of evidence used in multivariate analysis with their method of scoring (numerical taxonomy). The characters were codified and inputted into PAleontological Statistics (PAST) software to generate the dendrogram of the phylogenetic tree of the seven selected species of study (Figure 1).

Table 5: Morphological, epidermal and anatomical characters of the selected Euphorbiaceae species used in multivariate analysis with their method of scoring

S/N	CHARACTERS	STATE	CODE
		Ovate	1
		Obovate	2
1	Leaf Shape	Lanceolate	3
		Oblong	4
		Cordate	5
		Acute	1
2	Leaf Apex	Acuminate	2
		Obtuse	3
		Cuneate	1
3	Leaf Base	Cordate	2
		Rounded	3
		Entire	1
4	Leaf Margin	Crenulate	2
		Dentate	3
		Lobed	4
		1 -5cm	1
5	Leaf length	6 -10cm	2
		11 -15cm	3
		16 – 20cm	4
		1 – 5cm	1
6	Leaf width (broadness)	6 – 10cm	2
		11 – 15cm	3
		1 – 5cm	1
7	Petiole length	6 – 10cm	2
		11 – 15cm	3
		16 – 20cm	4
		Alternate	1
8	Phylotaxy	Opposite	2
		Whorled	3
		Reticulate	1
9	Venation	Palmate	2
		Cross – Venulate	3
10	Leaf pubescent	Present	1
		Absent	0

11	Habitat	Wild	1
		Cultivated	2
12	Habit	Herb	1
		Shrub	2
		Tree	3
13	Leaf type	Compound	1
		Simple	2
14	Plant Height	50-150 cm	1
		160-260 cm	2
		270--370 cm	3
		380-480cm	4
15	Stipules	Present	1
		Absent	0
16	Sexuality	Monoecious	1
		Dioecious	2
		Hermaphrodite	3
17	Type of bract	Ebracteate	0
		Bracteate	1
		Leafy-bracted inflorescences	2
18	Presence/absence of petals	Present	1
		Absent	0
19	Flower symmetry	Actinomorphic	1
		Zygomorphic	2
20	Terminal flowers	Determinate	1
		Indeterminate	2
21	Flower colour	Green	1
		Yellowish green	2
		Purple red	3
		Crimson red	4
		Reddish	5
		Golden yellow	6
22	Stomatal index (%) (U.E)	Nill	0
		1.0-19.0	1
		20.0 - 49.0	2
		50.0- 79.0	3
23	Stomatal index (%) (L.E)	Nill	0
		1.0-19.0	1
		20.0 - 49.0	2
		50.0- 79.0	3

24	Epidermal Cell shape (U.E)	Polygonal Irregular Irregular to polygonal Rectangular, Irregular to Polygonal	1 2 3 4
25	Epidermal Cell shape (L.E)	Polygonal Irregular Irregular to polygonal Rectangular, Irregular to Polygonal	1 2 3 4
26	Stomatal type (U.E)	Absent Anomocytic Paracytic Tetracytic and Anisocytic Paracytic and Diacytic Anomocytic and Tetracytic	0 1 2 3 4 5
27	Stomatal type (L.E)	Absent Anisocytic and Paracytic Anisocytic, Actinocytic and Paracytic Actinocytic and Paracytic Anisocytic,Tetracytic, Anomocytic and Paracytic	0 1 2 3 4 5
28	Trichomes (U.E)	Absent Present	0 1
29	Trichomes (L.E)	Absent Present	0 1
30	Papillae (U.E)	Absent Present	0 1
31	Papillae (L.E)	Absent Present	0 1
32	Anticlinal cell wall (U.E	Wavy Undulating Straight to wavy Straight to Undulating	1 2 3 4
33	Anticlinal cell wall (L.E)	Wavy Undulating Straight to wavy Straight to Undulating	1 2 3 4
34	Stomatal distribution	Amphistomatic Hypostomatic	1 2
35	Nature of epidermis (Midrib)	Uniseriate Biseriate Multiseriate	1 2 3
		2-3 layers 2-4 layers	1 2

36	Nature of xylem cells within midrib	3-4 layers	3
		4-5 layers	4
		5-6 layers	5
37	Nature of Cortical tissue (midrib)	Parenchyma cell	1
		Collenchyma cell	2
		Collenchyma and parenchyma cell	3
		Sclerenchyma	4
38	Nature of intercellular spaces	Small	1
		Large	2
39	Nature of parenchyma cells in (Midrib) cortex	6-7 layers	1
		7 – 8 layers	2
		8-9 layers	3
		10 – 11 layers	4
		10 – 13 layers	5
40	Nature of collenchyma cells (Midrib)	1 -2 layers	1
		1 -3 layers	2
		2-3 layers	3
		2-5 layers	4
		3-4 layers	5
41	Cell inclusions in midrib	Absent	0
		Present	1
42	Pith tissue (midrib)	Parenchyma	1
		Collenchyma	2
43	Midrib shape in Transverse section	Arc	1
		Rounded	2
		Crescent	3
44	Vascular bundles arrangement (Midrib)	Arc	1
		Rounded	2
		Crescent	3
45	Number of vascular bundle (Midrib)	1	1
		2	2
		3	3
46	Nature of Vascular bundle (Midrib)	Separated	1
		Compacted	2
47	Shape of vascular bundles in midrib	Arc	1
		Rounded	2
		Crescent	3
48	Trichomes in midrib	Absent	0
		Present	1
49	Protuberance or Ridges and furrows	Absent	0
		Present	1
50	Shape of stem tranverse section	Arc	1
		Rounded	2

		Crescent	3
51	Stem Cortex tissue	Parenchyma Collenchyma Collenchyma and Parenchyma Collenchyma, Parenchyma and Sclerenchyma	1 2 3 4
52	Cell inclusion in stem	Absent Present	0 1
53	Protuberance in stem	Absent Present	0 1
54	Pith tissue in stem	Parenchyma Hollow pith	1 2
55	Nature of stem Epidermis	Uniseriate Biseriate Multiseriate	1 2 3
56	Nature of cortical parenchyma cells in stem	5-6 layers 6-7 layers 30-31 layers 40-45 layers	1 2 3 4
57	Nature of cortical collenchyma cells in stem	1-2 layers 2- 3 layers 7-8 layers	1 2 3
58	Trichomes in stem	Absent Present	0 1
59	No. of collateral vascular bundles in stem	16-18 19-20 21-22 23-24 26-27	1 2 3 4 5
60	Conjugative tissue in vascular cylinder in stem	Parenchyma Collenchyma	1 2

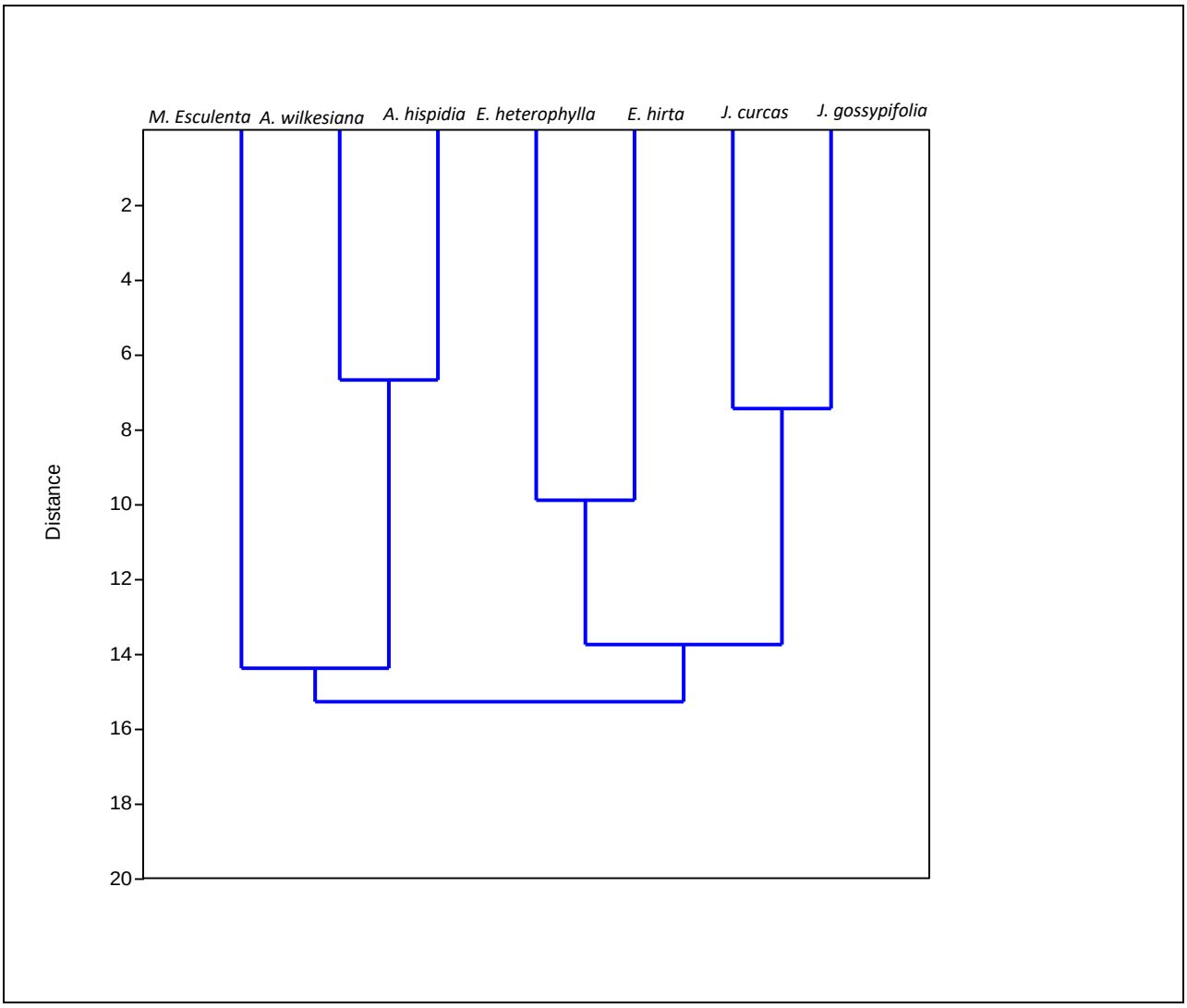

Figure 1: Dendrogram of the seven selected species from the euphorbiaceae family produced by cluster analysis using PAST software.

Discussion

The morphological features that were used to characterize and delineate the taxa (species and genera) showed that species belonging to same genus exhibited more similar characters than species belonging to other genera (table 1). These phenomena made it easy to group them together. These findings were in agreement with the report of [5]. These attributes provided characters for hypothesizing their phylogenetic relationships as was observed with the dendrogram constructed (Figure 1). Observation of the vegetative and reproductive organs of the species studied in this research showed that morphological characteristics such as the leaf shape, leaf apex, phylotaxy of the leaf, leaf base, Leaf type, arrangement of flowers, flower color, presence / absence of petals, type of bracts, leaf surface, presence / absence of stipules, sexuality of plant, leaf type, plant height, leaf length and width etc are of vital importance for taxonomic studies and this supported the reports of [20].

The epidermal study revealed that all studied species were amphistomatic in their stomatal distribution similar to the reports of earlier authors [21, 22]. While only *A. wilkesiana* was

hypostomatic in its stomatal distribution. Other distinguishable taxonomic characters includes stomatal index, epidermal cell shape, papillae, trichomes, stomatal types and Anticlinal cell wall. These findings also supported the report of [22] who reported similar characters for leaf epidermal study of Euphorbiaceae.

Anatomical features of the species studied revealed the structural diversity of this family. Taxonomic significance of the anatomical characters in this family is reported elsewhere [22-24]. The most important anatomical characters spotted out which can be used to differentiate or delineate the studied species are trichomes, nature of cortex and hypodermis, nature of pith, shape of transverse section of stem, root and midrib, nature of cortical parenchyma and collenchyma cells, the number of observed vascular bundles as well as the shape and arrangements of vascular bundles present in the leaf, stem and root. This is in agreement with the report of [25] that also spotted out similar anatomical characters.

The results of the dendrogram from the 60 morphological and anatomical characters used in this research produced four groups at distance of 10 along the similarity indices metre. The first group consists of the genus *Acalypha,* with both *A. hispida* and *A. wilkesiana* having the highest similarity rate at distance of 6.8. The second group consists of the genus *Jatropha:* where *J. curcas* and *J. gossipifolia* branched at phenolic line 7. The third group consists of the genus Euphorbia: where *E. heterophylla* and *E. hirta* branched further along the similarity distance indices meter at 10. While *M. esculenta* from the genus *Manihot* occupied the fourth group alone. The dendrogram showed that the genus *Jatropha* and *Euphorbia* are more closely related to each other with similarity at point 14 along the distance metre. But joined with the genus *Euphorbia* and *Manihot* further along the distance metre at 16. The result from the dendrogram validated previous systematics on this taxa (*Euphorbiaceae*), as all operational taxonomic units (OTUs) belonging to same genus grouped together, which is an indication that they are more related to each other. This finding is in agreement with that of other researchers who demonstrated how numerical techniques can be used to analyze data for biosystematics and taxonomic studies [5, 14, 26].

Conclusion

The study has clearly demonstrated that numerical taxonomy is of great significance in plant systematics as it enables more taxonomic work to be done by less highly skilled workers; conventional taxonomic data collected from sources like morphology, anatomy, physiology, chemistry, cytology etc can be improved by numerical taxonomy as it utilizes better and more number of described characters; numerical methods are also more sensitive in delimiting taxa because data obtained can be conveniently utilized in the construction of better keys and classification systems (as observed in the dendrogram), creation of maps, descriptions and catalogues; numerical taxonomy could also be utilized for the purpose of reinterpretation of a number of existing biological concepts.

It is therefore recommended that numerical taxonomic methods be applied to other group of plant for classification studies.

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