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Pollen morphology of some *Euphorbia* species: A review

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Abstract
Euphorbiaceae flaunt an astonishing range of growth forms, ranging from large desert succulents to trees and even small herbaceous types. Euphorbiaceae is the diverse family with great variability in the pollen structures. The variable structure of pollen grains is necessary for the delimitation of species and hence important for taxonomical purposes. The collected information gives account of the pollen morphology of the various species of *Euphorbia*. The pollen morphology varies from prolate to spheroidal structures. The presence of colpi is the prominent feature of the family. The foldable pollen structure is necessary for the maintenance of desiccation of pollen grains.

Keywords: *Euphorbia,* pollen structure, prolate, foldable, colpi, taxonomy

Introduction
Euphorbiaceae also called as spurge or crown of thorns family is renowned as one the largest families of dicotyledons. It is sixth in number among the largest families in the world (Radcliffe-Smith, 1987) [12] and in the Indian flora it occupies seventh position. Members of the family Euphorbiaceae are apparent in the field by the unisexual and mostly apetalous flowers; tricarpellary syncarpous pistil; floral glands; schizocarpic capsular fruits with three coci and persistant columella (Balakrishnan and Chakrabarty, 2007) [13]. The diversity of Euphorbiaceae is due to the presence of a wide range of unusual secondary metabolites, that makes most of the members poisonous (Seigler, 1994).
The astonishing range of growth forms, ranging from large desert succulents to trees and even small herbaceous types are present in Euphorbiaceae (Evans and Taylor, 1983) [14]. Incredible diversity of succulent and non-succulent plants that are ardently grown by horticultural enthusiasts are present in the Subgenus *Chamaesyce*- best known for its leafy non-succulent ornamental species, such as the Christmas Poinsettia (*E. pulcherrima* Willd. ex Klotzsch)- one of the most profitable potted plants in the world. Some other widely cultivated members are "Snow on the Mountain" (*E. marginata* Pursh.) and "Diamond Frost"-a cultivar of *E. graminea* Jacq (Yang *et al*., 2012) [15].

Medicinal importance
Many species of economic potential are present in the family hence contribute to the floristic wealth of tropical and subtropical countries of the world. The family comprises a number of endemic and endangered taxa. However the *in vitro* studies are confined only to a few genera of medicinal, aesthetic, timber yielding, rubber yielding, dye yielding, ornamental and food crops like *Acalypha, Baliospermum, Codiaeum, Cleistanthus, Croton, Euphorbia, Emblica, Eryngium, Excoecaria, Givotia, Glochidion, Hevea, Jatropha, Mallotus, Manihot, Phyllanthus, Putranjiva, Ricinus, Sapium* and *Uapaca* (Kondamudi *et al.*, 2009) [18]. Major components of *Euphorbia* latex are sterols, terpenoids, vitamins, insecticides and anticancer drugs (Martin *et al.*, 2005) [17].

Pollen morphology
Family Euphorbiaceae is one of the largest and most widespread dicotyledonous families in the tropics, subtropics and temperate zones. It is eurypalynous family with a great diversity of pollen types. The pollen grains are isopolar 3-colporate to prolate-spheroidal, and the tectum is either perforate, microreticulate, rugulate-reticulate or reticulate. The colpi in the family are long and the endopores arelolongate-lalongate (Punt 1962) [1]. The pollen apertures provide the main routes for exchange with the environment and serve as exit points for the pollen tube. The pollen wall structures are designed to allow the apertures to fold inwardly during harmomegathy thus reducing the rate of water loss. The pollen grain structural design can thus be interpreted as guiding harmomegathy along competing folding pathways. Under utmost circumstances, mirror buckling allows thin spherical shells to accommodate volume change with minimal stored elastic energy (Quilliet *et al*., 2008) [5]. The pollen morphological studies were carried out firstly in the family Euphorbiaceae Erdtman (1952) [2]. However, later on the pollen of various genera of the family were examined in relation to taxonomy and phylogeny.
The prominent pollen characters of the family Euphorbiaceae are, usually radially symmetrical, generally 3-colporate or subprolate, with a perforate, microreticulate or reticulate tectum. *Ricinus communis*, and *Pedilanthus tithymaloides* having shape more or less triangular. While *Jatropha curcas*, and *Acalypha indica*, showed spheroidal to oblate-spheriodal to suboblate shape. *Chrozophora prostrate* is having

quadrangular shape. The pollen grains size varies from 15 x 12µm to 94.5 x 90µm in all taxa. In case of colpi, all the taxa range from 3-7 colporate.

Euphorbieae have special apertural pollen grains, the sporoderm has an intine structure apparently not found in any other family. The endopore may be longitudinally or transversely elongated and the colpi are long. The most remarkable observation regarding these pollen grains is the special structure of the inner layer (intine) of the aperture. The aperture has a characteristic structure with paired thickenings, one on either side of the colpus. These thickenings are, however, thinner beneath the central area of the colpus. The structure and arrangement of the intinous thickenings varies depending on the distance from the endopore. The apertural system includes a well-developed spongy endexine layer in the centre of the aperture that provides resistance and protection during periods of desiccation (Suárez cervera *et al*. 2001) [3]. The apertural endexine of the *Euphorbia* is also a characteristic feature not seen in that form in any other genus (Saad and Ghazaly, 1988) [9]. In other taxa of Euphorbiaceae the endexine is well developed on both sides of the colpi. In *Euphorbia* and Chamaesyce the endexine is more compact and thicker under the colpi, but not at the margins which may represent a different strategy for preventing the excessive opening. *Euphorbia* is one of only five angiosperm genera in which both II and III pollen have been recorded (Brew- baker, 1967) [4]. The pollen grains in Euphorbiaceae vary greatly in size, shape, apertural configuration, and exine sculpturing (Punt, 1962) [1] hence diversity in the gametophytic structures within the exine wall is scarcely surprising. The morphology of pollen grains in Euphorbiaceae is so diverse that only the Acanthaceae can rival it. The great pollen diversity in Euphorbiaceae makes it difficult to identify consistent trends. Within all of the subfamilies except the Euphorbioideae, there is a tendency for multiplication and shortening of aperture that leads to polyporate grains; in the Crotonoideae, the apertures become obsolete. Crotonoid sexinous ornamentation is a unique synapomorphy within subfamily Crotonoideae (Webester, 1994) [16].

Table 1: General pollen characteristics of some *Euphorbia* species (Parveen *et al.*, 2005) [7]

Name of species	Shape
E.indica	Oblate spheroidal
E.maddenii	Oblate spheroidal
E.micractina	Prolate spheroidal
E.microsciodia	Sub prolate
E.prolifera	Sub prolate
E.prostrata	Prolate spheroidal
E.thymifolia	Prolate spheroidal
E.wallichii	Prolate spheroidal
E.hispididia	Sub prolate
E.hitra	Prolate spheroidal

Table 2: Pollen morphology of succulent *Euphorbia* species (Webester *et al*., 1985)

Name of species	Pollen structure	P/E
Euphorbia ingens	Tricolporate, prolate spheroidal to subpolrate	1.10-1.20
Euphorbia kamerunica	Tricolporate to prolate spheroidal to subprolate	1.10-1.27
Euphorbia milli	Tricolporate, prolate spheroidal to slightly subprolate	1.10-1.23
Euphorbia unisipina	Highly polymorphic, tectate perforate or microreticulate exine and variable ora	0.97-1.08

Table 3: Pollen structure of *Euphorbia* species (Gamal El-Ghazaly, 1989) [11].

Species	Structure
E. acalyphoides	Tectate-perforate
E. cuneata	Tectate-microreticulate, places perforate
E. falcate	Tectate-perforate
E. granulata	Tectate-perforate to microreticulate
E. obovita	Tectate-perforate to microreticulate
E. prostrate	Tectate-perforate to microreticulate
E. acalyphoides	Tectate-perforate
E. mauritanica	Tectate-perforate

Discussion

Palynological studies reveal that the characters of pollens are useful in the phylogenetic study of the plants these characters are reliable and fixed reproductive characters. Most remarkable variation is found in the, apertural types shape class and tectal surface. The pollen morphology of Euphorbiacea is significantly helpful at the generic, specific level and subfamilial level. Pollen morphology of the family is very helpful for taxonomic purposes. It helps in delineating one species from the another species. Pollen morphological characteristics are important in understanding the functional aspects of pollen such as pollination biology and pollen-pistil interaction.

The family Euphorbiacea is palynologically heterogeneous, however, fairly homogenous from embryological point of view (Rao and Airyshaw, 2003). The pollen morphological varations within the genera and species are enough to confirm and throw more light on its taxonomic classifications. These studies will be useful for identifying the flora and improve the conservation status of economically important plants as well as acting as a reference guide in identifying various species in their respective families.

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