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FLORAL ANATOMY AND SYSTEMATIC POSITION OF THE GENUS *BALANITES*

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A pedicel contains a ring of conjoint vascular bundles. Ten traces diverge out from the ring. Of these, five are sepal dorsals and the other five are compound, each splitting up tangentially to give rise to two marginal traces of adjacent sepals and a petal dorsal. The receptacular stele gives out ten staminal traces in two whorls of five each. Around the base of the ovary the disc is with prominent vascular supply. The receptacular stele finally consists of only five bundles which become completely used up in furnishing the vascular supply of the gynoecium. The placentation is anatomically and topographically axile.

There has been an acrimonious debate regarding the systematic position of the genus *Balanites*. It was originally placed in the Zygophyllaceae then shifted to the Simaroubaceae and finally a separate family Balanitaceae was created. Retention of the genus *Balanites* in the Zygophyllaceae is supported on the basis of floral anatomy, embryology, taxonomy and pollen morphology.

Key words: *Balanites*, embryology, floral anatomy, pollen morphology, systematic position, taxonomy

INTRODUCTION

The Zygophyllaceae is comprised of about 27 genera and 240 species. There has been much speculations regarding the systematic position of the genus *Balanites*. Bentham and Hooker (1862–1883) placed this genus in the Simaroubaceae, Engler and Prantl (1931) assigned it to the Zygophyllaceae. Takhtajan (1959) created a new monogeneric family Balanitaceae and this was supported by Hutchinson (1969). With a view to fill up this lacuna in our knowledge, the present study has been undertaken. In this paper floral anatomy, embryology, taxonomy and pollen morphology of *Balanites*, Zygophyllaceae and Simaroubaceae have been discussed.

MATERIAL AND METHODS

Flowering materials were collected locally and fixed in FAA. Floral buds were treated with hydrofluoric acid for two weeks to render the tissues soft.

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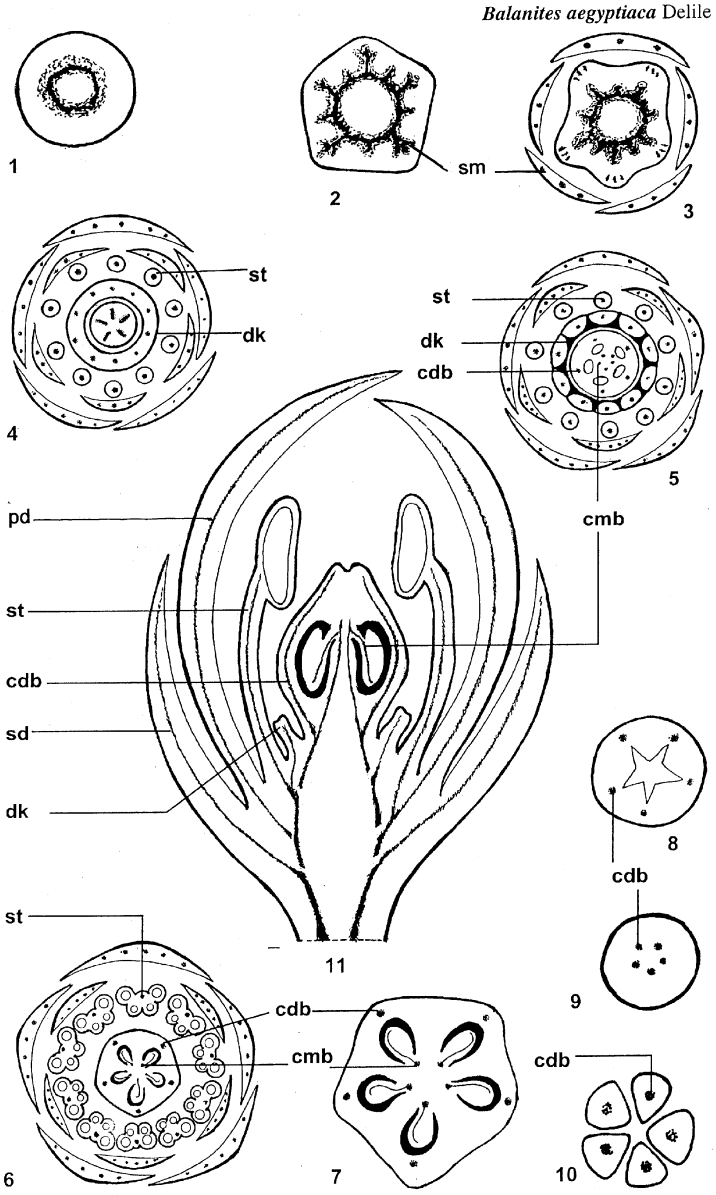
They were washed in running water for about 24 hours and then dehydrated and cleared by passing through various grades of alcohol and xylol and finally embedded in paraffin wax (Johansen 1940, Maheshwari 1939). Serial tranverse and longitudinal sections of the flower buds were cut at the thickness ranging from 10–15 μm on a rotary microtome. Crystal violet and erythrosine double-stain combination were used with satisfactory results. For the study of pollen morphology the "Acetolyses" method of Erdtman (1952, 1964) was used.

OBSERVATIONS

Balanites aegyptiaca Delile. The pedicel contains a ring of conjoint vascular bundles. In the top of the receptacle, the ring becomes continuous and ten vascular traces diverge out from it (Figs 1–2). Of these ten traces, five are the sepal dorsal traces (sd) and the other five which alternate with the sepal dorsal traces are compound, each splitting up tangentially to give rise to two sepal marginal traces (sm) of adjacent sepals and a petal dorsal (pd) trace (Figs 2–3). Both the sepal, as well as petal bundles undergo divisions in their upward course, so that an arc of several bundles in seen in their cross-sections (Figs 3–6).

After furnishing the vascular supply of the sepals and petals, the receptacular stele gives out ten staminal traces (st), in two whorls of five each (Figs 3–4). The staminal bundles remain unbranched throughout their course (Figs 4–6). Surrounding the base of the ovary, there is a disk with prominent vascular supply (Figs 4–5 and 11). The ten vascular traces of the disk branch off from the base of the staminal traces. At its top, the disk breaks up into about ten small lobes (Fig. 5).

After furnishing the vascular supply of the androecium, the receptacular stele consists of only five bundles which become completely used up in furnishing the vascular supply of the gynoecium. Five traces diverge out from the receptacular stele as the carpellary dorsal (cdb) bundles and the remaining five in the centre constitute the compound marginal (cmb) bundles of the five carpels (Figs 4–6). The carpellary dorsal and compound marginal bundles are situated on the same radii (Figs 5–7) and this shows that placenatation is topographically as well as anatomically axile. The odd carpel is anterior in position. Each loculus contains a single pendulous ovule, hanging from the upper inner angle of the loculus (Figs 7 and 11). Only the carpellary dorsal bundles continue upward into the style and stigmas (Figs 8–10).



Figs 1–11. Balanites aegyptiaca Delile. – 1–10: Serial transverse sections of a floral bud from below upward, showing the origin and subsequent coursing of the vascular supply of the different floral whorls (for explanation see text); – 11: Median longisection of a floral bud along the postero-anterior plane (diagrammatic reconstruction), showing vasculature. (Abbreviations: cdb = carpellary dorsal bundle; cmb = compound marginal bundle; dk = disk; pd = petal dorsal; sd = sepal dorsal trace; sm = sepal marginal trace; st = staminal bundle)

DISCUSSION

A comparative study of the *Balanites*, Zygophyllaceae and Simaroubaceae shows that there are great similarities between *Balanites* and Zygophyllaceae. On the other hand, *Balanites* shows remarkable differences with the Simaroubaceae. The systematic position of the *Balanites* can be discussed under the following head.

Floral anatomy

The floral anatomy of the genus *Balanites* resembles the other Zygophyllaceae, especially the genus *Tribulus* (Chauhan 1975). In all these taxa the marginal traces of adjacent sepals and the traces of antipetalous stamens are all compound. Thus, in this type in addition of cohesion among the marginal traces of the sepals, traces of three whorls, i.e. sepal, petal and stamen are adnated. The common anatomical features in *Balanites* and *Tribulus* are: sepals are 3-traced; petals and stamens 1-traced each; stamens ten in two whorls of five each, anatomically as well as topographically with obdiplostemony condition; gynoecium with five carpellary dorsal bundles and five carpellary marginal bundles; the five carpellary dorsal bundles enter the style and terminate in the stigmas and placentation is anatomically as well as topographically axile. So the floral anatomy of *Balanites* and *Tribulus* is remarkably similar except that in *Balanites* disk is vascularised and in *Tribulus* it is non vascular. Nair and Nathawat (1958) also suggested that *Balanites* is anatomically similar to the Zygophyllaceae. So floral anatomy favours the retention of *Balanites* in the Zygophyllaceae.

Embryology

The genus *Balanites* has little resemblance with the Simaroubaceae and show marked differences as tabulated below (Table 1).

Therefore, the placement of the genus *Balanites* in the Simaroubaceae (Bentham and Hooker 1862–1883) is not justified. On the other hand, the genus *Balanites* shows marked similarities with the other genera of the Zygophyllaceae in some of the peculiar embryological features like persistent middle layer of anther, poorly developed nucellus, presence of integumentary tapetum, *Polygonum* type of embryo sac and nuclear endosperm (Maheshwari 1963). So the embryological data support the placement of *Balanites* in the Zygophyllaceae.

The genus *Balanites* also exhibits some of its own embryological features as: (a) presence of supernumerary nuclei in pollen, (b) campylotropous ovule

Table 1
Embryological data of Simaroubaceae and *Balanites*

Characters	Simaroubaceae	*Balanites*
Ovule	anatropous or hemianatropous	campylotropous
Integument(s)	unitegmic, when bitegmic no space between integuments	bitegmic with space between integuments
Nucellus	massive	poorly developed
Nucellus cap	prominent	absent
Integumentary tapetum	absent	present

and (c) space between two integuments. However, raising to a separate family Balanitaceae (Takhtajan 1959, Hutchinson 1963) on the basis of these, is not justified.

Taxonomy

The taxonomic characters of Zygophyllaceae, *Balanites* and Simaroubaceae are tabulated below (Table 2).

The perusal of the taxonomic data of the Zygophyllaceae, *Balanites* and Simaroubaceae and moreover zygophyllaceous appearance of *Balanites* clearly reveals its affinities with the Zygophyllaceae.

Table 2
Taxonomic data of the Zygophyllaceae, *Balanites* and Simaroubaceae

Characters	Zygophyllaceae	*Balanites*	Simaroubaceae
Habit	shrub	shrub	tree
Habitat	xerophyte or hydrophyte	xerophyte	mesophyte
Leaf	opposite	opposite	alternate
Inflorescence	cymose	cymose	racemose
Flower	bisexual	bisexual	unisexual
Calyx	5–4	5	3–8
Corolla	5–4	5	3–7 rarely 0
Androecium	10	10	6–14
Gynoecium	5	5	4–5
	syncarpous	syncarpous	apocarpous
Placentation	axile	axile	basal
Gynophore	absent	absent	present

Table 3
Pollen morphological data of the Zygophyllaceae of the Indian Desert

Taxon	Aperture	Shape	Amb	Diameter (µm)	Exine thickness (µm)	Exine ornamentation
Seetzenia lanata	3-zonocolpate	suboblate	circular	23×28	4	reticulate
Tribulus lanuginosus	pantoporate	spheroidal	circular	50	7	reticulate
Tribulus pentandrus	pantoporate	spheroidal	circular	46	7	reticulate
Tribulus rajasthanensis	pantoporate	spheroidal	circular	65	8	reticulate
Tribulus terrestris	pantoporate	spheroidal	circular	51	5	reticulate
Zygophyllum simplex	3-zonocolporate	prolate-spheroidal	circular	21.2×20.4	2	reticulate
Peganum harmala	3-zonocolporate	prolate	circular	22.5×16.5	1.5	reticulate
Fagonia bruguieri	3-zonocolporate	prolate	circular	15×11	1	reticulate
Fagonia indica	3-zonocolporate	subprolate	circular	25×20	2	reticulate
Fagonia schweinfurthii	3-zonocolporate	prolate	circular	20×14	2	reticulate
Balanites aegyptiaca	3-zonocolporate	suboblate	circular	19.2×16.4	1.5	reticulate

Pollen morphology

Pollen analysis of the members of the family Zygophyllaceae, including *Balanites*, especially belonging to the Great Indian Desert, shows that 3-zonocolporate condition is common (Table 3) and other apertural conditions are pantoporate (*Tribulus* spp.) and 3-zonocolpate (*Seetzenia lanata*). In all the species investigation including *Balanites* exine ornamentation is reticulate and Amb is circular. Pollen morphology of *Balanites* is exactly similar to *Fagonia* spp. and *Zygophyllum simplex*. So, the pollen morphological data also support the placement of *Balanites* in the Zygophyllaceae.

There is no doubt that the genus *Balanites* differs from the Simaroubaceae in a number of features. On the other hand, the genus *Balanites* shows remarkable features of resemblance to the Zygophyllaceae in certain major features of the floral anatomy, embryology, taxonomy and pollen morphology. The most natural place of *Balanites* is, therefore, among the family Zygophyllaceae. It, however, shows the same individual features of embryology. The present investigation shows that the genus *Balanites* stands apart from other taxa of the family, hence the proposal to place in a separate tribe, i.e. Balanitoideae, of the family Zygophyllaceae, seem to be quite justified.

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