



# FAMILY EUPHORBIACEAE: REVIEW

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## Abstract

The Euphorbiaceae family was recognised by Jussie for its characteristics like the presence of latex, specialised types of inflorescences known as Cyathium, and unisexual flowers present on the same plants or on different plants. Current review comprises diversity and distribution of family Euphorbiaceae, taxonomic characters, history of nomenclature and taxonomy, classification and phylogeny, international, national and regional status of Euphorbiaceae family. Apart from this it also contains some suggestions regarding family Euphorbiaceae.

**Keywords:** *Cyathium, Euphorbiaceae, Invulcre, Phylogeny, Taxonomy*

## INTRODUCTION

The Euphorbiaceae family was recognised by Jussie for its characteristics like the presence of latex, specialised types of inflorescences known as Cyathium, and unisexual flowers present on the same plants or on different plants. This family has been much explored by various authors for its valuable utilisation in the fields of taxonomy, anatomy, morphology, palynology, ethnobotany, pharmacology, molecular biology, developmental biology, etc. The current study comprises a review of the family Euphorbiaceae, which lets us know the current status of this family in fields of taxonomy like nomenclature history and the current scenario of systematics, phytochemical work, palynological work, etc. It also let us know the research gap associated with this family.

### **Euphorbiaceae Juss. Diversity and Distribution**

Euphorbiaceae is known as the Spurge family. It is cosmopolitan, i.e., found everywhere; genera may be herbs, trees, climbers, monoecious, and dioecious; some are succulent; and latex is also found in this family. Globally, it consists of ca. 322 genera and ca. 8900 species, which are mostly found in subtropical and tropical regions. Among them, 47 genera and 153 species from Guiana, Washington, D.C., USA (Gillespie, 1993) and 22 genera and 89 species from Brazil (Alves, 1999) were reported. From India, 70 genera and ca. 410 species were found (Balakrishnan *et al.*, 2012), and 26 genera and 76 species were reported from Gujarat (Shah, 1978). Genera of this were mostly found in hot, dry areas; they were absent in cold, temperate areas like the arctic. In the subfamily Acalyphoideae, 18 genera and 49 species from Equatorial Guinea located in Western Africa (Barbera, 2013) were reported.

*Euphorbiaceae* Juss. first time recognised by Jussie in 1789, published in *Genera Plantarum*. Angiosperm Phylogeny Groups (APG IV) recognised it as an accepted name by records 42000236 in World Flora Online (<http://www.worldfloraonline.org/taxon/wfo-7000000224>)

### **Taxonomic character of Euphorbiaceae:**

Herbs, shrubs, trees (*Putranjiva*), climbers, with milky or coloured latex often resinous, plants unisexual as well as hermaphrodite stem branched, succulent, often woody, leaves simple and partite, stipulate, small, caudocous, often persistent, spine (*Euphorbia*), often exstipulate, and sometimes glands may present at the base of the lamina or petiole. Flowers are unisexual, with a special type of Cyathium inflorescence; involucre may or may not have a petaloid limb; involucre formed a cup-like structure; nectary and gland present; raceme (*Croton*); panicle (*Ricinus*). bracteate, actinomorphic or zygomorphic (*Pedilanthus*), hypogynous, tepals-5, rarely -6 (*Phyllanthus*), often absent (*Euphorbia*) petals usually in *Jatropha*, connate or free, stamen may be 1 (*Euphorbia*), 3 (*Phyllanthus*), 5 (*Bridelia*), or many (*Trewia*), branched filament (*Jatropha* and *Ricinus*), anther, basified, ditheous, free, androphore flowers with or without appendages, Gynoecium tricarpeal, syncarpous, 1-2 ovules in each locule, basal placentation, style 3, fruit schizocarpic capsule, drupe, seeds carunculate or ecarunculate, endospermous

### **History of Euphorbiaceae Nomenclature:**

Binomial nomenclature dates back to the time of Carl von Linnaeus. Carl Linnaeus recognised 56 species of *Euphorbia* and one species of *Breynia* in his species plantarum volume I (Linnaeus, 1753). In the second volume,



Linnaeus also recognised certain genera like *Tragia*, *Phyllanthus*, *Jatropha*, *Ricinus*, *Acalypha*, *Croton*, *Antidesma*, and *Dalechampia* (Linnaeus, 1753). In the second edition of *Species Plantarum*, he also recognised 114 species from the nine genera *Euphorbia*, *Tragia*, *Acalypha*, *Croton*, *Jatropha*, *Ricinus*, *Hippomane*, *Dalechampia*, and *Antidesma* (Linnaeus, 1762; Linnaeus, 1764). But the Euphorbiaceae family, as the order Euphorbiae class of Apetalae, was recognised by A. L. de Jussie in his *Genera Plantarum*. He also recognised 32 genera in his book *Genera Plantarum* (De Jussie, 1789). Bentham and Hooker changed the order Euphorbiae into the natural order Euphorbiaceae under the series Unisexuales (Bentham & Hooker, 1883). There are different names of Euphorbiaceae given by different authors, such as Peraceae by Klotzsch, Stilaginaceae by C. Agardh in 1824, and Trewiaceae in 1836, but by using the law of nomen conservada of the International Code of Botanical Nomenclature (Greuter *et al.*, 1994), the name suggested by A. L. Jussie in 1789 was conserved as Euphorbiaceae, and it was described as Euphorbiaceae Juss. (1789) nom. There are some synonyms of family also mentioned in APG I, such as Androstachyaceae, Bischofiaceae, Hymenocardiaceae, Picrodendraceae, Scpaceae, Stilaginaceae, and Uapacaceae (APG, 1998).

### Classification and Phylogeny

A natural classification system was developed by Bentham and Hooker (1862–1833) and is widely used by different taxonomists for the identification of plants. It is easy to use with the naked eye or a low-magnification microscope. They placed the Euphorbiaceae family as an order under the series Unisexuales of Apetalae of Dicot. Apart from this classification, various authors also developed classifications for the Euphorbiaceae. Classification was started by Adrien Jussie (1824), Bailon (1858), Jean Mueller (1866), Bentham (1880), Pax (1890), Pax and Hoffmann (1931), Hurusuwa (1954), Webster (1975), etc. However, certain classifications were given by various authors, such as Bentham and Hooker, Cronquist, Takhtajan, Webster, and APG, which were used by different authors to identify plants of Euphorbiaceae.

### History of Euphorbiaceae Taxonomy

Euphorbiaceae is named after De Jussie (1789), but the genera *Euphorbia*, which represent the family, have been recognised since the 1<sup>st</sup> king of Mauritius Euphorbias (Simpson, 2006), and this genus is also included in the classification of Linnaeus (1753). De Jussie classifies the family Euphorbiaceae as order Euphorbiae under the class Apetalae, along with some other orders such as Cucurbitaceae, Urticae, Amentaceae, and Coniferae (De Jussie, 1789). A. P. De Candolle (1815) mentioned Euphorbiaceae in his book “*Theorie Elementaire De La Botanique*” (Candolle, 1815). Adrien Jussieu described six sections of Euphorbiaceae without assigning them any names; he segregated the sections based on characters like numbers of ovules, inflorescence types, position of stamens, and petal condition, whether it was present or not (Jussieu, 1824). This name was retained by Bentham and Hooker (1882–1833) under the series Unisexuales of sub-class Apetalae, which includes 8 families: Balanopaceae, Urticaceae, Plantanaceae, Leitneriaceae, Junglandaceae, Myricaceae, Casurinaceae, and Betulaceae, viz.

Notes on the family Euphorbiaceae were written by Baillon, who mentioned that compound leaves are exceptional in cases where only partite leaves are present (*Dalechampia*); male florets were found to be modified in every possibility, i.e., varying from diplostemonous to infinite naked stamen; he also mentioned that the development of the caruncle (i.e., arise from the outer integument) and cellular cap (i.e., arise from the placenta) of the ovule are independent. Direction and structure of ovule and seed are fixed characters of the Euphorbiaceae order, but this character may modify. In some genera, such as *Buxus*, *Tricera*, *Sarcococca*, and *Pachysandra*, which have centripetal development of placentation, ovules are anatropous, which could be antagonist to the direction of Euphorbiaceae ovules, which possess exterior raphe, micropyle superior, and interior, along with this caruncle also arise from funiculus instead of outer integument; stylocereae are segregated from the family Euphorbiaceae, which form a small taxon near the Buxaceae. Hence, the order Euphorbiaceae comprises Scpaceae, Antidesmeae, and Callitrichaceae, while Buxaceae separated from Euphorbiaceae (Prideaux J. S. *et al.*, 1858).

Following the publication of Darwin's “*The Origin of Species by Charles Darwin*” in 1859 (Singh, 2021), there is a new revolutionary point for the classification, which initiates the phylogenetics classification based on evolutionary trends of plants, which was initiated by Eichler (1839–1887), Charles Bessey (1845–1915), John Hutchinson (1884–1972), Armen Takhtajan (1910–2009), Arthur Cronquist (1919–1992), Robert Thorne (1920–2015), etc.

Eichler recognises Euphorbiaceae under the series Tricoccae of the group chloripetalae, which have free petal or are absent; based on cotyledon size, narrow or wider family is divided into two groups. Stenolobeae and Platylobeae, viz., platylobeae, further divided into 7 sub-families: Phyllantheae and Brideliaceae (i.e., two ovules per locule), Crotonaceae, Acalyphaceae, Hippomaneae, Dalechampiaceae, and Euphorbiaceae (i.e., one ovule in each locule) (Eichler, 1883).

Charles Bessey includes the family Euphorbiaceae under the order Geraniales of the super order Apopetalae-Polycarpellatae (i.e., petals are free and Gynoecium more than two) and sub-class Strobiloideae of the class



Oppositifoliae; here Bessey placed the Euphorbiaceae family under the order Geraniales, which is near Primitive Angiosperm and also Depict origin from Ranales (Bessey, 1915).

Takhtajan placed the family Euphorbiaceae under the order Euphorbiales of the super order Euphorbianae, subclass Dilleniidae, and class Magnoliopsida. Euphorbiaceae was segregated from three other families by the ovule's characteristics, such as the crassinucellate ovule with obturator. Further Euphorbiaceae were divided into five subfamilies based on the number of ovules per locule, i.e., Phyllanthoideae and Oldfieldioideae, with 2 ovules per locule; Acalyphoideae, Crotonoideae, and Euphorbiodeae, with 1 ovule per locule (Taktajan, 1912–1992). Takhtajan revised his classification and published in 2009, He segregate subfamily Phyllanthoideae into two family Phyllanthaceae and Putranjivaceae based on character of inflorescence i.e flower on racemose, spicate or axillary or terminal in Phyllanthaceae and flower cauliflorous or axillary fascicled in Putranjivaceae; further Euphorbiaceae having one ovule per locules but Phyllanthaceae, Putranjivaceae and Picrodendraceae having two ovules per locules; based on laticifers character Euphorbiaceae was divided into six sub families namely StachyStemonoideae (Oldfilediodeae), Peroideae and Cheilosoideae where laticifers absent, Acalyphoideae may or may not have laticifers and Crotonoideae and Euphorbiodeae having inarticulate laticifers. (Takhtajan, 2009). Cronquist mentions the order Euphorbiales under Subclass Rosidae instead of Dilleniidae; he also depicts that Euphorbiales originate from the Celastrales order. Here, the family Euphorbiaceae was not further divided into subfamilies (Cronquist, 1981).

Robert Thorne placed the family Euphorbiaceae under the order Euphorbiales of Superorder Malviiflorae of Subclas Dicotyledoneae; further, he divided the family into 3 subfamilies: Phyllathoideae, Oldfilediodeae, and Euphorbiodeae (Thorne, 1968). Thorne revised his classification in 1976 and added two more subfamilies, Acalyphoideae and Crotonoideae (Thorne, 1976). It remains the same in the revised classification of Thorne in 1983 (Thorne, 1983). A new subfamily, Pandoideae, was added by Thorne in 1992, along with five past subfamilies of the family Euphorbiaceae (Thorne, 1992).

### **International Status of Spurge Research in 20th & 21st Century**

Euphorbiaceae family much explored since Linnaeus (1753) time, research during 20<sup>th</sup> and 21<sup>st</sup> century is in wide range from morphology to the cell structure. In 1943 Perry started to find phylogenetic relation among the genera of Euphorbiaceae with respect to the number of chromosomes, size and their behaviour; He analysed 109 species and varieties of 22 genera, by using smearing young leaf and stem tip material, and found that chromosomes number range from 8-200, annual species of Euphorbiaceae having average lower chromosomes number than perennial, this may be due to infrequent polyploidy in annual species. Polyploidy may rise to new species hence it is significant in evolution (Perry, 1943). Cytological work of chromosomal number in 23 species of 13 genera belongs to Phyllanthoideae and Crotonoideae were conducted by Miller and Webster (1966), in which least chromosomes found in *Andrachne phyllanthoides* (Nutt.) Coult. (13) and *Phyllanthus tenellus* Roxb. (13) and highest was found in *Phyllanthus grandifolius* L. (78) of Phyllanthoideae; along with this in Crotonoideae least chromosomes number *Croton lobatus* L. (9) and highest chromosomes numbers *Croton xalapensis* HBK. (60) was also found (Miller & Webster, 1966).

In the SouthEastern United States, the genera of Euphorbiaceae were studies by Webster (1967). Euphorbiaceae family was divided into several tribes, such works also conducted by Hutchinson (1969) to arrange tribes in phylogenetic way, He consider primitive characters like lack of disk, presence of petal, presence of rudimentary ovary in male flower etc., he arranged tribes from primitive to advance; most advance tribes are Hurea Dalechampiaeae, Pereaee, Ricineae, Crotonae, Joannsieae Euphorbieae. (Hutchinson, 1969). Taxonomical study of Euphorbiaceae also conducted on Banmaw (Nan, 2020).

Palaeobotany (i.e Study of Fossils of Plants) is very useful branch of botany to trace phylogeny and evolution among the plants. By studying pollen grain (i.e., Palynology) of fossils one can find the evolution and relation among the taxa such works conducted by Martin (1974) to identify tertiary pollen among the Euphorbiaceae, he found five different forms of tertiary pollens in Euphorbiaceae (Martin, 1974). Some Palynological work were conducted on Euphorbiaceae by Punt (1961) on Pollen Morphology; Alyas *et al.*, (2020) on Palynological characterisation using Scanning Electron microscope; Webster & Rupert (1973) on pollen nuclear number significance in Euphorbiaceae phylogeny.

Study of Epidermal characters are also very useful tools for the Plant Systematics such research has been done by Rudall (1987) on laticifers in Euphorbiaceae;

For the study of any taxa there is always a taxonomic problem we find, taxonomic problems like study of character, affinities among the taxa, controversial characters, hierarchy, phylogenetics relation etc. some taxonomist put affords tried to solve such taxonomic problem such as Radcliffe-Smith, separate five families from the Euphorbiaceae to make monophylentic group instead of polyphylentic; Buxaceae, Aextoxicaceae, Didymelaceae, Daphniphyllaceae, Pandaceae viz separated from the Euphorbiaceae (Radcliffe-Smith, 1987); Webster provides identification key for subfamilies (5), tribes (49), and genera (312), along with this he also proposed Croizatiaeae and Podocalyceae two new tribes with four new subtribes, s, Leptopinae, Podocalycinae, Pycnocominae, and



Tetracoccina viz. (Webster, 1994). There is one more taxonomic problem for Euphorbiaceae is whether it is sensu lato or sensu stricto; to propose this certain research also were conducted such as molecular phylogenetic analysis of uniolvulate Euphorbiaceae by using DNA sequencing of Plastid rbcL and trn-L (Wurdack, *et al.*, 2005); also, molecular research performed by Tokuoka (2007) by sequencing rbcL, atpB, matK and 18S rDNA from 85 species and 83 genera of Euphorbiaceae sensu stricto (Tokuoka, 2007). Euphorbiaceae sensu lato overview from Brazil also studied (Secco *et al.*, 2012). Details study of Euphorbiaceae was studied by Webster () Taxonomic notes also prepared by different author such as Wheeler (1983),

Certain work over the plant tissue culture also conducted on Euphorbiaceae such as organogenesis performed on cell culture of leafy spurge in USA (Davis *et al.*, 1988). Various pharmacological works like antibacterial, antifungal, antiviral, and anticancer also has been conducted such as study of 34 Amazonian species of Euphorbiaceae for its pharmacological activity (MacBae *et al.*, 1988). Various parts of the plants are explored for the tissue culture Node (Bhagwat *et al.*, 1996; Kaewsuwan *et al.*, 2005; Liang & Keng, 2006), Shoot tip (Ripley & Preece, 1986; Shibata *et al.*, 1996; Asma Nasib *et al.*, 2008), Leaf (Raemakers *et al.*, 1993; Marconi & Radice, 1997; Raemakers *et al.*, 2000; Ma and Xu, 2002), Callus (Ferreira *et al.*, 1992; Montoro *et al.*, 1995; Souissi *et al.*, 1997; Woodward & Kaerlas, 2001; Lima *et al.*, 2008) etc. (Kondamudi *et al.*, 2009).

Physiological research on Euphorbiaceae were conducted by certain researchers such as photosynthetic xylem hydraulic process was studied in three species (*Hevea brasiliensis*, *Macaranga denticulata* and *Bischofia javanica*) of Euphorbiaceae in south western china (Chen, *et al.*, 2009). At last, some ethanobotanical studies of Euphorbiaceae also were studied by different authors (Tewari *et al.*, 2017; Smith, 2023).

### **National and Regional Status of Spurge Taxonomy (19th to 21st Century)**

Plant systematics deals with the classification, identification, nomenclature, and phylogeny of taxa. Certain taxonomic evidences are used to study the taxa such as palynology, embryology, anatomical characters, morphological characters, cytological character and phytochemical characters etc. from India various taxonomic studies of family Euphorbiaceae were conducted to solve taxonomical problem associated with Euphorbiaceae such as various morphological study were conducted by Hooker (1887) Balakrishnan & Chakrabarty (2007), (Balakrishnan *et al.* 2012) Singh (1994); Nomenclature notes of species of Euphorbiaceae by Balakrishnan (1961), Rao & Prasad (1987).

In systematics reproductive character are more important than vegetative character of plants for the identification, classification; field of biology which deals with study of reproductive character are known as Embryology. Some works which delimits classification of Euphorbiaceae also conducted based on Embryology such works performs by Kapil & Bhatnagar (1994).

Various parts of the plants are explored for the tissue culture Node (Johnson & Manickam, 2003; Jasrai *et al.*, 2003; Datta *et al.*, 2007), Shoot tip (Rajasubramaniam & Saradhi, 1997; Sujatha and Reddy, 1998; Bhattacharyya & Bhattacharya., 2001; Rajore & Batra, 2005), Shoot bud (Quraishi & Mishra, 1998), Callus (Sehgal & Khurana, 1985), Anther (Jayasree *et al.*, 1999) etc. (Kondamudi *et al.*, 2009).

Several authors researched upon genera of Euphorbiaceae such as *Paracroton* by (N. P. Balakrishnan & Chakrabarty, (1993); Prain (1918), Haines (1921), Santapau (1954), Ramaswamy & Razi (1966), Whitmore (1978), Mandal & Panigrahi (1983, 1984), Shukla & Roy (1984), Gandhi (1990, 1991a, 1991b, 1994), Singh (1992a, 1992b, 1993a, 1993b), Pritchard (1997), and Binojkumar & Balakrishnan (1999, 2010).

Many authors made new additions & new records to India such as Balakrishnan & Chakrabarty (2012) added 19 new combination and new name in *Breynia*; Barber (1901), Gase (1914), Haines (1914), Sebastine & Henry (1960), Ellis & Saroja (1961), Chavan & Bedi (1962), Bennet (1965), Henry (1966), Singh (1967), Mitra (1969, 1971), Bahaduret *et al.*, (1973), Panigrahi (1974, 1975), Sivarajan & Manilal (1975, 1977), Ghosh & Murmu (1977), Raghavan & Kulkarni (1980), Sivarajan & Balachandran (1984, 1985), Bennet & Chandra (1985), Chakrabarty & Basu (1985), Kamilya (1992), Ramachandran *et al.* (1992), Singh (1993), Venkataraju & Pullaiah (1994), Janarthnam & Yadav (1995), Binojkumar & Gopalan (1998), Carter (2000) and Paul (2001, 2002). Cytological work on Euphorbiaceae by Gill *et al.*, (1981) on Woody Euphorbiaceae from North and Central India; Anatomical research of Euphorbiaceae by Raju & Rao (1977) on epidermal character like foliar stomata study; Seshagiri Rao and Prasad (1986) on typology of latex starch grains; Kulshreshtha, & Ahmad (1992) on cuticular ornamentation; Inamdar & Gandadhara (1997) on Trichomes of some Euphorbiaceae; Thakur & Patil (2011) on foliar epidermal studies; Tadavi & Bhadane (2014) on taxonomic significance of petiole, petiolule and rachis anatomy; Tadavi & Bhadane (2014) on leaf architecture in Euphorbiaceae; Elumalai *et al.*, (2014) on foliar anatomical studies; Alyas *et al.*, (2020) on application of Scanning Electron microscope for the study of Foliar anatomy with special reference to taxonomy of Euphorbiaceae

Apart from the taxonomical works there is also Euphorbiaceae family explored for the Ethanobotany (Kumar & Chaturvedi, 2010), Diversity around the nuclear power project (Ramarajan *et al.*, 2015), Chromosomal Studies of Euphorbiaceae species (43) from Eastern Himalaya (Hans, 1973).



### **History of Botanical Exploration and Current Status of Spurge Research in Gujarat**

Botanical exploration on spurge (Euphorbiaceae) researched since 19<sup>th</sup> century. Various floristic researched on different regions of Gujarat were conducted by different authors (Bharathi, 1959; Blatter, 1909; Chavan & Mehta, 1966; Chavan et al., 1962; Chavan et al., 1962a; Devkar, 1942; Joshi & Patel, 1971; Inamdar, 1968; Inamdar & Patel, 1971; Bhatt et al., 1969; Saxton & Sedwick, 1918; Shah, 1978). In previous botanical exploration Euphorbiaceae plants species were listed from different localities but particular botanical exploration was not conducted except the study of family Euphorbiaceae from suarashtra (Baxi, & Bhatt, 2003) and Sabarmati River of Gujarat (Maitreya, 2015).

Recent scenario indicates that there is emerging branch of phytochemical analysis which analyse the phytoconstituents of plants and their quantity Phytochemical such work from the Gujarat on different species of euphorbiaceae also explored (Ashok et al., 2011; Mehta & Jain, 2013; Mehta & Jain, 2016; Parmar, & Pundarikakshudu, 2017; Gupta et al., 2020; Vadalia et al., 2020; Srivastav et al., 2022). Apart from this molecular reserch like molecular markers study on Euphorbia milli also been explored (Chudasama et al., 2018).

Anatomical research on some species of Euphorbiaceae also were conducted form Gujarat such as anatomy of wood and histochemical change of sap wood in *Bridelia retusa* during heartwood formation (Nair et al., 1981;), trichomes of some Euphorbiaceae (Inamdar & Gangadhara, 1977)

In cyathium inflorescence which special type of inflorescence found in family Euphorbiaceae has flora nectaries which attract the insect for the pollination. The research work on this extra floral nectary for its development conducted (Dave & Patel, 1975)

### **CONCLUSION**

Euphorbiaceae family widely explored in various field. The current review on Euphorbiaceae family deals with distribution of Euphorbiaceae family worldwide, floristic study. Family name Euphorbiaceae was retained by the law of nomen conservada. This family widely classified in different classification system like Natural classification, phylogenetic classification, phenetic classification and molecular classification like APG. International status of this family indicates its wide exploration in field of Cytological work like chromosomal studies, paleobotany, taxonomic work, Palynology, epidermal studies, plants tissue culture and physiology. National status of Euphorbiaceae family in India indicates its exploration in field of embryology, plant tissue culture, cytological work, new addition to flora, anatomical works, ethanobotany. Regional status of the family Euphorbiaceae from Gujarat state deals with floristic study, molecular study, anatomical work and epidermal study. Further this family need to explored for its valuable potential in the field of pharmaceutical, ethanobotany, molecular palynology, embryology etc.

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