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Phenetic Analysis of Certain Taxa of Euphorbiaceae Grown in Egypt.

M.M. Moawed, Salma Saaid, Zeinab Abdelsamie, M. Tantawy*.
Botany Department, Faculty of Science, Ain Shams University, Egypt.

Euphorbiaceae is one of the major flowering plant families. Macro- and micromorphological as well as vein architectural characters of 34 taxa of Euphorbiaceae (14 genera, 29 species and eight varieties) were investigated. The studied taxa were collected from natural habitats and from different botanical gardens in Egypt. The macro-, micromorphological characters and vein architectural aspects were considered diagnostic characters which facilitate the separation between the taxa under investigation. The sum of 346 attributes were numerically analyzed using NTsys-pc program (version 2.02). The resulted phenogram is discussed showing two outgroups and five major clusters. The present study recommends the separation of *Andrachne aspera* and *Putranjiva roxburghii* in two separate families; Phyllanthaceae and Putranjivaceae respectively

Keywords: Euphorbiaceae, Petiole, Vasculature, Stomata, Vein architecture.

Euphorbiaceae comprise 322 genera, 8910 species (Thakur and Patil, 2011 a, b) grouped in 52 tribes and five subfamilies Phyllanthoideae, Oldfieldioideae, Acalyphoideae, Crotonoideae, and Euphorbioideae Webster (1975). To cite but a few we can refer to the system of classification which deal with the position of Euphorbiaceae *e.g.* Bentham and Hooker (1862-1883), Bessey (1915), Wettstein (1935), Engler and Diels (1936), Benson (1957), Hutchinson (1959, 1969, 1973), Melchior (1964), Cronquist (1968, 1981, 1988), Rendle (1969), Pax (1884), Takhtajan (1969, 1980), Airy Shaw (1965, 1975, 1980), Webster (1975), APG (2003, 2009) and Simpson, (2006).

Euphorbiaceae displays an extraordinary range of growth forms, perhaps equaling or surpassing any other angiosperm family (Mahlberg and Sabharwal, 1968). The same authors also, stated that the laticifer development in Euphorbiaceae has concentrated in *Euphorbia* and closely related genera. The presence or absence of laticifers was used as characters in Webster (1975) classification of Euphorbiaceae. Latex is of very widespread occurrence among Crotonoideae and Euphorbioideae. (Spix & Martius, 1828; Schaeffer, 1971; Roosmalen, 1985; Mcpherson & Tirel, 1987, and Rudall, 1994). Lamina composition and anatomy has been considered to be important for the characterization of Euphorbiaceae for more than a century since the works of

Solereder (1908) and Metcalfe & Chalk (1950). Anatomy of the family was investigated by different anatomists Metcalfe & Chalk, (1950) Scott *et al*, (1960); Mennega, (1987) Hayden, (1994) Hayden & Hayden, (1999) and Thakur & Patil, (2011 a & b). Stem, petiole and lamina anatomy show varied shape and vasculature (Dehay, 1935; Metcalfe & Chalk, (1950) and Scot *et al*., (1960). Stomata within the Euphorbiaceae show considerable variation as indicated by Raju and Rao (1977).

The value of leaf architecture in taxonomic studies was performed by many authors to differentiate or clarify the relations between different species (Klucking, 1987; Yu & Chen, 1991 and Angélica *et al*., 2009). Concerning the leaf architecture of the family Euphorbiaceae, the following aspects were observed: Primary vein category: actinoromous or pinnate. Secondary vein: category: brochidodromous, craspedodromous (*Euphorbia hirta, E. retusa, Ricinus communis*) or semicraspedodromous (*Acalypha wilkesiana* 'Hoffmanii', *A. wilkesiana* var. *macafeana, Hura crepitans and Putranjiva roxburghii*). Spacing: decreasing toward base (*Breynia disticha & Euphorbia tithymaloides*), increasing toward base, irregular or uniform (*Euphorbia milli* var. *splendens* and *Hura crepitans*). Angle: decreasing toward base, increasing toward base, one pair acute basal secondaries or two pair acute basal secondaries (*Euphorbia tithymaloides*).Tertiary vein: category: alternate percurrent, mixed opposite/alternate percurrent or random reticulate. Course: admedially ramified or exmedially ramified. Quaternary and Quinary vein category: regular polygonal reticulate in all studied taxa. Freely ending ultimate veins: may be absent, once branched (*Euphorbia tithymaloides* and *Putranjiva roxburghii*) or two or more branched. Marginal ultimate looped in all studied taxa.

The ultimate goals of this study are to discuss whether Macro- and micromorphological as well as vein architectural characters can provide a fundamental tool which help in explanation of the taxonomic trends within the family. The investigation of lamina abaxial and adaxial surface and stomata types is an attempt to reveal additional characteristics that might be useful for identification and assessment of taxonomic relationships among the species studied.

Material and Methods

The present study comprised 34 wild and ornamental taxa of Euphorbiaceae (Table 1). The studied taxa were collected from botanical gardens, natural habitats in Egypt (wild species) and Herbarium of Faculty of Science, Ain Shams University. Identification of taxa under investigation was confirmed according to Täckholm (1974) and Boulos (2000). The macromorphological characters of the whole plant, habit, stem, leaf, inflorescence, and flowers were studied and described directly from the living and herbarium specimens. Stem, petiole parts and a portion of the middle lamina including the midrib were prepared according to Johanson (1940). Terminology of Eames (1929) and Metcalfe & Chalk (1950) was used to describe the anatomical features. Lamina epidermal samples were prepared from fresh materials and herbarium specimens for examination of epidermal characteristics, stomata and trichomes. Terminology of epidermal characteristics was based on Metcalfe and Chalk (1950), LAWG (1999) and

Prabhakar (2004). For lamina vein architecture place leaf in a large beaker with ethanol (70% ethanol) and boil until become clear. The chlorophyll dissolves in the ethanol. After the leaves are clear place them in a warm (56 ˚C) solution of 5-10 % NaOH. They may then be removed, rinsed with water and studied. Leaf architectural terminology generally follows Hickey (1973, 1979) and LAWG (1999). Examination and photomicrographs were taken using (LM) and Digital Camera (Canon power-shot A720, 8.0 mega pixels). The magnification power was expressed by (x).

The data obtained from macro- and micromorphology as well as lamina vein architecture of the investigated taxa were subjected to the numerical analysis. The cluster analysis was performed using NTsys program version 2.02 software (Rohlf, 1989) and the tree was constructed using the unweighted pair group method with arithmetic averages (UPGMA). The program can be used to find sets of similar objects (clusters) and to display low dimensional views (ordinations) of multivariate spaces. The grouping of operational taxonomic units (OTU's) produced from the analysis were examined and compared with the previous and current taxonomic classifications of the Euphorbiaceae.

Results and discussion

The morphological criteria extracted from the taxa under investigation are summarized in Table 2 as 0, 1. The phenogram showing the clustering of the studied taxa based on 346 macro and micro morphological character states (Fig. 2) revealed that; at the reference line of 1.17 level; two outgroups and five major clusters *viz.* A, B, C, D and E are separated. Outgroup 1 distinguished as a separate phenetic line at the level 1.23 includes *Andrachne aspera* while outgroup 2 separated at the level 1.21 includes *Putranjiva roxburghii*.

Andrachne aspera and *Putranjiva roxburghii* were classified in the Euphorbiaceae by Webster (1975) and Engler & Prantl (1931) under subfamily Phyllanthoideae where *Putranjiva roxburghii* under tribe Drypeteae and *Andrachne aspera* under tribe Poranthereae and subtribe Poranthereae. APG II and III (2003, 2009) include *Andrachne aspera* and *Putranjiva roxburghii* in families Phyllanthaceae and Putranjivaceae consequently which are two of the five segregates of Euphorbiaceae *sensu lato*. APG II (2003) recognises five lineages of Euphorbiaceae *sensu lato* at family rank: Euphorbiaceae *sensu stricto*, Pandaceae, Phyllanthaceae, Picrodendraceae and Putranjivaceae all are members of Malpighiales in the eurosid I clade (Chase *et al.*, 2002; Davis & Chase, 2004; Wurdack *et al.*, 2004; Davis *et al.*, 2005; Hoffmann *et al.*, 2006; Simpson, 2006 and Tokuoka & Tobe, 2006).

The first comprehensive study of one of the segregate families Phlyllanthaceae was published by Wurdack *et al.* (2004). It used molecular data of 52 genera including all tribes of Euphorbiaceae-Phyllanthoideae as well as selected outgroup taxa of the other subfamilies *sensu* Webster (1994 a, b) and Radcliffe-Smith (2001), representing all five euphorbiaceous families *sensu* APG II (2003).

TABLE 1. The studied taxa and their sites of collection.

No.	Taxa	Locality or Source
1	*Acalpha wilkesiana* 'Hoffmanii'	A
2	*A. wilkesiana* var. *macafeana* W. Miller	A
3	*Aleurites moluccanus* (L.) Willd.	B
4	*Andrachne aspera* Spreng.	D
5	*Breynia disticha* J. R. Forst. & G. Forst.	A
6	*Chrozophora brocchiana* (Vis.) Schweinf.	C
7	*C. oblongifolia* (Delile) A. Juss. Ex Spreng.	C
8	*C. plicata* (Vahl) A. Juss. ex Spreng	C
9	*C. tinctoria* (L.) A. Juss.	C
10	*Codiaeum variegatum* a*	A
11	*C. variegatum* b*	A
12	*C. variegatum* c*	A
13	*C. variegatum* d*	A
14	*Euphorbia cyathophora* Murray	A
15	*E. dendroides* L.	E
16	*E. helioscopia* L.	F
17	*E. hirta* L.	F
18	*E. milii* var. *splendens* (Bojer ex Hooker) Ursch & Léandri	A
19	*E. milii* var. *tananarivae* Léandri	B
20	*E. paralias* L.	I
21	*E. peplis* L.	A
22	*E. peplus* L.	F
23	*E. pseudograntii* Bruyns	B
TABLE 1. Cont.		
24	*E. pulcherrima* Willd. ex Klotzsch	A
25	*E. retusa* Forssk.	G
26	*E. tithymaloides* L.	B
27	*Hura crepitans* L.	B
28	*Jatropha integerrima* Jacq.	B
29	*J. multifida* L.	B
30	*Joannesia princeps* Vell.	B
31	*Mercurialis annua* L.	E
32	*Putranjiva roxburghii* Wall.	B
33	*Ricinus communis* L.	F
34	*Triadica sebifera* (L.) Small	H

a*, b*, c* & d* are cultivars; a*: Codiaeum variegatum 'Norma' ; b*: C. variegatum 'Aucubifolium';
c*: C. variegatum 'Ann Rutherford' and 'Picasso's Paintbrush'; d*: C. variegatum 'Joseph's Coat'
A: Botanical Garden, Botany Department, Faculty of Science, Ain Shams University, Alabbassia, Cairo. B:
Orman Botanical Garden, Giza. C: Herbarium, Botany Department, Faculty of Science, Ain Shams University, Alabbassia, Cairo. D: Wadi Talaa, Saint Katherine, South Sinai. E: Edku Lake, 30 Km East of Alexandria. F: Burg El-Arab, Alexandria. G: Cairo- El-Suez Desert Road. H: Giza Zoo. I: Mersa Matrouh, El- Gharam Sea Shore.

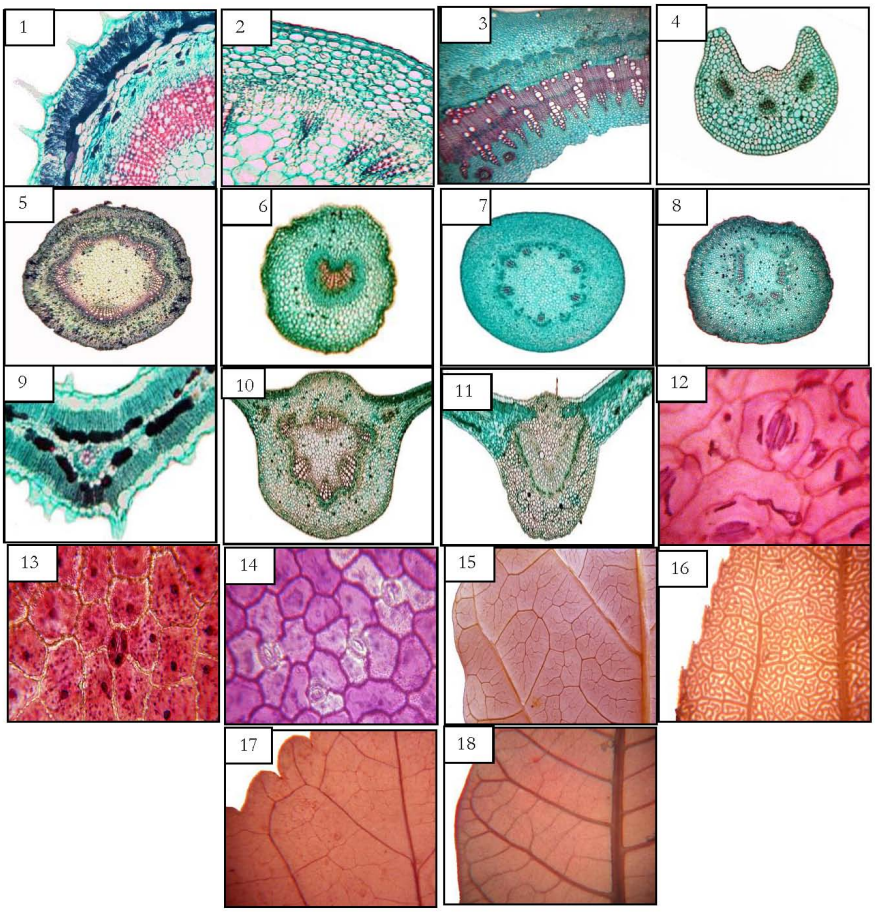

Fig. 1. Transverse section of *Andrachne aspera* stem x = 10; 2: Transverse section of *Euphorbia helioscopia* stem x = 10; 3: Transverse section of *Ricinus communis* stem showing medullary bundles x = 10; 4-8: Petiole microphotographs showing different vasculature aspects; 4: Arc shape distinct bundles in *Mercurialis annua* x = 5; 5: Siphonostele vasculature in *Aleurites moluccanus* x = 5; 6: kidney shape vasculature in *Breynia disticha* x = 5; 7: Ring shape distinct bundles in *Hura crepitans* x = 5; 8: Horse shoe shape vasculature in *hura crepitans* x = 5; 9: Lamina microphotographs showing Iso-lateral mesophyll with extended palisade tissue in *Andrachne aspera* x = 10; 10: Isobilateral mesophyll with palisade tissue not extended in *Hura crepitans* x = 10; 11: Dorsiventral with palisade tissue not extended in *Jatropha integrrima* x = 10; 12: Lamina abaxial surface of *Acalypha wilkesiana var. macafeana* showing paracytic stomata x = 40; 13: Lamina abaxial surface of *Euphorbia helioscopia* showing anomocytic stomata x = 20; 14: Lamina abaxial surface of *Euphorbia retusa* showing anisocytic and anomotetracytic stomata x = 20; 15: Lamina architecture showing brochidodromous 2º vein category in *Aleurites moluccanus*; 16: Lamina architecture showing craspedodromous 2º vein category in *Euphorbia hirta*; 17: Lamina architecture showing semi-craspedodromous 2º vein category and alternate percurrent 3º vein categry in *Acalypha wilkesiana* var. *macafeana;* 18: Lamina architecture showing mixed opposite/alternate percurrent 3º vein in *Euphorbia pulcherimma*.

TABLE 2. Coding of 346 Characters States Representing Macro- and Micromorphological Attributes (0) = Absent (1) = Present.

Macromorphological Characters (Whole Plant)	
Duration	Anuual (0) (1) Perennial (0) (1)
Habit	Herb (0) (1) Shrub (0) (1) Succulent Shrub (0) (1) Tree (0) (1)
Latex	Laticiferous (0) (1) Non-laticiferous (0) (1)
Texture	Glabrous (0) (1) Glabrous-Hairy (0) (1) Glabrous-Pubescent (0) (1) Glabrous/Spiny (0) (1) Hairy (0) (1) Hairy/Pubescent (0) (1) Scabrous (0) (1)
Stem Strenght	Erect (0) (1) Erect/Prostrate (0) (1) Climbing (0) (1) Prostrate (0) (1)
Stem External appear	Angular (0) (1) Terete (0) (1)
Stem internal appear	Hollow (0) (1) Hollow/Solid (0) (1) Solid (0) (1)
Leaf Stipules	Detection (0) (1)
Leaf Phyllotaxis	Alternate (0) (1) Alternate/Opposite (0) (1) Opposite (0) (1) Spirally (0) (1)
Leaf Petiole	Detection (0) (1) Apical Gland Pair (0) (1)
Lamina Composition	Compound Palmate (0) (1) Simple (0) (1) Simple/Lobed (0) (1) Palmatly Lobed (0) (1)
Lamina Shape	Broad Ovate (0) (1) Elliptic (0) (1) Elliptic/Lanceolate (0) (1) Elliptic/Oblong (0) (1) Linear (0) (1) Linear/Lanceolate (0) (1) Oblong-triangular/Lanceolate (0) (1) Obovate (0) (1) Obovate/Lanceolate (0) (1) Obovate/Oblanceolate (0) (1) Obovate/Oblong-Spathulate (0) (1) Orbicular (0) (1) Ovate (0) (1) Ovate/Elliptic (0) (1) Ovate/Lanceolate (0) (1) Ovate/Reniform Curled (0) (1) Ovate/Rhombic (0) (1) Rhombic/Elliptical (0) (1) Rhombic/Lanceolate (0) (1) Spathulate (0) (1) Sub-orbicular/Reniform (0) (1)
Lamina Apex	Acuminate (0) (1) Acute (0) (1) Acute/Acuminate (0) (1) Caudate (0) (1) Caudate/Acuminate (0) (1) Cuspidate/Acuminate (0) (1) Mucronate (0) (1) Notched (0) (1) Obtuse (0) (1) Retuse/Blunt (0) (1)
Lamina Base Shape	Cordate (0) (1) Cuneate (0) (1) Cuneate/Cordate (0) (1) Cuneate/Rounded (0) (1) Rounded (0) (1) Rounded/Cordate (0) (1)
Lamina Base Symmetry	Asymmetrical (0) (1) Symmetrical (0) (1)
Lamina Margin	Crenate-Serrate (0) (1) Dentate (0) (1) Entire (0) (1) Entire/Dentate (0) (1) Entire/Serrate Toward Apex (0) (1) Serrate (0) (1) Slightly Toothed (0) (1) Undulate (0) (1)

TABLE 2. Cont.

Lamina Colour	Bluish Green (0) (1) Bronze Green to Copper Red Mottled Red & Purple (0) (1) Dark Green-Creamy Margin (0) (1) Dark Green on Upper Surface, Pale Below (0) (1) Green (0) (1) Green in Shades With Age and in Sunny Areas Becomes Variegated With Red & Pink, to Pure White (0) (1) Green Variegated With Red or Pink (0) (1) Green Spoted Yellow (0) (1) Green/Yellow (0) (1) Pale to Dark Green With Purple Spots (0) (1) Rusty Whitish-Yellow (0) (1) Whitish Above When Young/Green With Age (0) (1)
Flower Colour	Green (0) (1) Pink (0) (1) Red (0) (1) Scarlet Red (0) (1) White (0) (1) Whitish Green (0) (1) Yellow (0) (1) Yellowish Green (0) (1) Yellowish White (0) (1)
Staminate Grouping	(0) (1)
Staminate Type	Catkin (0) (1) Cymose (0) (1) Solitary (0) (1) Raceme (0) (1) Cyathium in Cymes (0) (1) Cyathium in Umbels (0) (1) Cyathium in Clusters (0) (1) Cyathium Solitary (0) (1) Spike (0) (1)
Staminate Position	Axillary (0) (1) Terminal (0) (1) Terminal-Axillary (0) (1)
Stamen Number	1 (0) (1) 2 (0) (1) 3 (0) (1) 4-12 (0) (1) 10-20 (0) (1) 15-32 (0) (1) Up to 1000 (0) (1)
Staminate Branching	(0) (1)
Pistillate Grouping	(0) (1)
Pistillate Type	Catkin (0) (1) Cymose (0) (1) Solitary (0) (1) Raceme (0) (1) Cyathium in Cymes (0) (1) Cyathium in Umbels (0) (1) Cyathium in Clusters (0) (1) Cyathium Solitary (0) (1) Spike (0) (1)
Pistillate Position	Axillary (0) (1) Terminal (0) (1) Terminal-Axillary (0) (1)
Locules Number	2-4 (0) (1) 5-20 (0) (1)
FruitType	Capsule (0) (1) Drupe (0) (1)
Seed Shape	Broadly Ovoid (0) (1) Conical (0) (1) Depressed-Conical (0) (1) Globose (0) (1) Ovoid (0) (1) Ovoid/Elliptic (0) (1) Ovoid/Hexagonous (0) (1) Subglobose (0) (1) Subglobose/Ovoid (0) (1) Trigonous (0) (1) Tetragonus (0) (1) Triangular/Ovoid (0) (1)
Seed Surface	Glossy (0) (1) Reticulate (0) (1) Smooth (0) (1) Smooth/Minutely Dotted (0) (1) Warty (0) (1) Wrinkled (0) (1)
Micromorphological Characters (Stem Anatomy)	
Outline in T. S.	Angled (0) (1) Compressed Ring (0) (1) Oval (0) (1) Terete (0) (1) Terete/V- shape Furrows (0) (1)
Eglandular Trichomes	Unicellular, Unbranched, Uniseriate (0) (1) Multicellular, Unbranched, Uniseriate (0) (1) Stellate Unbranched, Multicellular, Multiseriate (0) (1) Stellate (0) (1) Multicellular, Unicellular, Unbranched, Uniseriate (0) (1)
Glandular Trichomes	Multicellular, Uni- & Biseriate Stalk with Multicellular Gland (0) (1) Multicellular Sessile Gland (0) (1) Multicellular Gland with or without Unicellular Stalk (0) (1) Unicellular, Uniseriate Stalk with Unicellular Gland (0) (1)
Cuticle	Thin (0) (1) Thick (0) (1)
Subepidermal Periderm	(0) (1)

TABLE 2. Cont.

Epidermal Cells	Radially (0) (1) Tangentially (0) (1) Tangentially/Radially (0) (1)
Type of Cortical Tissues	Parenchyma (0) (1) Parenchyma, Extra-xylary Fibers (0) (1) Parenchyma, Collechyma (0) (1) Parenchyma, Chlorenchyma, Extra-xylary Fibers (0) (1) Parenchyma, Collechyma, Extra-xylary Fibers (0) (1) Parenchyma, Collechyma, Proto-phloem fibers (0) (1) Parenchyma, Palisade –Like, Extra-xylary Fibers (0) (1) Parenchyma, Collechyma, Chlorenchyma, Extra-xylary Fibers (0) (1)
Pith Width	Wide (0) (1) Narrow (0) (1)
Pith Cell Type	Thin Walled Parenchyma (0) (1) Thick Walled Parenchyma (0) (1)
Internal Appearance	Hollow (0) (1) Solid (0) (1) Hollow-Solid (0) (1)
Vascular System Aspect	Distinct (0) (1) Siphonostelic (0) (1)
Cambium	Fascicular (0) (1) Fascicular + Interfascicular (0) (1)
Fascicular Region	Vertical System Only (0) (1) Vertical + Horizontal (Uniseriate Rays) (0) (1) Vertical + Horizontal (Uni- + Biseriate Rays) (0) (1)
Interfascicular Region	Parenchyma (0) (1) Vertical system [Phloem (Sieve Tube, Companion, Parenchyma cells) & Xylem (Vessels, Fibers, Parenchyma)] (0) (1) Vertical system [Phloem (Parenchyma) & Xylem (Fibers)] (0) (1) Horizontal (Uniseriate Rays) (0) (1) Horizontal (Biseriate Rays) (0) (1) Horizontal (Uni- + Biseriate Rays) (0) (1)
Cortical Bundles	(0) (1)
Medullary Bundles	(0) (1)
Crystals	Druses (0) (1) Druses-Solitary (0) (1)
Micromorphological Characters (Petiole Anatomy)	
Outline in T. S.	Crescentiform (0) (1) Half-Circle (0) (1) Terete with Ridges and Furrows (0) (1) Terete (0) (1)
Eglandular Trichomes	Unicellular Unbranched, Uniseriate (0) (1) Multicellular, Unbranched, Uniseriate (0) (1) Unicellular, Multicellular, Unbranched,Uniseriate (0) (1) Stellate (0) (1) Stellate/Unbranched, Uniseriate, Multicellular (0) (1) Multicellular Unbranched, Uniseriate & Multiseriate Hooked (0) (1)
Glandular Trichomes	Unicellular Gland and Multicellular Uniseriate Stalk (0) (1) Short Multicellular Stalk and Head (0) (1) Multicellular, Uni- and Biseriate Stalk/Multicellular Gland (0) (1) Unicellular, Uniseriate Stalk/Unicellular Gland (0) (1)
Cuticle	Thin (0) (1) Thick (0) (1)
Epidermal Cells	Radially (0) (1) Tangentially (0) (1) Radially-Tangentially (0) (1)
Type of Ground Tissues	Parenchyma (0) (1) Parenchyma, Collechyma (0) (1) Parenchyma, Palisade-Like (0) (1) Parenchyma, Collechyma, Extra-xylary Fibers (0) (1) Parenchyma, Chlorenchyma, Collechyma, Extra-Xylary Fibers (0) (1)
Vascular System Aspect	Arc Shape (0) (1) Horse Shoe (0) (1) Kidney Shape (0) (1) Ring (0) (1) Siphonostele (0) (1)
No. of Vascular Bundles	3 (0) (1) 4 (0) (1) 5 (0) (1) 6 (0) (1) 7 (0) (1) 8 (0) (1) 9 (0) (1) 10 (0) (1) 11 (0) (1) 12 (0) (1) 15 (0) (1) 18 (0) (1) 20 (0) (1)
Crystals	Druses (0) (1) Druses/Solitary (0) (1)
Micromorphological Characters (Lamina Anatomy)	

TABLE 2. Cont.

Outline in T.S.	Flattened Adaxially (0) (1) Furrowed Adaxially (0) (1) Lobed Adaxially (0) (1) Raised Adaxially (0) (1)
Eglandular Trichomes	Multicellular,Unbranched, Uniseriate (0) (1) Multicellular, Unicellular, Unbranched, Uniseriate (0) (1) Stellate (0) (1)
Glandular Trichomes	Multicellular Uni-Biseriate Stalk-Multicellular Gland (0) (1) Unicellular,Uniseriate Stalk-Unicellular Gland (0) (1)
Cuticle	Thick (0) (1) Thin (0) (1)
Epidermal Cells	Papillose (0) (1) Radially (0) (1) Tangentially (0) (1) Tangentially-Radially (0) (1)
Mesophyll Tissue	Dorsiventral (0) (1) Iso-bilateral (0) (1) Iso-lateral (0) (1)
No. of Palisade Rows	1(0) (1) 2 (0) (1) 4 (0) (1)
Palisade Extended at Mid Rib Region	(0) (1)
Collenchyma Type	Angular (0) (1) Angular/Annular (0) (1) Angular/Lamellar (0) (1) Annular (0) (1) Lamellar (0) (1)
Ground Tissue Types	Parenchyma (0) (1) Parenchyma, Chlorenchyma (0) (1)
Vascular System Aspect	Centric Single (0) (1) Crescentiform (0) (1) Horse Shoe (0) (1) Plate (0) (1) Ring (0) (1)
Vascular Bundles No.	1 (0) (1) 3 (0) (1) 4 (0) (1) 5 (0) (1) 6 (0) (1) 7 (0) (1) 11 (0) (1) 12 (0) (1) 15 (0) (1)
Crystals	Druses (0) (1) Raphides (0) (1) Solitary/Druses (0) (1)
Micromorphological Characters (Lamina Epidermal Characteristics)	
Abaxial Cell Shape	Tetragonal (0) (1) Tetragonal &Pentagonal (0) (1) Tetragonal,Pentagonal & Hexagonal (0) (1) Trigonal, Tetragonal &Pentagonal (0) (1) Pentagonal (0) (1) Pentagonal & Hexagonal (0) (1)
Abaxial Anticlinal Wall	Straight(0) (1)Wavy (0) (1)
Adaxial Cell Shape	Tetragonal (0) (1) Tetragonal, Pentagonal (0) (1) Pentagonal,Hexagonal (0) (1) Trigonal, Tetragonal, Pentagonal (0) (1) Tetragonal,Pentagonal, Hexagonal (0) (1)
Adaxial Anticlinal Wall	Straight (0) (1) Wavy (0) (1)
Stomata Type	Anomocytic (0) (1) Brachyparacytic (0) (1)Paracytic (0) (1) Anomocytic & Anisocytic (0) (1) Anomocytic & Anomotetracytic (0) (1) Anomocytic & Brachyparacytic (0) (1) Paracytic & Anisocytic (0) (1) Paracytic & Brachyparacytic (0) (1) Anomotetracytic, Anomocytic, Paracytic & Brachyparacytic (0) (1)
Lamina Vein Architecture	
1° Vein Category	Actinoromous (0) (1) Pinnate (0) (1)
2° Vein Category	Brochidodromous (0) (1) Craspedodromous (0) (1) 330 Semicraspedodromous (0) (1)
2° Vein Spacing	Decreasing Toward Base (0) (1) Increasing Toward Base (0) (1) Irregular (0) (1) Uniform (0) (1)
2° Vein Angle	Decreasing Toward Base (0) (1) Increasing Toward Base (0) (1) One Pair Acute Basal Secondaries (0) (1) Two Pair Acute Basal Secondaries (0) (1)
3° Vein Category	Alternate Percurrent (0) (1) Mixed Opposite/Alternate Percurrent (0) (1) Random Reticulate (0) (1)
3° Vein Course	Admedially Ramified (0) (1) Exmedially Ramified (0) (1)

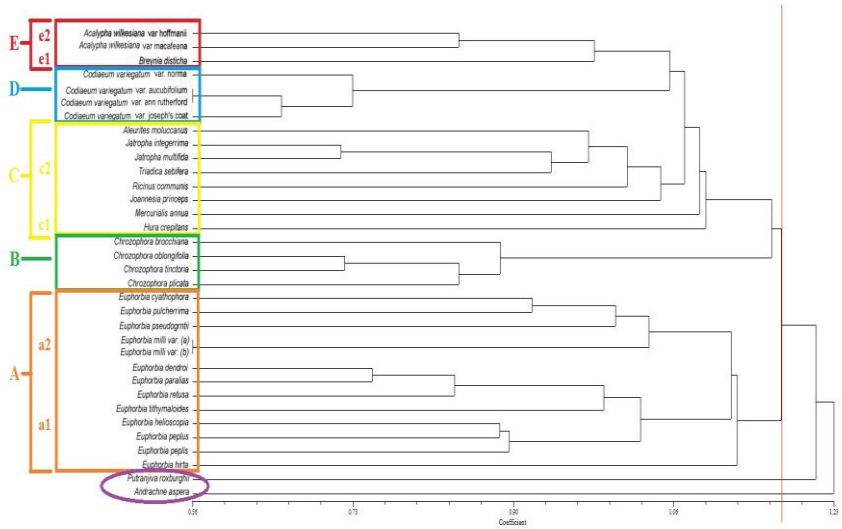

Fig. 2. Phenogram Showing Clustering of the Studied Taxa Based on the 346 Macro/Micro Morphological Character States.

Andrachne aspera is separated as an outgroup in the present study on the basis of morphologically characters *viz.* absence of latex, scabrous texture, prostrate, suborbicular/reniform leaf shape; notched apex, solitary flowers; stamens 5-6. Anatomically, stem epidermal cells tangentially/radially elongated; palisade-like tissue in cortex of stem, palisade-like tissue in cortex of petiole, petiole vascular tissue aspect kidney shape, brachparacytic and anomocytic stomata. *Putranjiva roxburghii* is separated as outgroup which is morphologically characterized by cymose inflorescence, stamens three, drupe fruit. Anatomically it characterized by the presence of solitary/druses crystals, stem trichomes eglandular multicellular unbranched uniseriate, anomotetracytic and anomocytic stomata. These data confirmed those of Chase *et al.* (2002), APG II (2003), Davis & Chase (2004), Wurdack *et al.* (2004), Davis *et al.* (2005), Hoffmann *et al.* (2006), Tokuoka & Tobe (2006) and APG III (2009) in regarding the placement of *Andrachne aspera* and *Putranjiva roxburghii* in the families Phyllanthaceae and Putranjivaceae consequently which are two of the five segregates of Euphorbiaceae *sensu lato.*

Cluster A

comprises two minor groups a_1 & a_2 that are grouped together at the similarity level of 1.12. In the present study, all taxa of *Euphorbia* are clustered together in the major cluster A. They are morphologically characterized by presence of latex, absence of petiole glands, simple lamina composition, cyathium inflorescence, ovary with three locules, capsule fruit. Anatomically, they are characterized by absence of stem fascicular and interfascicular rays, absence of glandular trichomes. The foregoing data were confirmed by Webster (1975) and APG III (2009) classification systems in placing the taxa of

Euphorbia at the same subfamily (Euphorbioideae), tribe (Euphorbieae) and subtribe (Euphorbiinae). The subtribe includes the species with a true cyathium, because of this unique structure; most species of Euphorbiinae have been treated as members of the genus *Euphorbia* Park and Jansen (2007).

The first minor group a_1

comprises eight species of *Euphorbia viz. E .hirta, E. peplis, E. peplus, E. helioscopia, E. tithymaloides, E. retusa, E. paralias* and *E. dendroides. Euphorbia hirta* is distinguished as a separate phenetic line at the level 1.12. *E. peplus* and *E. helioscopia* are grouped together at the level of 0.885 and *E. peplis* is clustered with them at the level of 0.895. E. *tithymaloides* is clustered with the rest three species at the level of 0.986. *E. paralias* and *E. dendroides* are grouped together at the level of 0.749 and *E. retusa* is clustered with them at the level of 0.836.

Euphorbia hirta is distinguished as a separate phenetic line on the basis of the following morphological characters *viz*. erect/prostrate stem, opposite leaves, rhombic/lanceolate lamina, serrate margin, terminal/axillary cyathium in clusters. *E. peplus* and *E. helioscopia* are grouped together and *E. peplis* is clustered with them. These taxa were morphologically clustered due to annual herbs, solid stem, alternate leaves, cuneate lamina base, and green lamina colour. Anatomically, they are clustered together due to terete stem outline, absence of trichomes, absence of cortical and medullary bundles, absence of crystals, flattened adaxial lamina outline, radially elongated lamina epidermal cells with tetragonal/pentagonal wavy anticlinal walls, dorsiventral mesophyll tissue. Venation pattern; brochidodromous secondary vein category with irregular spacing, admedially ramified tertiary vein course.

In Webster (1975) classification he placed *Pedilanthus* as a genus in the subtribe Euphorbiinae tribe Euphorbieae subfamily Euphorbioideae in the family Euphorbiaceae. In Bentham & Hooker (1880 - 1883) and Engler & Prantl (1931) they placed *Pedilanthus* in the tribe Euphorbieae. According to Webster (1994 a, b), seven genera belong to the subtribe Euphorbiinae: *Chamaesyce* (± 300 species), *Cubanthus* (3 spp.), *Endadenium* (1 sp.), *Euphorbia* (± 2000 spp.), *Monadenium* (± 70 spp.), *Pedilanthus* (14 spp.) and *Synadenium* (4 spp.) (Bruyns *et al.*, 2006). Steinmann (2003), Bruyns *et al.* (2006) and APG III (2009) works which based on molecular data consider the genus *Pedilanthus* as a synonym of *Euphorbia* and make a valid name *Euphorbia tithymaloides.*

In the present study, *E. tithymaloides* is clustered with the other *Euphorbia* species due to presence of latex, absence of petiole glands, simple lamina composition, cyathium inflorescence and capsule fruit. Anatomically, they are characterized by absence of glandular trichomes. The present data confirmed those of Steinmann (2003), Bruyns *et al.* (2006) and APG III (2009).

E. paralias and *E. dendroides* are grouped together and *E. retusa* is clustered with them. These taxa were clustered on the basis of the following morphological characters *viz*. perennial, glabrous texture, solid stem, alternate

leaves, absence of stipules, absence of petiole, symmetrical lamina base, cyathium grouped in umbels, smooth seed surface. Anatomically, they are clustered together due to terete stem outline, absence of trichomes, siphonostelic stem vascular aspect, absence of crystals, flattened adaxial lamina outline, epidermal cells with tetragonal/pentagonal and hexagonal straight anticlinal walls. Venation pattern; secondary vein category with irregular spacing and angle decreasing toward base, tertiary vein category random reticulate and admedially ramified course.

The second minor group a_2

comprises *Euphorbia milii* var. *splendens*, *E. milii* var. *tananarivae*, *E. pseudograntii, E. pulcherrima* and *E. cyathophora. Euphorbia milii* var. *splendens* and *E. milii* var. *tananarivae* are grouped together at the 0.56 level. *E. pulcherrima* and *E. cyathophora* grouped together at the level of 0.918 and clustered with *E. pseudograntii* at the level of 0.996. *Euphorbia milii* var. *splendens* and *E. milii* var. *tananarivae* are grouped together on the basis of the following morphological characters *viz.* perennial succulent, glabrous/spiny texture, climbing angular solid stem, presence of stipules, alternate leaves, presence of petiole, lamina simple; obovate-oblong/spathulate, mucronate apex, cuneate symmetrical base, entire margin, green colour, cyathium in axillary cymes, ovoid seed with warty surface. Anatomically due to absence of crystals, absence of stem and leaf trichomes; siphonostylic vascular tissue aspect, presence of cortical bundles, crescentiform petiole outline; arc shape vascular tissue aspect, flattened adaxial lamina outline; radially elongated epidermal cells, dorsiventral mesophyll type, palisade two rows extended at mid rib region, crescentiform vascular tissue aspect, lamina epidermis tetra-/pentagonal with wavy anticlinal walls abaxially and the same adaxially but with straight anticlinal wall, stomata paracytic. Venation pattern: Pinnate primary vein, secondary vein category brochidodromous.

E. pulcherrima and *E. cyathophora* grouped together and clustered with *E. pseudograntii.* These taxa were morphologically clustered due to glabrous/pubescent texture, erect hollow stem, petiole present, lamina base cuneate; green colour, cyathium in cymes; stem vascular tissue siphonostele, petiole vascular tissue aspect arc shape, lamina epidermal cells tangentially/radially elongated; dorsiventral mesophyll type, lamina vascular tissue aspect crescentiform. Venation pattern: primary vein pinnate, secondary vein category brochidodromous. Tertiary vein category mixed opposite/alternate percurrent, absence of freely ending ultimate veins.

E. pseudograntii in Webster (1975) classification was placed as *Synadenium* genus in the subtribe Euphorbiinae tribe Euphorbieae subfamily Euphorbioideae in the family Euphorbiaceae, and in Bentham & Hooker (1880 - 1883) and Engler & Prantl (1931) place *Synadenium* under the tribe Euphorbieae.

As mentioned before according to Webster (1994 a, b), seven genera belong to the subtribe Euphorbiinae: *Chamaesyce* (± 300 species), *Cubanthus* (3 spp.), *Endadenium* (1 sp.), *Euphorbia* L. (± 2000 spp.), *Monadenium* (± 70 spp.),

Pedilanthus (14 spp.) and *Synadenium* (4 spp.) (Bruyns *et al.*, 2006). The genera *Endadenium*, *Monadenium* and *Synadenium* are reduced to synonymy under *Euphorbia* and the species are all transferred to *Euphorbia*. Consequently the subtribe Euphorbiinae now consists of the single, very large, very widely distributed and very diverse genus *Euphorbia* (Bruyns *et. al.*, 2006). Steinmann (2003), Bruyns *et al.* (2006) and APG III (2009) works which based on molecular data reduce the genus *Synadenium* as a synonym of *Euphorbia* and make a valid name *Euphorbia pseudograntii*. In the present study *E. pseudograntii* grouped with other *Euphorbia* species on the basis of the following morphological data *viz.* presence of latex, absence of petiole glands, simple lamina composition, cyathium inflorescence, capsule fruit. Anatomically, they are characterized by absence of stem fascicular and interfascicular rays, absence of glandular trichomes. The forgoing data were confirmed by Steinmann (2003), Bruyns *et al.* (2006) and APG III (2009).

Cluster B

comprises four studied species of *Chrozophora* and grouped together at the 0.887. The genus placed under subfamily Acalyphoideae tribe Chrozophoreae according to Webster (1975) and APG III (2009). The species of *Chrozophora* share many characters and grouped together morphologicaly due to the following data; herb, absence of latex, hairy texture, solid stem, presence of stipules, alternate leaves, presence of petiole, presence of petiolar gland, lamina simple; symmetrical base, undulate margin, inflorescence simple raceme, ovary with three locules, fruit capsule. Anatomically, they are clustered together due to presence of crystals and stellate trichomes in both of stem, petiole and leaf. The stem and petiole epidermal cells radially elongated and cortex have two types of tissues, (parenchyma & collenchyma). Absence of stem cortical and medullary bundles, dorsiventral mesophyll type, palisade one row not extended at mid rib region, crescentiform vascular tissue aspect, stomata paracytic. Venation pattern of pinnate primary vein.

Cluster C

comprises two minor groups c_1 & c_2 and clustered with cluster B at the 0. 173 level. The first minor group c_1 is distinguished as a separate phenetic line including *Hura crepitans* at the level of 1.09. The second minor group c_2 comprises *Mercurialis annua, Joannesia princeps, Ricinus communis, Triadica sebifera, Jatropha integerrima, J. multifida* and *Aleurites moluccanus*. *Mercurialis annua* is distinguished as a separate phenetic line at the level of 1.086. *Joannesia princeps* is clustered with the rest species at the level of 0.046. *Ricinus communis* is distinguished as a separate phenetic line at the level of 1.008. *Jatropha integerrima* and *J. multifida* are grouped together at the level of 0.715 and *Triadica sebifera* is clustered with them at the level of 0.935. *Aleurites moluccanus* is clustered with *Triadica sebifera, Jatropha integerrima* and *J. multifida* at the level 0.97.

The first minor group c_1

is distinguished as a separate phenetic line including *Hura crepitans* which is placed in tribe Hureae and subfamily Euphorbioideae according to Webster

(1975) and APG III (2009) classification. In the present study *Hura crepitans* is distinguished as a separate phenetic line morphologically due to glabrous/spiny texture, broad ovate lamina; caudate/acuminate apex, undulate margin, male flowers grouped in catkin inflorescence with 10-20 stamens and solitary female flowers with ovary with 5-20 locules, Anatomically, due to absence trichomes in stem, petiole and leaf, absence of stem cortical and medullary bundles, isobilateral mesophyll type, palisade four row not extended at mid rib region. Venation pattern: secondary vein spacing uniform.

Mercurialis annua is distinguished as a separate phenetic line morphologicaly due to annual herb, opposite leaves, male flowers with 6-12 stamens and grouped in spike inflorescence, female flowers with ovary with two locules and grouped in spike inflorescence. Anatomically, stem, petiole and lamina cortex tissue of one type (parenchyma), absence of stem fascicular and interfascicular rays, absence of stem cortical and medullary bundles, lamina vascular tissue aspect distinct bundles in plate manner.

Joannesia princeps is clustered with the rest species morphologicaly due to the following data; perennial, presence of latex, erect stem, alternate leaves, petiole present, lamina base symmetrical. Anatomically, they grouped together due to presence of crystals, terete stem outline; siphonostelic vascular system with fascicular and interfascicular rays, petiole ground tissues two types (parenchyma and collenchyma), dorsiventral mesophyll tissue type with palisade not extended at mid rib region. Venation pattern; secondary vein spacing irregular, tertiary vein course admedially ramified.

Ricinus communis is distinguished as a separate phenetic line morphologicaly due to hollow/solid stem, lamina palmatly lobed; cordate base, serrate margin, branched stamen and number up to 1000, seed with glossy surface. Anatomically, due to stem epidermal cells radially elongated; presence of stem medullary bundles, lamina abaxial epidermal cells penta- and hexagonal shape with straight anticlinal wall. Venation pattern: Secondary vein category craspedodromous.

Jatropha integerrima and *J. multifida* are grouped together and *Triadica sebifera* is clustered with them morphologicaly due to perennial, presence of latex, glabrous texture, erect solid stem, presence of stipules, alternate leaves, presence of petiole, lamina base symmetrical, entire margin, fruit capsule, seed with smooth surface. Anatomically, they are clustered together due to presence of crystals, absence of stem and petiole trichomes, terete stem outline; epidermal cells tangentially elongated, siphonostelic vascular system with fascicular and interfascicular rays, petiole ground tissues two types (parenchyma & collenchyma), lamina outline raised adaxially; epidermal cells tangentially/radialy elongated, dorsiventral mesophyll type, crescentiform vascular tissue aspect, stomata type paracytic. Venation pattern; secondary vein category brochidodromous and irregular spacing, tertiary vein category mixed opposite/alternate percurrent, freely ending ultimate veins two or more branched.

Aleurites moluccanus is clustered with *Triadica sebifera*, *Jatropha integerrima* and *J. multifida* morphologicaly due to perennial, presence of latex, erect solid stem, presence of stipules, alternate leaves, presence of petiole, lamina base symmetrical, entire margin, and seed with smooth surface. Anatomically, they are clustered together due to presence of crystals, absence of stem trichomes, terete stem outline; epidermal cells tangentially elongated, siphonostelic vascular system with fascicular and interfascicular rays, petiole ground tissues two types (parenchyma and collenchyma), lamina outline raised adaxially; epidermal cells tangentially/radialy elongated, dorsiventral mesophyll type. Venation pattern; secondary vein category brochidodromous and irregular spacing, freely ending ultimate veins two or more branched. The all recorded criteria are in accordance with the different systems of Webster (1975) and APG III (2009) that insure the occurance of these studied taxa in the subfamilies: Acalyphoideae, Crotonoideae and Euphorbioideae.

Cluster D

comprises the four varieties of *Codiaeum variegatum* and grouped together at the 0.73. The genus placed under subfamily Crotonoideae tribe Codiaeae according to Webster (1975) and APG III (2009) and grouped together based on the morphological characters *viz*. perennial shrub, presence of latex, glabrous texture, erect solid stem, presence of stipules, alternate leaves, presence of petiole, absence of petiolar gland, lamina simple/lobed; cuneate symmetrical base, entire margin, inflorescence simple raceme, ovary with three locules, fruit capsule, subglobose seed with smooth surface. Anatomically, they are clustered together due to presence of crystals, terete stem outline, absence of stem cortical and medullary bundles, petiole epidermal cells radially elongated, lamina outline raised adaxially; lamina trichomes absence, epidermal cells tangentially/radialy elongated, dorsiventral mesophyll type, palisade one row not extended at mid rib region, ring vascular tissue aspect. Venation pattern; pinnate primary vein, secondary vein category brochidodromous, tertiary vein category random reticulate, absence of freely ending ultimate veins.

Cluster E

comprises two minor groups e_1 and e_2 and clustered with cluster D at the 1. 053 level. The first minor group e_1 is distinguished as a separate phenetic line including *Breynia disticha* at the level of 0.975. The second minor group e_2 comprises *Acalypha wilkesiana* 'Hoffmanii' and *A. wilkesiana* var. *macafeana* which are grouped together at the level 0.843.

The first minor group e_1

is distinguished as a separate phenetic line including *Breynia disticha*.

The second minor group e_2

comprises *Acalypha wilkesiana* 'Hoffmanii' and *A. wilkesiana* var. *macafeana* which are grouped together. As mentioned before Webster (1975) classified Euphorbiaceae into five subfamilies: Phyllanthoideae, Oldfieldioideae, Acalyphoideae, Crotonoideae and Euphorbioideae. In the APG III (2009)

classification, only the latter three subfamilies are included within Euphorbiaceae, the Phyllanthoideae and Oldfieldioideae are elevated to family rank, Phylanthaceae and Picrodendraceae, respectively in the Malpoghiales (Simpson, 2006). This is in accordance with the recorded criteria in the present study especially the data of the studied varieties of *Acalypha.*

Breynia disticha and *Andrachne aspera* was classified in the Euphorbiaceae by Webster (1975) under the subfamily Phyllanthoideae. APG II and III (2003 &2009) includes *Breynia disticha* and *Andrachne aspera* in the family Phyllanthaceae which is one of the five segregates of Euphorbiaceae *sensu lato* recognised at family level.

APG II (2003) recognises five lineages of Euphorbiaceae *sensu lato* at family rank: Euphorbiaceae *sensu stricto*, Pandaceae, Phyllanthaceae, Picrodendraceae and Putranjivaceae all are members of Malpighiales in the eurosid I clade (Chase *et. al.*, 2002; Davis & Chase, 2004; Wurdack *et. al.*, 2004; Davis *et. al.*, 2005; Hoffmann *et. al.*, 2006 and Tokuoka & Tobe, 2006).

In the present study the closer relationships of *Breynia disticha* with *Acalypha wilkesiana* 'Hoffmanii' and *A. wilkesiana* var. *macafeana* based on morphological characters *viz.* perennial shrub, absence of latex, erect solid stem, presence of stipules, alternate leaves, presence of petiole, absence of petiolar gland, lamina simple; rounded symmetrical base, ovary with three locules, fruit capsule, smooth seed surface. Anatomically, they are clustered together due to presence of crystals, terete stem outline; epidermal cells tangentially elongated, siphonostelic vascular tissue aspect, absence of stem cortical and medullary bundles, lamina outline raised adaxially; dorsiventral mesophyll type, palisade one row not extended at mid rib region. Venation pattern; tertiary vein course admedially ramified, absence of freely ending ultimate veins. The distinction between *Breynia disticha* and *Acalypha wilkesiana* 'Hoffmanii' and *A. wilkesiana* var. *macafeana* based morphologicaly on texture, lamina shape, apex, margin and colour, inflorescence type, seed shape, and anatomically based on presence of stem, petiole and lamina trichomes in *Acalypha* and absence in *Breynia,* absence of stem rays *in Breynia*, petiole outline and dermal, ground and vascular systems of *Breynia* differ from that of *Acalypha.* Also they differ in vascular tissue of lamina, lamina epidermal characters. Venation pattern differences; primary and secondary veins.

The closer relationships of *Breynia disticha* with *Andrachne aspera* based on the following morphological criteria *viz*. absence of latex, solid stem, presence of stipules, alternate leaves, presence of petiole, absence of petiolar gland, lamina simple; symmetrical base, entire margin, ovary with three locules, fruit capsule. Anatomically, they are clustered together due to presence of stem and lamina crystals, terete stem outline; siphonostelic vascular tissue aspect with absence of rays, absence of stem cortical and medullary bundles, petiole vascular tissue aspect kidney shape. Venation pattern; secondary vein category brochidodromous, absence of freely ending ultimate veins. The distinction between *Breynia disticha* and *Andrachne aspera* based morphologicaly on habit,

texture, stem strength, lamina shape, apex, base and colour, inflorescence type, seed shape and surface. Anatomically the differences based on presence of stem, petiole and leaf trichomes in *Andrachne* and absence in *Breynia*, differences in stem dermal and ground systems, petiole outline and dermal & ground systems of *Breynia* differ from that of *Andrachne*. Also they differ in lamina outline; dermal, mesophyll and vascular tissues, lamina epidermal characters. Venation pattern differences: primary vein, secondary vein spacing & angle, tertiary vein.

Conclusion

According to the recorded data in the present study *Breynia disticha* placed in the family Euphorbiaceae and this is supported by the work of Webster (1975) and these data conflicted with those of Chase *et al.* (2002), APG II (2003), Davis and Chase (2004), Wurdack *et al.* (2004), Davis *et al.* (2005), Hoffmann *et al.* (2006), Tokuoka & Tobe (2006) and APG III (2009) in which they placed *Breynia disticha* with *Andrachne aspera* in the family Phyllanthaceae that is one of the five segregates of Euphorbiaceae *sensu lato* recognized at family level. We suggest keeping *Breynia disticha* in the family Euphorbiaceae and this is in accordance with the recorded criteria in the present study. The results indicated that macro- and micromorphological as well as vein architectural characters are considered as valuable taxonomic criteria help in explanation of some taxonomic trends within the family Euphorbiaceae.

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التحليل التطوري لوحدات تصنيفية معينة من الفصيلة الفربيونية النامية فى مصر

محمد معوض، سلمى سعيد، ذينب عبد السميع، محمد طنطاوي
قسم النبات - كلية العلوم- جامعة عين شمس- مصر.

تعتبر العائلة الفربيونية واحدة من العائلات النباتية المزهرة الكبرى. في هذه الدراسة تم دراسة الصفات المورفولوجية والتشريحية لعدد ٣٤ وحدة تصنيفية تابعة لهذه العائلة تشمل ١٤ جنسا، ٢٩ نوعا وثمانية أصناف. وقد تم جمع الأصناف قيد الدراسة من المواطن الطبيعية والحدائق النباتية المختلفة في مصر. إعتبرت الصفات المورفولوجية والتشريحية من الصفات التشخيصية التي سهلت الفصل بين الأنواع قيد الدراسة، حيث أظهرت نتائج التحليل العددي لمجموع ٣٤٦ من السمات باستخدام برنامجNTsys -PC (الإصدار ٢،٠٢) أن الوحدات قيد الدراسة قد تم الفصل بينها في الـ phenogram إلى خمس مجموعات رئيسية بالإضافة لإثنين منها خارج المجموعة. ولذلك أوصت هذه الدراسة بفصل كل من *Andrachne aspera* و *Putranjiva roxburghii* في عائلتين منفصلتين هما Phyllanthaceae و Putranjivaceae على التوالي .