

POLLEN FLORA OF PAKISTAN –XLIX. ZYGOPHYLLACEAE

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Abstract

Pollen morphology of 14 species representing 5 genera of the family Zygophyllaceae from Pakistan has been examined by light and Scanning Electron Microscope. Pollen grains are usually radially symmetrical, isopolar or apolar, 3-polycolporate or pantoporate, prolate-spheroidal to subprolate or prolate often oblate-spheroidal. Sexine thinner or thicker than nexine. Tectum generally coarsely reticulate rarely rugulate - reticulate or foveolate to reticulate often striate. On the basis of tectum types 4 distinct pollen types are recognized viz., *Nitraria retusa*, *Peganum harmala*, *Tribulus terrestris* and *Zygophyllum simplex*. Palynological data has been useful at generic and specific level.

Introduction

Zygophyllaceae is a family of about 25 genera and 240 species (Mabberley, 1987). Widespread in tropical, subtropical and warm temperate, often in drier areas. In Pakistan it is represented by 8 genera and 22 species (Ghafoor, 1974).

Cronquist (1968) treated this family under the order Sapindales. However, Engler (1964), Dahlgren (1980) kept the family in the order Geraniales and Takhtajan (1980) placed the family in the order Rutales. Plants annual or perennial herbs, leaves stipulate, opposite also alternate or in fascicles. Flowers perfect, regular. Sepals imbricate or valvate, free, persistent or deciduous. Petals usually free, imbricate or convolute in bud. Disk or nectary glands present or absent, sometimes acting as a gynophore. Ovary superior, 2 to 5 or 10-lobed. Fruit capsule, often spiny or tuberculate. Family is important for *Lignum vitae* wood (*Guaiacum officinale*), spices, and few ornamentals. The chief genera of the family are *Fagonia*, *Zygophyllum*, *Guaiacum* and *Tribulus*.

Pollen morphology of the family has been examined by Erdtman (1952), Sladkov (1954), Shimakura (1973), Kuprianova & Alyoshina (1978). Yunus & Nair (1988) examined pollen morphology of 3 genera of the family Zygophyllaceae from India. There are no reports on pollen morphology of the family Zygophyllaceae from Pakistan. Present investigations are based on the pollen morphology of 14 species representing 5 genera of the family Zygophyllaceae by light and Scanning Electron Microscope.

Materials and Methods

Pollen samples were obtained from Karachi University Herbarium (KUH) or collected from the field. The list of voucher specimens is deposited in KUH. The pollen grains were prepared for light (LM) and scanning microscopy (SEM) by the standard methods described by Erdtman (1952). For light microscopy, the pollen grains were mounted in unstained glycerin jelly and observations were made with a Nikon Type-2 microscope under (E40, 0.65) and oil immersion (E100, 1.25), using 10x eye piece. For SEM studies, pollen grains suspended in a drop of water were directly transferred with a

fine pipette to a metallic stub using double sided cello tape and coated with gold in a sputtering chamber (Ion-sputter JFC-1100). Coating was restricted to 150 Å. The S.E.M examination was carried out on a Jeol microscope JSM-2. The measurements are based on 15-20 readings from each specimen. Pollen diameter, polar axis (P) and equatorial diameter (E), aperture size and exine thickness were measured (Table 1 and 2).

The terminology used is in accordance with Erdtman (1952), Kremp (1965), Faegri & Iversen (1964) and Walker & Doyle (1975).

General pollen characters of the family Zygophyllaceae

Pollen grains are usually radially symmetrical, or apolar 3-polycolporate-pantoporate, prolate-spheroidal to sub-prolate or prolate rarely oblate-spheroidal. Sexine thinner or thicker than nexine. Tectum coarsely reticulate or reticulate-rugulate often foveolate-reticulate or striate. On the basis of exine ornamentation four distinct pollen types are recognized viz., *Nitraria retusa*-type, *Peganum harmala*-type, *Tribulus terrestris* - type and *Zygophyllum simplex*-type.

Key to the pollen types

- 1 + Pollen grains pantoporate *Tribulus terrestris*-type
 - Pollen grains tricolporate to polycolporate 2
- 2 + Pollen grains tricolporate 3
 - Pollen grains polycolporate *Nitraria retusa*
- 3 + Tectum rugulate-reticulate *Peganum harmala*
 - Tectum reticulate or reticulate-foveolate *Zygophyllum simplex*

Pollen type: *Nitraria retusa* -type (Fig. 1A-C).

Pollen class: Polycolporate.

P/E ratio: 1.35.

Shape: Prolate

Apertures: Ectocolpus long narrow with acute ends.

Exine: Sexine thinner than nexine.

Ornamentation: Striate.

Measurements: Size: Length = (38.5-) 39.8 ± 0.2 (-40.5) μm and breadth (25.75) 28 ± 0.11 (32.5) μm , colp (27.8-) 30.75 ± 0.42 (32.8) μm long. Mesocolpium c. 25 μm . Apocolpium c. 1.25 μm . Exine 1.75 (2.08 ± 0.5) 2.5 μm thick, sexine thinner than nexine. Tectum striate.

Species included: *Nitraria retusa* (Forssk.) Aschers.

Pollen type: *Peganum harmala* (Fig. 1D & E).

Pollen class: Tri-colporate.

P/E ratio: 1.28

Shape: Sub-prolate to prolate.

Apertures: Ectocolpus long narrow with acute ends.

Exine: Sexine thicker than nexine.

Table 1. General pollen characters of species included in pollen type *Tribulus terrestris*.

Name of taxa	Shape	Length in μm	Breath in μm	Pore diameter μm	Exine μm	Tectum
<i>Tribulus ochroleucus</i> (Maire) Ozenda & Quezel	Ob-Sp	37.5 (39.0 \pm 0.6) 40.0	36.25 (40.25 \pm 1.14) 42.5	1.75 (2.15 \pm 0.14) 2.5	4.25 (4.85 \pm 0.14) 5.0	Ct
<i>T. longipetalus</i> Liv. subsp. <i>macropterus</i> (Boiss) Maire ex Qzenda & Quezel.	Ob-Sp	40.0 (44.75 \pm 1.2) 52.5	42.0 (44.82 \pm 0.77) 48.75	2.5 (2.75 \pm 0.09) 3.25	c. 5 6.82 (7.18 \pm 0.05)	C-Rt
<i>T. pentandrus</i> Forsk.	Sp	36.2 (40.24 \pm 1.66) 50.26				C-Rt
<i>T. terrestris</i> L.	Ob-Sp	32.3 (35.9 \pm 0.71) 34.5		1.52 (1.72)	6.82 (7.14 \pm 0.06) 7.18	C-Rt

Ob-Sp= Oblate-spheroidal, Pr= Prolate, Sub-Pr= Subprolate, Rt= Reticulate, Rt-Fov= Reticulate-foveolate, C-Rt= Coarsely reticulate

Table 2. General pollen characters of species included in pollen type *Zygophyllum simplex*.

Name of taxa	Shape	Polar axis μm (P)	Equatorial diameter μm (E)	Colpus length μm	Mesocolpium μm	Apocolpium μm	Exine thickness μm	Tectum
<i>Fagonia olivieri</i> DC	Pr.	27.5 (31.32 \pm 0.56) 36.25	17.5 (22.7 \pm 0.64) 26.75	22.5 (25.62 \pm 0.47) 30.0	13.75 (16.5 \pm 0.5) 17.5	1.25 (2.03 \pm 0.32) 3.75	1.51 (1.8 \pm 0.04) 2.0	Rt
<i>F. bruquieri</i> DC	Pr.	27.5 (30.63 \pm 0.50) 32.5	20.27 (22.27 \pm 0.36) 25.0	25.0 (27.5 \pm 0.53) 31.25	15.0 (15.31 \pm 0.31) 17.5	1.25 1.75	1.0 (1.52 \pm 0.08) 1.75	Rt
<i>F. indica</i> Burn. f. var. <i>schweinfurthii</i> Hadidi	Pr.	21.0 (24.2 \pm 0.50) 26.6	15.4 (17.85 \pm 0.66) 22.4	19.6 (21.10 \pm 0.72) 23.8	11.12 (11.9 \pm 0.31) 21.6		1.26 (1.38 \pm 0.02) 1.4	Rt
<i>F. glutinosa</i> Delie	Pr.	26.25 (29.79 \pm 0.70) 33.0	17.5 (21.4 \pm 0.69) 25.0	22.5 (26.02 \pm 0.73) 28.5	15.0 (16.8 \pm 0.4) 18.75	1.25 (1.87 \pm 0.23) 2.5	1.25 (1.45 \pm 0.04) 1.75	Rt
<i>Zygophyllum propinq</i> DC.	Pr.	11.2 (12.69 \pm 0.25) 14.0	8.4 (9.08 \pm 0.22) 11.06	9.8 (10.9 \pm 11.0) 12.5	5.6 (6.72 \pm 0.28) 8.4	1.4 (2.11 \pm 0.20) 2.8	0.98 (1.17 \pm 0.03) 1.26	Medium-Rt
<i>Z. fabago</i> L.	Sub-Pr.	16.25 (16.46 \pm 0.11) 17.0	11.0 (12.57 \pm 0.54) 14.5		7.5 (10.0 \pm 0.64) 12.5	1.25	1.25 (1.39 \pm 0.04) 1.5	Rt-Fov.
<i>Z. simplex</i> L.	Sub-Pr.	9.10 (9.8 \pm 0.68) 10.50	7.0 (7.93 \pm 0.22) 9.8	7.0 (7.9 \pm 0.23) 8.4	5.6 (6.09 \pm 0.25) 7.7	c. 2.8	0.7 (0.84 \pm 0.05) 1.26	Rt
<i>Z. eurypterum</i> Boiss & Buhse	Sub-Pr.	21.25 (22.45 \pm 0.24) 23.75	17.5 (19.45 \pm 0.26) 20.0	17.5 (19.25 \pm 0.37) 20.0	12.5 (13.33 \pm 0.83) 15.0	1.25 (1.66 \pm 0.41) 2.5	1.25 (1.57 \pm 0.05) 1.75	Rt-Fov.

Fig. 1. Scanning Electron micrographs of pollen grains. *Nitraria retusa*: A, Polar view; B, Equatorial view; C, Exine pattern. *Peganum harmala*: D, Equatorial view; E, Exine pattern. *Fagonia bruquieri*: F, Polar view.
Scale bar = A, B, D-F = 10 μm . C= 1 μm

Ornamentation: Rugulate-reticulate

Measurements: Size: Length = (21.5-) 22.8± 0.2 (-22.5) µm and breadth (15.75) 16.5 ± 0.11 (17.5) µm, colp (9.8-) 13.75 ± 0.42 (131.8) µm in long. Mesocolpium 12.5 µm. Apocolpium c. 1.25 µm. Exine 1.75 (2.08 ± 0.5) 2.5 µm thick, sexine thicker than nexine. Tectum rugulate-reticulate.

Species included: *Peganum harmala* L.

Pollen type: *Tribulus terrestris* (Fig. 2C & D).

Pollen class: Pantoporate.

P/E ratio: 100-102

Shape: Spheroidal rarely oblate-spheroidal.

Apertures: Pore circular or oval with or without operculum.

Exine: Sexine thicker or thinner than nexine.

Ornamentation: Coarsely reticulate.

Measurements: Size: Polar axis P = 32 (44 ± 1.2) 52, and equatorial diameter E = 36 (42 ± 2.1) 48 µm. Pore 1.75-3.25 µm in diameter. Exine 4.25-7.73 µm thick, sexine thicker or thinner nexine. Tectum coarsely reticulate.

Species included: *Tribulus ochroleucus* (Maire) Ozenda & Quezel., *T. longipetalus* subsp. *macropterus* (Bioss.) Maire ex Ozenda & Quezel., *T. pentandrus* Forsk, *T. terrestris* L.

Key to the species

- 1 + Pollen grains oblate-spheroidal 2
 - Pollen grains spheroidal *Tribulus pentandrus*
- 2 + Exine 1.75-2.5 µm thick *Tribulus ochroleucus*
 - Exine c.5-7.18 µm thick 3
- 3 + Polar length of pollen grains 40-52.5 µm *T. longipetalus*
 - Polar length of pollen grains 32.4-39.5 µm *T. terrestris*

Pollen type: *Zygophyllum simplex*-type (Fig. 1F; Fig. 2 A & B; E & F)

Pollen class: Tri-colporate.

P/E ratio: 115-138.

Shape: Sub-prolate to prolate.

Apertures: Ectocolpus long narrow with acute ends.

Exine: Sexine thicker than nexine.

Ornamentation: Reticulate rarely rugulate-reticulate or reticulate-foveolate.

Measurements: Size: Polar axis = (9.5-) 22.8± 0.2 (-36.5) µm and equatorial diameter (8.75) 20 ± 0.11 (32.5) µm, colpi (9.8-) 13.75 ± 0.42 (13.8) µm long. Mesocolpium 5.6 (10.83 ± 0.25) 18.6 µm. Apocolpium 1.25 (2.0 ± 1.24) 2.8 µm. Exine 1.75 (2.08 ± 0.5) 2.5 µm thick, sexine thicker than nexine. Tectum reticulate or rugulate-reticulate or foveolate-reticulate.

Species included: *Fagonia olivieri* DC., *F. bruguieri* DC., *F. indica* Burm., var. *schweinfurthii* Hadidi, *F. glutinosa* Delile, *Zygophyllum propinquum* DC., *Z. fabago* L., *Z. simplex* L., *Z. eurypterum* Boiss. & Buhse.

Fig. 2. Scanning Electron micrographs of pollen grains. *Fagonia bruquieri*: A, Equatorial view; B, Exine pattern. *Tribulus longipetalus*: C, Pollen grain' D, Exin pattern. *Zygophyllum fabago*: E, Equatorial view; F, Exine pattern.
Scale bar = A-E = 10 μ m. F= 1 μ m

Key to the species

- 1 + Polar length of pollen grains 9-17 μm 2
 - Polar length of pollen grains 18-33 μm 4
- 2 + Pollen grains prolate *Zygophyllum propinquum*
 - Pollen grain sub-prolate 3
- 3 + Polar length of pollen grains 9-10 μm *Zygophyllum simplex*
 - Polar length of pollen grains 11-17 μm *Z. fabago*
- 4 + Pollen grains subprolate *Z. eurypterum*
 - Pollen grains prolate *Fagonia indica* – group
 (*Fagonia olivieri* DC., *F. bruguieri* DC., *F. indica* Burm. f. var., *schweinfurthii* Hadidi, *F. glutinosa* Delile.)

Discussion

Zygophyllaceae is a very heterogeneous family. Pollen data is based on 14 species distributed in 5 genera. Pollen grains are generally prolate to sub-prolate rarely oblate-spheroidal or spheroidal, 3-polycolporate or pantoporate tectum coarsely to medium reticulate or foveolate-reticulate often rugulate-reticulate or striate. It shows considerable variation in all pollen characters viz., polarity, shape, size, apertural types and exine ornamentation. In the genus *Tribulus* spheroidal to oblate-spheroidal, apolar, pantoporate grains are found (Erdtman, 1952; Yunus & Nair, 1988). In contrast to this in *Zygophyllum*, *Fagonia*, *Nitraria* and *Peganum* isopolar, tricolporate, prolate to sub-prolate pollen are found. *Zygophyllum* and *Fagonia* are more closely related as depicted by palynological characters as compared to *Nitraria* and *Peganum*. In *Zygophyllum* and *Fagonia* tectum is reticulate, while in the *Nitraria* (*N. retusa* (Forssk.) Aschers.) tectum is striate and in the genus *Peganum* (*P. harmala* L.) rugulate-reticulate tectum is observed. The above palynological data supports the idea of Dahlgren (1989) who treated them as two distinct entities (Nitrariaceae and Peganaceae). Engler (1964), Dahlgren (1980) have placed the family Zygophyllaceae in the order Geraniales whereas Hutchinson (1969) kept it in Sapindales and Takhtajan (1980) in the order Rutales.

Present findings favour the treatment of Engler (1964) and Dahlgren (1989), because pollen grains of Rutaceae (Rutales) and Sapindaceae (Sapindales) are different from Zygophyllaceae grains (Qaiser & Perveen, 1997).

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